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All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

CANTOR LECTURES.

The third lecture of the fifth course on "Carving and Furniture" was delivered on Monday evening, March 23rd, by Mr. J. Hungerford Pollen, who, after explaining the arrangements of the old country mansions, and the prominent position which carved wood occupied in their decoration, devoted special attention to the productions of the age of Gibbons and Boule.

The lecture was illustrated by photographs of examples shown on the screen by means of the lantern.

The lectures will be printed in the *Journal* during the summer recess.

FOREIGN & COLONIAL SECTION.

Commander Cameron's paper on "The Congo and the Conference, in reference to Commercial Geography," will be printed in the next number of the *Journal*.

Proceedings of the Society.

SIXTEENTH ORDINARY MEETING.

Wednesday, March 25th, 1885; Sir Frederick Abel, D.C.L., C.B., F.R.S., Chairman of the Council, in the chair.

The following candidates were proposed for election as members of the Society:—

Dalyell, Hon. Robert Anstruther, C.S.I., LL.D., 21, Onslow-gardens, S.W.
Hardy, G. Hurlstone, Park-lodge, East Twickenham.
Head, John, F.G.S., 12, Queen Anne's-gate, S.W.
Hodges, Herbert J., Chesterfield-house, Barclay-road, Fulham, S.W.
Kendal, James, 106, Cheapside, E.C.
Pears, Andrew, Spring-grove, Isleworth.
Stenning, Allan E., East Grinstead, Sussex.
White, William Henry, Lower Condercum, Newcastle-on-Tyne.

The following candidates were balloted for and duly elected members of the Society:—

Clare, Octavius Leigh, Hindley-cottage, East Sheen, S.W.
Gilbert, William Henry Sainsbury, 9, Old Jewry-chambers, E.C.
Kirkaldy, John, 40, West India-road, E.
Partington, Charles Frederick, 47, Lower Belgrave-street, S.W.
MacWilliam, George Greenshields, 20, Bartlett's-buildings, Holborn, E.C.
Patterson, George, 85, Carleton-rd., Tufnell-pk., N.
Sharp, James, Carr-hall, Wyke, near Bradford.
Ward, Howard Charles, Yeatton, Lymington, Hants.
Watson, John, Cement Works, Gateshead-on-Tyne.

The paper read was—

ON THE MUSICAL SCALES OF VARIOUS NATIONS.

By Alexander J. Ellis, F.R.S.

I.—Introduction.

The title of this paper was meant to be "On the Musical Scales of *all* Nations." *All* is a big word, and I have had to withdraw it, and take refuge in the neutral term *various*. As I glance at Greece, Arabia, India, Java, China, and Japan, this term is at least not too comprehensive. The difficulties in collecting and co-ordinating information, even to this extent, have been many and great. Although some of the matter I have to bring to your notice may be found by those who know how to look for it, in papers already published, by far the greater part is entirely new. The very method by which the results have been obtained, and the language in which they are expressed, are also new, the results of my own investigations. I have been assisted throughout by the delicate ear of Mr. Alfred James Hipkins, of J. Broadwood and Sons. Indeed, I may say at the outset, that without his remarkable power of discriminating small intervals between tones of very different qualities, one of which in each comparison was often of very short duration, and without his great kindness in putting his faculty at my disposal, and his hearty sympathy in all my musical work, this paper could not have come into existence for want of materials, and the only reason why I have not associated his name with mine at the head of it is, that I do not wish to make him responsible for the shape in which our joint work is produced. The calculations, the arrangement, the illustrations,* as well as the original conception, form my part. The judgment of ear, musical suggestions, and assistance in every way form his.

II.—Musical Scales.

In my "History of Musical Pitch" (*Journal of the Society of Arts*, 5th March and 2nd April, 1880, and 7th Jan., 1881), Art. 2, I defined "the pitch of a musical note to be the number of double or complete vibrations, backwards and forwards, made in each second by a particle of air while the note is heard;" and I gave a full account of the methods by which this is ascertained, and showed how, by means of a sufficiently long series of tuning-forks, first, their own pitch, and then the pitch of all other notes of sufficient duration which fall within their compass, can be ascertained to one vibration in ten seconds. I chiefly used the forks of the late celebrated Scheibler for that paper. For the present investigation I have employed a much longer series of forks, with their pitch ascertained from those of Scheibler within that limit. Further, in Art. 3, I defined *musical* pitch to be "the pitch of any named musical note which determines the pitch of all the other notes in a particular system of tuning." By that *system* we are therefore able to tune all the notes on an instrument. These notes, when sounded in succession from the lowest to the highest—that is, from that which has the smallest to that which has the largest pitch number—forms the *scale* of the instrument, from which are selected the notes used for any piece of music forming the scale of that composition. The word scale properly means *ladder*, because the notes thus sounded gives us the sensation of ascending by definite distances. An *interval* between any two notes is the sensation of the distance passed over in proceeding

* The reading of this paper was entirely occupied by illustrations connected by the fewest possible explanations, because it was considered more important that the audience should actually hear the scales than be merely spoken to about them. But to make this at all intelligible to a reader I have been obliged to extend my paper to an unusual length. The illustrations were rendered on several instruments.

1. A *Dichord*, an instrument of two strings, most kindly constructed for me, with a beautiful sounding board, by Messrs. John Broadwood and Sons. The vibrating wires were No. 2, gauge 3-10th millimetres, about 1-80th inch, the thinnest drawn, and had a vibrating length of 1,200 millimetres (of which 3,048 make 10 feet). The nut was raised 7 mm., and the bridge 24 mm. from the sounding board. The wires were fastened as on a pianoforte, and screwed to pitch C 132 vib., or tenor C, by the usual tuning hammer. A number of laths, about 5 mm. thick and 915 mm. long, were constructed to serve as finger boards. On one of these was first marked through two octaves the place where the wire should be stopped by the finger (or, rather, side of the thumb nail, to be more accurate) to produce the notes of the just major scale, calculated on the usual hypothesis, that the numbers of vibrations would be inversely proportional to the lengths. Owing to the necessity of having the wires to stand some distance from the finger-board (as on the violoncello), the increased tension arising from bringing the wire to the board in each case sharpened the note considerably. To overcome this difficulty, the notes were played on a justly intoned harmonical, tuned from forks which had been accurately adjusted by myself, and then, as each note was sounded, Mr. Hipkins marked off the position where he had to stop the wire for perfect unison. From these I was able to calculate and mark off, on a geometrical scale, the exact position for stopping the string, so as to produce an interval of any given number of cents (see this term explained in Art. 3), and hence draw the finger board for any musical scale whatever. Marking each such scale on its own board, I could thus render any scale distinctly audible. This must have been entirely new to almost every one of the audience.

2. Five *English Concertinas*, tuned for me with great care by Mr. Saunders, of Messrs. Lachenal and Co., the first concertina house in London. The English concertina had, for my purposes, two important advantages over any other instrument. First, I had been familiar with it from boyhood, having possessed some of the earliest concertinas made. Second, it has 14 notes to the octave, and was hence well adapted to introduce extra notes for various purposes. These five instruments were tuned thus: *a*. Meantone, giving the old unequal temperament with extra *A* flat and *D* sharp. *b*. Equal and Bagpipe, giving the complete equal temperament, and also the Bagpipe scale, and Meshaqah's Arabic scales, allowing me to illustrate these by playing airs. *c*. Just, giving the accurate harmonic scales of F, C, G major, and E major and minor, enabling me to illustrate the ancient Greek tetrachords. *d*. Pythagorean, containing the 14 notes tuned as a succession of perfect Fifths, enabling me to illustrate the Pythagorean or later Greek form of the several Greek modes, and also most of the the mediæval Arabic scales. *e*. Javese, the white keys giving the Salendro, and the black the Pelog scales. This was tuned from forks adjusted by myself to the pitches of the Javese instruments which were played at the Aquarium in London, in 1882, as ascertained by Mr. Hipkins and myself from careful examination. This enabled me to play several Javese airs.

3. An Indian *Sitár*, or long-necked guitar, most kindly presented to me by H.H. the Raja Ram Pal Singh, who had himself played upon it to Mr. Hipkins and myself, to enable us to record some Indian scales. One of these scales was set upon the Sitár so that it could be played, the others were placed on the Dichord.

4. Two *Vinas*, kindly lent me by M. Victor Mahillon, of Brussels.

5. A *Gambang* or *Balafong*, that is, a wood harmonicon, played by a hammer, sent direct from Singapore to Mr. Hipkins, who kindly lent it for this purpose. As instruments of this kind are much used in the East, and I gave several scales obtained from them, this enabled me to show the nature of their construction and tone.

6. A *Koto*, the national Japanese instrument, also kindly lent by Mr. Hipkins, tuned for the occasion by the musicians of the Japanese Village.

7. A small Chime of Chinese Bells, and a set of Japanese Pitch-pipes, kindly lent by Mr. Hermann Smith.

from the first note to the second. It is measured properly by the ratio of the smaller pitch number to the larger, or by the fraction formed by dividing the larger by the smaller. When these ratios are known for each successive pair of notes, the scale itself is known, for means then exist for tuning the whole scale when one of its notes is given. Clearly, if we assume, for the purposes of calculation, that the lowest note makes one vibration in a second (which could not be heard as a note), the ratios mentioned would give the corresponding numbers of vibrations for each note, and these all multiplied by the real audible number of vibrations in the lowest note, would give the *absolute* pitches of the actual notes heard. These ratios, therefore, are the important matters to ascertain, and they are said to give the *relative* pitch of each note in the scale. The absolute numbers, which is what engaged my attention last time, are now of little consequence. We do not want to know how to tune at any particular pitch, but how to tune at any pitch whatever. Hence it is the law which determines the relative pitch that we wish to find, or, in other words, the system of ratios or of their equivalents.

III.—Cents.

Now these ratios convey no conception whatever to the musician, who, without considerable instruction, can attach no musical meaning to such ratios as 2 : 3, 3 : 4, 4 : 5, 5 : 6, 6 : 7, 7 : 8, 8 : 9, 9 : 10, and so on. Hence some other way of expressing them is necessary, especially for describing scales. To that end I must anticipate somewhat. It will not be, perhaps, too great an assumption to presuppose that every one present is acquainted with the pianoforte, and knows that it is divided into sets of tones called octaves, and that there are 12 digitals or finger keys to each octave, 7 long and white, 5 short and black. But, perhaps, every one may not know (as he ought to know) that the object of the tuner is to make the interval (or sensation of distance or ascent) between any two notes answering to any two adjacent finger keys throughout the instrument precisely the same. The nearer he succeeds the better the tuner. The result is called *equal temperament* or tuning, and is the system at present used throughout Europe. (See "History of Musical Pitch," Art 4. and Appendix 1). For the purposes of measurement, I must assume that the tuner has succeeded, although I am bound to say that no tuner ever has as yet succeeded perfectly, on account of the great difficulty to be overcome. Then we say that the interval of an Octave is divided into twelve equal intervals called Semitones. Now I must go a step further. Suppose a piano made of such a gigantic size that we could interpose 99 smaller finger keys between any two at present existing, and that we could tune these at exactly equal intervals, called *cents*, so that 100 cents would form an equal semitone. It is as well to know at once that this is impossible*. No ear has yet succeeded in hearing the interval of 1 cent between two notes played in succession. Even the interval of 2 cents requires very favourable circumstances to perceive, although 5 may be easily heard by good ears, and 10 to 20 ought to be at once recognised by all singers and tuners. When the two notes are played at the same time, these 2 cents make a distinct difference in consonances, and 5 cents are felt to be out of tune. The tuner has constantly to deal with intervals of from 2 to 22 cents, and he corrects his ear by playing the notes together. If, then, I say that a certain interval has 316 cents, I mean that it contains 3 semitones (counted by the keys on a piano) and 16 cents or a very little more. But how are we to determine the number of cents? By finding the interval ratio already mentioned, which is best ascertained from the absolute pitch numbers of each note, and may be approximately ascertained by taking the ratio of the sounding lengths of two pieces of the same musical string, when they are in unison with the two notes as determined on an accurate monochord. Having found these two numbers, the discovery of the number of cents is a mere matter of arithmetic.† When the numbers of cents have

* Although this is quite impossible on a piano, we may approximate very closely to a conception of such a division on my Dichord, which is tuned to tenor *C* 132 vibrations. Take two notes as *D* and *D* sh. an equal semitone apart in the lower portion of the scale. Their stopping places are 2½ inches apart. Now, if the finger be glided over this interval after the string is plucked, a gradual and continuous alteration of sound is heard in passing from *D* to *D* sh, and it is evident that if the finger stop anywhere a continuous tone will be produced. Now, to divide 2½ inches into a hundred parts, gives the very sensible distance of the fortieth part of an inch for each. And if we placed the finger at each we should get intervals almost (not quite) 1 cent apart. How small this interval is was shown by stopping at intervals of 10 cents, or a quarter of an inch, in passing from *D* to *D* sh.

† If of the two numbers expressing the interval ratio, 3 times the larger is *not* greater than 4 times the smaller, multiply 3,477 by their difference, and divide by their sum to the nearest whole number, adding 1 to the result if over 450. Thus if the ratio is 4 : 5 (where 3 times 5 the larger = 15, is less than 4 times 4 the smaller number = 16), the difference is 1, and sum 9, and dividing 3,477 by 9, the result is 386, the cents required. If the ratio is greater than 3 : 4 and les

been ascertained by the process described in the footnote, a scale, which I particularly leave unnamed, is written thus:—

Vib.	270		308		357		411		470		540
Cents	I	228	II	256	III	244	IV	232	V	240	I
Sums	0		228		484		728		960		1200

Here I, II, &c., are the notes of the particular scale, of which there are here five, I' being the octave of I. The numbers *between* these note-symbols show the number of cents in the interval from one to the other. The numbers *under* them show the number of cents in the interval from I to the note in question. The number *above* is the absolute pitch number of the note as already defined, that is, the number of vibrations which it makes in a second, as found from observations. But this may be omitted when merely the relative pitch is wanted.

than 2 : 3, multiply the larger number by 3, and the smaller by 4, proceed as before, and finally add 498 to the result. Thus for 32 : 45, multiply 45 by 3, and 32 by 4, giving 128 : 135, difference 7, sum 263. Then 7 × 3477 ÷ 263 gives 92, and 92 + 498 gives 590, the cents required. Lastly, if the ratio exceeds 2 : 3, multiply the larger number by 2 and the smaller by 3, and proceed as in first case, adding 702 to the result. Thus for 5 : 8, take 3 × 5 : 2 × 8 or 15 : 16; difference 1, sum 31; then 3,477 ÷ 31 = 112, and this added to 702, gives 814 the required number of cents. This process is sometimes very convenient, but when a large number of results have to be obtained, always tedious. In this case, those who can use logarithms, will find the following table very simple, and it will give the result to one-tenth of a ceut.

TO CONVERT LOGARITHMS INTO CENTS, AND CONVERSELY.

Cents.	Logarithms.	Cents.	Logarithms.	Cents.	Logarithms.	Cents.	Logarithms.
109	·02509	10	·00251	1	·00025	·1	·00003
200	·05017	20	·00502	2	·00050	·2	05
300	·07526	30	·00753	3	·00075	·3	08
400	·10034	40	·01003	4	·00100	·4	10
500	·12543	50	·01254	5	·00125	·5	12
600	·15051	60	·01505	6	·00151	·6	15
700	·17560	70	·01756	7	·00176	·7	18
800	·20069	80	·02007	8	·00201	·8	20
900	·22577	90	·02258	9	·00226	·9	23
1000	·25086						
1100	·27594						
1200	·30103						

Subtract the logarithms of the pitch numbers or of the numbers of their ratio. Thus for 32 : 45, log 45 = 1·65321, log 32 = 1·50515, difference ·14806, the next least log in the table, ·12543 gives 500 cents. Subtract this from former log, result ·02263, next least ·02258, giving 90 cents, total 590 cents to the nearest cent as before. But we can now, if we like, go a step farther, and subtracting the two last logs we get ·00005, which in the last column corresponds to ·2 cents. Final result 590·2. It is, as a general rule, unnecessary to go beyond the nearest whole number of cents.

The following are a few of the best known intervals expressed in cents and ratios for comparison with those whieh follows:—

Cents.	Ratios.	Name.
2	32768 : 32805	Skhisma.
22	80 : 81	Comma (of Didymus).
24	524288 : 531441	Comma of Pythagoras.
27	63 : 64	Septimal Comma.

Cents	Rations.	Name.
50	239 : 246	Quartertone.
70	24 : 25	Small Semitone.
90	243 : 256	Pythagorean Limma.
92	128 : 135	Small Limma.
100	‖ 84 : 89	Equal Semitone.
112	15 : 16	Diatonic Semitone.
114	2048 : 2187	Apotome.
151	11 : 12	Trumpet three-quarter Tone.
182	9 : 10	Minor Second.
200	‖ 400 : 449	Equal Tone.
204	8 : 9	Major Second.
267	* + 6 : 7	Septimal minor Third.
300	‖ 37 : 44	Equal minor Third.
316	* 5 : 6	Just minor Third.
355	22 : 49	Zalzal's neutral Third.
386	* 4 : 5	Just major Third.
400	‖ 50 : 63	Equal major Third.
408	64 : 81	Pythagorean major Third.
476	243 : 320	Grave Fourth.
498	* 3 : 4	Just Fourth.
500	‖ 227 : 303	Equal Fourth.
583	* + 5 : 7	Septimal Fifth.
590	32 : 45	Just Tritone.
600	‖ 99 : 140	Equal Tritone.
680	27 : 40	Grave Fifth.
700	‖ 289 : 433	Equal Fifth.
702	* 2 : 3	Just Fifth.
704	160 : 248	Acute Fifth.
800	‖ 63 : 100	Equal minor Sixth.
814	* 5 : 8	Just minor Sixth.
853	11 : 18	Zalzal's neutral Sixth.
884	* 3 : 5	Just major Sixth.
900	‖ 22 : 37	Equal major Sixth.
906	16 : 27	Pythagorean major Sixth.
969	* ‖ 4 : 7	Septimal or harmonic minor Seventh.
996	9 : 16	Just minor Seventh.
1000	‖ 55 : 98	Equal minor Seventh.
1088	8 : 15	Just major Seventh.
1100	‖ 89 : 168	Equal major Seventh.
1110	128 : 243	Pythagorean major Seventh.
1200	* ‖ 1 : 2	Octave.

* Consonant intervals, the rest are dissonant.

* + The consonance of these intervals is disputed.

‖ Equally tempered intervals. The ratios assigned to these intervals (with the exception of the Octave) are only very close approximations, the real ratios being incommensurable, or not expressible in whole numbers.

IV.—Theory and Practice.

Of course practice preceded theory in music as in everything else. The sound of a Fourth was perfectly well known to singers and lyrists, long before it was discovered that the whole length of a string and three-quarters of its length, when plucked, would give this very interval. But this once found, theory followed rapidly, and intervals were defined by lengths of string with great minuteness. It was the ratio of these lengths of string that was used to determine the intervals; and it is only of recent years that these lengths were found to be inversely proportional to the pitch numbers of the notes, and then these pitch numbers, which were applicable to all musical sounds, and not to those of strings only, became exclusively employed. The property just named, that the pitch numbers of notes are inversely proportional to the length of strings producing them, is, unfortunately, quite true only for a heavy perfectly flexible and elastic mathematical line, limited by mathematical points, and any attempt to divide a real string of wire or catgut by bridges or frets fails for several reasons. In the case of frets, the pressure of the finger behind the fret increases the tension of the string and increases the pitch. This circumstance is of great importance in the Indian Vina, which has very high frets, so that the pressure of the finger behind the fret can easily raise the pitch of the note by a Semitone, that is, 100 cents or more. Even in the modern guitar the intervals are sensibly sharpened. Hence the lengths of the strings for the principal intervals can only be termed a happy guess; and it remained for quite recent observers, such as Helmholtz, to establish, by ingenious instruments, that the actual ratios of vibrations for the consonant intervals was precisely those given for them in the last table, and could not be any other. Thus it was possible to have a theory of the scale. It is not my purpose to go into that theory. It would lead me much too far. But the theory implied exact measurements, all very well for instrument makers, but not for musicians, who have only one standard to go by, their own ear, that is, their own appreciation of interval or relative pitch. Some musicians, like the Indian, repudiate all measurement and all arithmetic from the first, and leave everything to the judgment of the ear. In this country we are familar with the pianoforte, harp, and violin, all of which are tuned exclusively by ear. For the harmonium, indeed, "beats" are available, but they are rarely used. On the contrary, organ tuners are accustomed to a rough appreciation of the occurrence of beats, but few of them know the exact numbers, or understand how to employ them properly. Hence, as we may expect, tunings by ear, or the actual notes produced in the scale by a tuner, seldom or never give precisely those intervals which theory lays down. It seemed to me advisable, before trying uncivilised or semi-civilised nations, to see how well good English tuners could tune. Mr. Hipkins, who has the best possible means of knowing, says that it takes a quick man *three years* to learn to tune a piano properly. We may take it for granted, then, that most pianos are improperly tuned. The following examples (1, 2, 3, 4) give an octave on the piano, as tuned by Broadwood's tuners—(1) was a cottage piano tuned a fortnight previously, but not played on during that time, (2, 3, 4) were grand pianos tuned especially for this examination, (5) was an organ tuned a week previously by one of Mr. Hill's tuners and only played on once, (6) an harmonium tuned by one of Messrs. Moore and Moore's tuners, and (7) an harmonium tuned

Examination of Equal Tuning.

Note.	*C*	*C* sh	*D*	*D* sh.	*E*	*F*	*F* sh.	*G*	*G* sh.	*A*	*A* sh.	*B*	*C*
Theory.	0	100	200	300	400	500	600	700	800	900	1000	1100	1200
1	0	96	197	297	392	498	590	700	797	894	990	1089	1201
2	0	99	200	305	411	497	602	707	805	902	1003	1102	1206
3	0	100	200	300	395	502	599	702	800	897	999	1100	1200
4	0	101	199	299	399	500	598	696	800	899	999	1100	1200
5	0	101	192	297	399	502	601	702	806	898	1005	1099	1201
6	0	98	200	298	396	498	599	702	800	898	999	1099	1199
7	0	100	200	300	399	499	600	700	800	900	1001	1099	1200

as a standard a year previously under the favourable conditions of a constant blast, with strict calculation and counting of beats by Mr. Blaikley, of Boosey's. Only the cents in the interval from the lowest note are given in each case.

These are very good specimens indeed, but, with the exception of the last, they are not quite perfect. In the last it is difficult to state whether the tuning or the measurement was occasionally in error by one cent.

For a critical consideration of these results, and rules by which these errors may be avoided, as time would fail me to enter upon the subject, I must refer to Appendix XX., Sec. G., of my new edition of Helmholtz's great work "On the Sensations of Tone," which is almost all in type, and will soon be published by Messrs. Longman.

Now, in order to find the scales which I have to communicate to-night, there were two courses only open—theory and practice. For Greece, Arabia and Persia, India and Japan, treatises exist, giving the scales more or less accurately; probably also for China, but they were not accessible to me. Where I could find these couched in intelligible language (very far from being generally the rule), I was glad to follow them, as they showed what those best able to judge considered to be aimed at in tuning. But the treatises that furnish accurate numbers are confined to Greece and Arabia, with Persia. Indian treatises rather ostentatiously eschew arithmetic, so that in reality their theory depends on oral tradition. In India, then, in China, in Java, and the various savage countries, there was nothing accessible but the instruments, and perhaps (as at the Aquarium in 1882, the International Health Exhibition of 1884, and the Japanese Village in 1885), native musical performers on a visit to England. Now any musical instrument on which a native can play to the observer furnishes a set of notes actually produced, and these can have their pitch numbers determined with more or less certainty. In this way I was fortunate enough to get thirteen scales, five Indian, seven Chinese, and one Japanese, all recorded in numbers of vibrations, by the kind help of Mr. Hipkins.

Instruments without a native performer seldom record themselves. Wind instruments, of course, require a native practised musician to blow, because the pitch can be greatly varied by the style of blowing. Stringed instruments without frets, or with movable frets, are also worthless without a native player. A stringed instrument with fixed frets (like the ordinary guitar), is to a certain extent available. If there are several strings, the law of tuning them is generally unknown. But if there are many frets on one string, enough to cover an octave (as on the guitar), then by measuring the vibrating lengths of the strings from the bridge to the edge of the fret next to the bridge, we can approximate to the relative pitch of the scale of notes which would be produced by sounding the string when properly stretched. The absolute pitch it is of course impossible to discover. That can only be obtained by help of a native performer, and would probably differ from one performer to another, for I have discovered nothing like a standard pitch anywhere. We have not yet arrived at fixing a standard pitch even for Europe. But by stringing the instrument over the frets, tuning it when open to a convenient pitch, and after stopping it at the frets in succession, determining the pitch of the notes heard, we can approximate more closely to the relative pitch intended. The different natures of the strings—wire of various thickness, steel or brass, gut, tightly corded silk (used in China and Japan)—all tend to vary not only the absolute pitch of each note, but also necessarily the intervals between them. Moreover, it is exceedingly difficult to determine identity or minute differences of pitch between notes with qualities of tone so different as those of plucked strings and tuning forks.

There are some instruments which play themselves. Anyone with proper tuning forks could count the pitch of the notes in a piano, dulcimer, harmonium, or organ, when they have once been tuned, provided they have not since had an opportunity to get out of tune, as such instruments so easily have—the harmonium least. The Chinese Shêng (and Japanese Shô) are reed instruments, not easy to sound certainly, but presumably rendering very nearly the sounds to which they have been tuned. The main instruments of uncivilised music, however, are flutes, bells, gongs, and harmonicons, consisting of bars of wood or metal. It is the last which have enabled us to obtain the pitch of the notes used even without the assistance of native players. Unfortunately, such harmonicons are apt to fall out of tune, and their intonation is injured by travelling, and (especially the wooden ones) by damp.

Hence there is no practical way of arriving at the real pitch of a musical scale, when it cannot be heard as played by a native musician; and even in the latter case, we only obtain that particular musician's tuning of the scale; not the theory on which it was founded. To reverse the process, to go back from the best we can do with the instrument to an hypothesis concerning the relations intended, is very risky indeed. We certainly ought to do the best we can in this way, but we should never forget to give the observed data whence our hypothesis is derived.

After all, we have only determined the notes used, not the scales employed for any piece of music. It would be impossible, from our knowing the twelve semitones to the octave used in Europe, to determine the double form of the major scale (without and with the grave Second), and the triple form of the minor scale (without and with the major Sixth and Seventh), not to mention the so-called ecclesiastical modes. So in other countries. Here we are thrown entirely on theorists or information from natives, and where these fail us, we only know the notes employed, not the scales made by selecting some of them. In a few cases these are known, but in others we can only guess.

There are, however, two distinct kinds of scales, considered as divisions of the Octave used in playing airs. In the first, between a note and its Octave, six notes are interposed, and the Octave derives its name from the circumstance of being the eighth note, including both extremes. Occasionally two or more notes are left out, and occasionally one to three are inserted as alternative notes. But the main run of the scales consists of seven notes. These scales are called *heptatonic,* and are prevalent in Europe, Arabia, India, and other places. The next great division inserts only four notes between the first and what, from European habits, we still term the Octave, which, however, is now the sixth note, both inclusive. These scales have in later times been often filled up by inserting two other notes; but these are clearly intrusive, and in the most typical case, Java, it has not been done. These scales are therefore termed *pentatonic.* They are found in the South Pacific, Java, China and Japan, and it is believed, from the nature of older Scotch, Irish, and Welsh melodies, were used by the Celts.

First Division.—Heptatonic Scales.

V.—Ancient Greece and Modern Europe.

Of the music of Egypt we know nothing; the instruments preserved, and their pictures, do not suffice to give a scale. We cannot tell what influence Egypt had on Greece. We do not know whence Greece derived her music, though Persia is a possible source. I am not going into a critical examination of the Greek scale. It does not at all form a part of my investigations.

The original Greek division depended on the interval of a Fourth, that is, the interval between the tones derived from any length of a string, and three-quarters of that length, containing 498 cents. The interval was too large for musical purposes, and hence one or two notes were always interposed. To represent these in systematic notation would require a long explanation, which would be out of place. I use therefore the ordinary notation *B C D E F G A* with sh, ssh, fl, ffl, for sharp, double sharp, flat, and double flat, leaving the numbers of cents interposed between any two notes to mark the interval and point out its relative value with precision. Of the 11 forms of the tetrachord given by Helmholtz, only the most usual 7 need be considered. These give the following "Tetrachords," or divisions of a Fourth, literally "four strings."

1. Of Olympos	*B*	112	*C*	286	*E*.				
2. Old Chromatic ..	*B*	112	*C*	70	*C*sh	316	*E*.		
3. Diatonic	*B*	112	*C*	204	*D*	182	*E*.		
4. Of Didymus	*B*	112	*C*	182	*D*	204	*E*.		
5. Doric	*B*	90	*C*	204	*D*	204	*E*.		
6. Phrygian	*B*	182	*C*sh	134	*D*	182	*E*.		
7. Lydian	*B*	182	*C*sh	204	*D*sh	112	*E*.		

Two of these tetrachords of the same kind, with a Tone of 204 cents, either placed before or after, or else between them, give an octave and are the foundation of the Greek heptatonic scale in its various modes. The distinctive differences of intonation, however, rapidly disappeared, and all the scales came to be played with the Doric tetrachord, known as Pythagorean, which for most purposes may be sufficiently represented by our ordinary equally tempered scale. This produced the following seven modes, in which the intervals occur in the same order as in the major scale begun on each of its degrees in succession. They are here given, however, as if they all began with *C*, and flats are introduced to render the intervals correct. The cents of the intervals are, as before, placed between the notes. The name of the mode derived from the note with which the major scale of *C* must be begun, is prefixed, then follows the ancient Greek name, the ecclesiastical name as wrongly given by Glarean, but usually adopted, and Helmholtz's new names. For particulars refer to my second edition of Helmholtz, pp. 262-272.

LATER GREEK MODES.

1. *C* mode, or ancient Lydian, Glarean's Ionic, Helmholtz's mode of the First or major mode. *C* 204 *D* 204 *E* 90 *F* 204 *G* 204 *A* 204 *B* 90 *c*.
2. *D*-mode, or ancient Phrygian, Glarean's Doric, Helmholtz's mode of the minor Seventh. *C* 204 *D* 90 *E* fl 204 *F* 204 *G* 204 *A* 90 *B* fl 204 *c*.
3. *E*-mode, or ancient Doric, Glarean's Phrygian, Helmholtz's mode of the minor Sixth. *C* 90 *D* fl 204 *E* fl 204 *F* 204 *G* 90 *A* fl 204 *B* fl 204 *c*.
4. *F*-mode, or ancient Syntonolydian, Glarean's Lydian, Helmholtz's mode of the Fifth. *C* 204 *D* 204 *E* 204 *F* sh 90 *G* 204 *A* 204 *B* 90 *c*.
5. *G*-mode, or ancient Ionic, Glarean's Mixolydian, Helmholtz's mode of the Fourth. *C* 204 *D* 204 *E* 90 *F* 204 *G* 204 *A* 90 *B* fl 204 *c*.
6. *A*-mode, or ancient Eolic, Glarean's Eolic (likewise), Helmholtz's mode of the minor Third or minor mode. *C* 204 *D* 90 *E* fl 204 *F* 204 *G* 90 *A* fl 204 *B* fl 204 *c*.
7. *B*-mode, or ancient Syntonolydian, Glarean's Lydian (as for the *F*-mode), Helmholtz's mode of the Fifth. *C* 90 *D* fl 204 *E* fl 204 *F* 90 *G* fl 204 *A* fl 204 *B* fl 204 *c*.

Now, different as all those scales are in character, mainly shown by the final cadence, they all agreed in one point. They were purely melodic. They could not be sung in harmony, as in the modern chorale or part-song. To do this properly, it was necessary to alter all the intervals slightly. The principles on which this was possible are fully explained in my second edition of Helmholtz, App. XX., Sec. E, and cannot be intruded here. The final result, however, may be added. In this the *C*-mode was retained, and the others were fused into the *A*-mode, to which three forms were given.

1. Major mode, harmonic, compare with the *C*-mode. *C* 204 *D* 182 *E* 112 *F* 204 *G* 182 *A* 204 *B* 112 *c*.
2. Minor mode, descending form, harmonic, compare with the *A*-mode. *C* 204 *D* 112 *E* fl 182 *F* 204 *G* 112 *A* fl 204 *B* fl 182 c.

   The same, ascending, first form. *C* 204 *D* 112 *E* fl 182 *F* 204 *G* 112 *A* fl 274 *B* 112 *c*.

   The same ascending, second form, to avoid the difficult interval of 274 cents between *A* fl and *B*. *C* 204 *D* 112 *E* fl 182 *F* 204 *G* 182 *A* 204 *B* 112 c.

All these forms give beautiful consonances, which may be heard from almost any unaccompanied chorus, especially of Tonic Sol-faists, but the consonances are greatly injured by the equal temperament which reduces the European scales to the following:—

1. Major mode. *C* 200 *D* 200 *E* 100 *F* 200 *G* 200 *A* 200 *B* 100 *c*.
2. Minor mode, three forms:—

   C 200 *D* 100 *E* fl 200 *F* 200 *G* 100 *A* fl 200 *B* fl 200 *c*.

   C 200 *D* 100 *E* fl 200 *F* 200 *G* 200 *A* fl 300 *B* 100 *c*.

   C 200 *D* 100 *E* fl 200 *F* 200 *G* 200 *A* 200 *B* 100 *c*.

This intonation, as I explained in my paper on the "History of Musical Pitch," is only about forty years old in England. The scales played before that time at the Philharmonic concerts, and on all organs, though probably never heard from unaccompanied part singers, were in "meantone intonation," or—

1. Major mode. *C* 193 *D* 193 *E* 119 *F* 194 *G* 193 A 193 B 117 *C*
2. Minor mode in three forms:—

   C 193 *D* 117 *E* fl 193 *F* 194 *G* 117 *A* fl 193 *B* fl 193 *C*

   C 193 *D* 117 *E* fl 193 *F* 194 *G* 117 *A* fl 269 *B* fl 117 *C*

   C 193 *D* 117 *E* fl 193 *F* 194 *G* 193 *A* 193 *B* 117 *C*

The object of all these changes was to reduce the number of necessary notes in the octave to 12. The last, or mean tone system, perfected by Salinas in 1577, prevailed over Europe for nearly 300 years. As long as only three sharps, *F* sh, *C* sh, and *G* sh, and two flats, *B* fl and *E* fl, were required, it admirably answered its purpose of furnishing organs with endurable harmonies. But modern music requires perfectly free modulation, and the equal temperament was the only one which would furnish this within the limits of 12 notes to the octave. Hence, notwithstanding the harshness of its chords, arising from the undue sharpness of its major Third, Sixth, and Seventh, it has prevailed universally, and many modern musicians are not even aware of its nature and defects, or that there ever was any other possible intonation.

VI.—PERSIA, ARABIA, SYRIA, AND SCOTTISH HIGHLANDS.

Of the ancient Persian scale we know nothing, but it was most probably the progenitor of the older Greek. At the earliest period of which we have precise knowledge, the writings of Al Farabi (who died A.D. 950), give an account of the Lute, Tambours (long-necked guitars) of Bagdad and of Khorassan, the Flute, and Rabāb (a two-stringed viol). These have been published by Prof. J. P. N. Land, of Leyden, in Arabic, with a French translation under the care of M. Goeje, and a preliminary dissertation.*

The Arabs and Persians—for we must consider their systems identical in Al Farabi's time—had very various scales which not only could not be played together, just as our major and minor scales cannot be played together, but which were composed on such different principles for different instruments, that two instruments of different kinds could not be tuned to play the same scale together. They must, therefore, have been simple accompaniments for the voice, not in our modern sense of accompaniment (for there was and is no notion of harmony), but merely as steadiers of the voice, touching the notes that had to be sung, or else instruments for solo performance. We must, therefore, take them separately.

(1.) *The Lute* (*al'ood*, whence our word *lute* is derived). An instrument like the European lute, with four, and subsequently five, strings, nearly touching at the nut, and spreading out at moderate angles, so as to be well apart at the striking place. This was originally tuned in Fourths, each successive string being a Fourth higher than the next lower. A series of ligatures, answering to frets, were tied across the finger board. The places were at an early time, though perhaps not originally, determined so as to give on each string the Greek tetrachord of I 204 II 204 III 90 IV, where I, II, &c., represent the names of the notes. Of these I occupied the open string, II was stopped by the first, III by the fourth, and IV by the little finger, after which, and the string, they were named. Theoretically the note II used $\frac{8}{9}$ of the string, the note III used $\frac{8}{9}$ of this or $\frac{64}{81}$ of the whole length, and the note IV. used $\frac{3}{4}$ of the whole string. Practically, this would have made the notes too sharp, hence doubtless the position of the frets was accommodated as on the Japanese Biwa, which is an existing form of Al Farabi's lute. Calling the notes for the first or *C* string, *C* 204 *D* 204 *E* 90 *F*; those for the next, or *F* string, would be *F* 204 *G* 204 *A* 90 *B* fl; for the third, or *B* fl string, *B* fl 204 *C* 204 *D* 90 *E* fl; and for the fourth, or *E* fl string, *E* fl 204 *F* 204 *G* 90 *A* fl. The first octave, then, was *C* 204 *D* 204 *E* 90 *F* 204 *G* 204 *A* 90 *B* fl 204 *C*, the Greek *G*-mode (see Sect. V), with which Al Farabi was quite familiar, using the Greek names. Observe that the middle finger had nothing to do. The old plan was to introduce a fret for it between *D* and *E*, at *E* fl, a tone 204 cents flatter than *F*, so that the length of string for *E* fl was $\frac{9}{8}$ the length for *F* (corrected of course). On the second string there was, therefore, a corresponding *A* fl. This gave as the scale—

C 204 *D* 90 *E* fl 114 *E* 90 *F* 204 *G* 90 *A* fl 114
0 204 294 408 498 702 792

A 90 *B* fl 204 *C*
906 996 1200

But this old "middle finger" note did not please. First a Persian modification was tried, by tying a ligature halfway between those for 204 and 408 cents, which would (theoretically) give 303 cents on the first string, and 801 cents on the second. But these notes, which were as nearly as possible our own equally-tempered *E* fl 300, and *A* fl 800, also grew out of favour. Something sharper was required. Possibly they longed for the perfect minor Third *E* fl 316, and minor Sixth *A* fl 814. But they went much sharper. One Zalzal, a celebrated lutist, who died a century and a half before Al Farabi, tied a ligature halfway between the Persian 303 cents and the Greek 408 cents, and got a tone of 355 cents on the first and 853 cents on the second string. These notes became of great importance in Arabic music, and effectually distinguished this older Arabic form from the later Greek. The scale now practically became—

C 204 *D* 151 *E*° 143 *F* 204 *G* 151 *A*° 143
0 204 355 498 702 853

B fl 204 *C*
996 1200

where *E*°, *A*° represent for the moment these new tones. To this important scale, quite different from anything we have yet met with, I shall have to devote considerable attention presently.

Designating the strings as simply FIRST (or lowest), SECOND, THIRD, FOURTH, and FIFTH, and the notes as "Open, Index, Middle, Ring, Little"—namely, played with those fingers—as more generally intelligible than the Arabic names used by Professor

* *Recherches sur l'histoire de la Gamme Arabe. Tiré du Vol II. des Travaux de la 6e session du Congrès international des Orientalistes à Leide, par* J. P. N. Land. Mr. Land is a D.D., Professor of Mental Philosophy at Leyden, an Orientalist and a musician, and as his researches are the most recent, while he had access to all previous accounts, I follow him implicitly.

Land, I give all the notes that arose in different times in the two octaves, with the interval from the lowest note to the nearest cent. Professor Land, at my suggestion, gave them in equal Semitones to three places of decimals. On account of the notes in any string being a Fourth higher than those in the preceding, the two Octaves do not quite agree, and hence the cents are given for each, but are reduced by omitting the 1200 cents which would have to be added to each note in the second Octave. Of course it must be well

EARLIER NOTES ON THE ARABIC LUTE.

Notes.	First Octave.	Second Octave.	Cents.	
			1st Oct.	2nd Oct.
C	FIRST: open	THIRD: index	0	0
D fl	ancient near index	ancient middle	90	90
		Persian middle	..	99
	Persian near index		145	..
		Zalzal's middle	..	151
	Zalzal's near index		168	..
D	index	ring	204	204
E fl	ancient middle	little = FOURTH: open	294	294
	Persian middle		303	..
	Zalzal's middle		355	..
F fl		FOURTH: ancient near index	..	384
E	ring		408	..
		Persian near index	..	439
		Zalzal's near index	..	462
F	little = SECOND: open	index	498	498
G fl	SECOND: ancient near index	ancient middle	588	588
		Persian middle	..	597
	Persian near index		643	..
		Zalzal's middle	..	649
	Zalzal's near index		666	..
G	index	ring	702	702
A fl	ancient middle	little = FIFTH: open	792	792
	Persian middle		801	..
	Zalzal's middle		853	..
B ffl		FIFTH: ancient near index	..	882
A	ring		906	..
		Persian near index	..	937
		Zalzal's near index	..	960
B fl	little = THIRD: open		996	..
C fl	THIRD: ancient near index	FIFTH: ancient middle	1086	1086
		Persian middle	..	1095
	Persian near index		1141	..
		Zalzal's middle	..	1147
	Zalzal's near index		1164	..
C	index	ring	1200	1200

understood that all these divisions were not in use at the same period, but some at one and some at another, and that at all times the scales were made by selections from them. Two "near index" notes and some exceptional "middles" are omitted by Professor Land, as presenting no difficulties to those who take an interest in them.

It will be seen that each string is divided exactly like the first; that the cents on SECOND are found by adding 498 to those on FIRST; those on THIRD 498 to those on SECOND (rejecting 1200 when we reach the second octave), those on FOURTH by adding 498 to those on THIRD, and those on FIFTH (which was Al Farabi's proposal) by adding 498 to those in FOURTH. There is one extra note not in the table, the "little" on FIFTH which is 90 (properly 2490) cents, but which was probably not used.

On observing the names of the notes in the above table they will be found to contain the following 14 forming Fourths up, as the Arabs considered them, or Fifths down, as we should say, *E A D G C F B*fl *E*fl *A*fl *D*fl *G*fl *C*fl *F*fl *B*ffl. But that these did not comprehend the Persian or Zalzal's "middle" upon any string, which refused to fit into this series of Fourths. This offended the systematic spirit of subsequent theorists, and we find, four centuries later, in the writings of Mahmoud of Shiraz (died A.D. 1315) and Abdulqadir, that they succeeded in replacing these Zalzal notes by adding three more Fourths proceeding from *B*ffl 882, contained in the former series, to *E* ffl 180, *A* ffl 678, *D* ffl 1176. The name of Zalzal was retained, but used for *F* fl 384 and *B* ffl 882, which already existed in the second octave (see table). Persian was used for *E*fl 294, and Persian and Zalzal "middle" were banished. The term "near" was used for "near the index" and made 180 instead of 145 and 168. While the "ancient near index" became the "remnant" 90, or what was left after going back two whole tones from the Fourth (498—408 = 90). The scale then became simply the later 17 division of the Octave.

No.	Notes.	First Octave.	Second Octave.	Cents. 1st Oct.	2nd Oct.
1	*C*	FIRST: open	THIRD: index	0	0
2	*D* fl	remnant	Persian	90	90
3	*E* ffl	near	Zalzal	180	180
4	*D*	index	ring	204	204
5	*E* fl	Persian	little	294	294
6	*F* fl	Zalzal	FOURTH: remnant	384	384
7	*E*	ring	....	408	..
			near *G* ffl	..	474
8	*F*	little	index	498	498
9	*G* fl	SECOND: remnant	Persian	588	588
10	*A* ffl	near	Zalzal	678	678
11	*G*	index	ring	702	702
12	*A* fl	Persian	little	792	792
13	*B* ffl	Zalzal	FIFTH: remnant	882	882
14	*A*	ring	....	906	..
			near *C* ffl	..	972
15	*B* fl	little	index	996	996
16	*C* fl	THIRD: remnant	Persian	1086	1086
17	*D* ffl	near	Zalzal	1176	1176
1'	*C*	index	ring	1200	1200

This, in fact, gives 19 notes, but *G* ffl 474 and *C* ffl 972 only found in the second octave, although they occur in this table, seem not to have been reckoned in. They do not form part of the scales. Without them the octave would be divided into 17, and with them into 19 unequal parts. But Villoteau supposes that the Arabs proceeded by intervals of the Third of an equal tone or 66⅔ cents. It is not easy to see how he could have muddled himself to such an extent. That he was quite wrong appears from the above table arranged from Professor Land's. The interval between any two notes in the same octave is either 90 or 24 cents, that is, the Pythagorean *limma* or *comma*. But in going from *E* in the first to *G* ffl in the second octave, and also from *A* in the first to *C* ffl on the second, we do get intervals of 1266 cents, which is in fact an Octave and one-third of a Tone. This, however, is the only approach to a division by thirds of a Tone, and even for this purpose two tones have to be used which the Arabs ignored in their scales. Hence Professor Land has quite disproved this erroneous conception of thirds of Tones.

Now this large collection of notes was of course not used as a single scale, but, like our own 12 semitones, as a fund out of which scales might be formed by selection. And the following are the 12 historical scales reported by the Arabian systematists as described by Prof. Land. But I have here given the letter names to the notes which are used in the above list (the Arabic names have no connection with them) and added the cents both between the notes, and from the lowest note. The orthography adopted by Professor Land for the names of the *maqamat* or scales is French.

THE TWELVE ARABIC SCALES.

1. *'Ochaq*—*C* 204 *D* 204 *E* 90 *F* 204 *G* 204
0 204 408 498 702
A 90 *B* fl 204 *C*.
906 996 1200.

2. *Nawa*—*C* 204 *D* 90 *E* fl 204 *F* 204 *G*
0 204 294 498 702
204 *A* 90 *B* fl 204 *C*.
906 996 1200.

3. *Bousilik*—*C* 90 *D* fl 204 *E* fl 204 *F* 90 *G* fl
0 90 294 498 588
204 *A* fl 204 *B* fl 204 *C*.
792 996 1200.

4. *Rast*—*C* 204 *D* 180 *F* fl 114 *F* 204 *G* 180
0 204 384 498 702
B ffl 114 *B* fl 204 *C*.
882 996 1200.

5. *'Iraq*—*C* 180 *E* ffl 204 *F* fl 114 *F* 180 *A* ffl
0 180 384 498 678
204 *B* ffl 114 *B* fl 180 *D* ffl 24 *C*.
882 996 1176 1200.

(There are eight tones to this scale, because there are two forms of *C*, namely *B* ffl and *C*, differing from each other by a Pythagorean comma, but these two forms were probably not played in succession, but were alternated, just as the major or minor Seventh, and the major or minor Sixth in our own minor scale, which, if these were included, would be made to have 9 tones. The grave Second in our just major scale would have been a more apt illustration, had it not been lost in tempered music.)

6. *Isfahan*—*C* 180 *E* ffl 204 *F* fl 114 *F* 204 *G*
0 180 384 498 702
180 *B* ffl 114 *B* fl 180 *D* ffl 24 *C*.
882 996 1176 1200.
(Another eight tone scale, see remarks on last.)

7. *Zirafkend*—*C* 180 *E* ffl 114 *E* fl 204 *F* 180
0 180 294 498
A ffl 114 *A* fl 90 *B* ffl 204 *C* fl 114 *C*.
678 792 882 1086 1200.
(Eight notes, four intervals semitones.)

8. *Bouzourk*—*C* 180 *E* ffl 204 *F* fl 114 *F* 180 *A* ffl
0 180 384 498 678
24 *G* 204 *A* 180 *C* fl 114 *C* (eight tones).
702 906 1086 1200.

9. *Zenkouleh*—*C* 204 *D* 180 *F* fl 114 *F* 180 *A* ffl
0 204 380 498 678
204 *B* ffl 114 *B* fl 204 *C*.
882 996 1200.

10. *Rahawi*—*C* 180 *E* ffl 204 *F* fl 114 *F* 180
0 180 384 498
A ffl 114 *A* fl 204 *B* fl 204 *C*.
678 792 996 1200.

11. *Hhosaïni*—*C* 180 *E* ffl 114 *E* fl 204 *F* 180
0 180 294 498
A ffl 228 *A* 90 *B* fl 204 *C*.
678 906 996 1200.

12. *Hhidjazi*—*C* 180 *E* ffl 114 *E* fl 204 *F* 180
0 180 294 498
A ffl 204 *B* ffl 114 *B* fl 204 *C*.
678 882 996 1200.

Suppose we begin this last scale on *B* fl, it would become *B* fl 204 *C* 180 *E* ffl 114 *E* fl 204 *F* 180 *A* ffl 204 *B* ffl 114 *B* fl, where the intervals 182, 114 cents differ only by 2 cents each from 182, 112, which would occur in our just scale of *B* fl, which is *B* fl 204 *C* 182 *D* 112 *E* fl 204 *F* 182 *G* 204 *A* 112 *B* fl. Now this difference is imperceptible even in chords, and this 12th scale could therefore be used for harmony even better than our usual equally tempered scale. Yet the Arabs never used harmony at all, and were probably quite unaware of this property of their scale, which was pointed out by Professor Helmholtz.

Zalzal's intervals of 355 and 853 cents, although effectually banished from classical music during our middle ages by this new scale of 17 (or 19) unequal divisions, was evidently too deeply rooted in popular feeling to be really lost. Eli Smith, an American missionary at Damascus, having been forced to study the Arabic musical system in order to make the children sing in his mission schools, as they could not be taught the European intervals, fortunately became acquainted with Michael Meshaqah, a very intelligent man, a mathematician and a musician, who had written a treatise on Arabic music. This treatise Eli Smith translated in an abridged form and published at Boston, U.S. America, in 1849, in the *Journal of the American Oriental Society* (vol. 1, pp. 171—217, with a plate). It shows that Meshaqah adopted an equal temperament of 24 Quartertones, or 24 equal divisions of the octave, each containing 50 cents, and that in this he considered the following as the normal scale, which might begin upon any one of the Quartertones—

I	200	II	150	III	150	IV	200	V	150	VI	150
0		200		350		500		700		850	
						VII	200	I'			
						1000		1200			

Comparing Zalzal's—

I	204	II	151	III	143	IV	204	V	151	VI	143
0		204		355		498		702		853	
						VII	204	I'			
						996		1200			

we find a practical identity, showing that Meshaqah's scale is a pure survival of Zalzal's. It appears, however, from the following specimens of 95 Arabic melodies given by Eli Smith, that one or more of the notes were frequently sharpened or flattened by a Quartertone or 50 cents, giving intervals with different characters. He has engraved 11 of these so-called melodies, without any indication of time or rhythm, in a peculiar notation for which we may substitute a simple modification of ordinary notation, using *q* (or in music notation the inverted sign for *flat*) read *quarter*, to signify "sharpened by a quarter of an equally tempered tone." Taking the first note of the scale as *A*, the normal scale throughout two octaves, with the name of each note in Arabic (as Eli Smith writes them, omitting diacritical signs) will be—*A* yegah, *B* osheiran, *C*q araq, *D* rest, *E* dugah, *F*q sigah, *G* jehargah, *a* nawa, *b* huseiny, *c*q auj, *d* mahur, *e* muhhaigar, *f*q buzrek, *g* mahuran, *á* remel-tuty.

Each Quartertone has also its peculiar name throughout two octaves, and by means of them the following melodi s were written in the original Arabic treatise, here translated as above.

The scales subjoined have been collected from the melodies, and give every note in each melody independent of octave. Of course every note in a scale does not occur in every melody. There is no notion of a tonic, but Eli Smith calls the *final* (to use a medieval term for the last note of a melody) the "keynote," and hence I have arranged the scale from and to the final in each case. Though the melodies are "free," that is, not fixed in rhythm or length, some notes in some melodies are marked as "distinct" (to these I have added an acute accent), and others as "glanced at, obscure, highly touched" (to these I have added the mark of degree °), of which Eli Smith says he does not fully understand the technical meaning. However, it cannot be far from *forte* and *piano*, or accented and unaccented, or long and very short.

Arabic Melodies from Meshaqah.

[Capitals indicate the lower, small letters the upper octave.]

1. *Shed Araban.—a b*fl *a d d*fl *b*fl *a e f e d d*fl *b*fl *a G F E D D*fl *B A*. [Scale, *A* 100 *B*fl 100 *B* 200 *D*fl 100 *D* 200 *E* 100 *F* 200 *G* 200 *a*, in which there is no note not in our equally tempered scale.]
2. *Araq.—a G F*q *E D C*q. [This is portion of the normal scale descending from *a* to *C*q.]
3. *Araq Zemzemy.—C*q *D E a G F*q *E D C*q *F*q' *e c*° *a G F*q *E F*q *E D C*q *B A D F*q *a G F*q *E*. [Scale, *A* 200 *B* 100 *C* 50 *C*q 150 *D* 200 *E* 150 *F*q 150 *G* 200 *a'*. This lightly touched *c*° is possibly mere grace note.]
4. *Rahhat el Arwahh.—a a*fl *a*fl *E F E D F E D C*q. [Scale, *A* 350 *C*q 1˛0 *D* 200 *E* 100 *F* 300 *A* fl 100 *a'*.]
5. *Remel.—a G G a a*fl *b*° *a G G G*flq *G a*° *F*q' *F E D C*q. [Scale, *A* 200 *B* 150 *C*q 150 *D* 200 *E* 150 *F*q 100 *G* flq 50 *G* 100 *A* fl 100 *a*. The *G* flq is a mere grace note, and probably *G* fl would do as well.]
6. *Nikriz.—a a*fl *F*q' *b a' a* fl *F*q *E D*. [Scale *A* 200 *B* 300 *D* 200 *E* 150 *F*q 250 *A*fl 100 *a*.]
7. *Nishawerk.—a' a*fl *G* fl *E D*. [Scale *A* 500 *D* 200 *E* 200 *G* fl 200 *A* fl 100 *a*.]
8. *Penjgah.—a' a*fl Gfl' *a*fl *a c*q' *b' a' a*fl *G*fl' *G' F*q *E D*. [Scale, *A* 200 *B* 150 *C*q 150 *D* 200 *E* 150 *F*q 50 *G* fl 100 *G* 100 *A* fl 100 *a*.]
9. *Sadhkar el muta'arif.—D E G*fl' *E D a' b' a G G* fl *E' B C*q *D*. [Scale, *A* 200 *B* 150 *C*q 150 *D* 200 *E* 200 *G*fl 100 *G* 200 *a*]
10. *Hhejaskar,—E b c b a a*fl *F*q *E B E*. [Scale, *A* 200 *B* 100 *C* 400 *E* 150 *F*q 250 *A* fl 100 *a*.]
11. *Shawerk of the Egyptians.—a' G*° *F*q' *E' D C*. [Scale, *A* 300 *C* 200 *D* 200 *E* 150 *F*q 150 *G* 200 *a*.]

In these 11 melodies there is only one, No. 2, which contains the notes of the normal scale, *A B C*q *D E F*q *G a*, unaltered. On looking through the whole of the 95 melodies I find only 6 others with unvaried notes. These are

12. *Mukhalif arak.*—*C*q *D E G F*q *E D C*q.
13. *Rest.*—*D E F*q *G a G E D A D.*
14. *Ssuba called Rekb.*—*G' b*° *G F*q *E.*
15. *Sigah.*—*F*q *D F*q *a d c*q *b a G F*q.
16. *Bestniker.*—*c*q *d c*q *b a' d c*q *b a G F*q.
17. *Nejdy-Sigah.*—*F*q *G a b c*q *b a b c*q *d c*q *b a G F*q.

These scales and melodies introduce two entirely new points, unknown in European and common in Oriental music. First, the series of "neutral" intervals, intermediate in position and character between the European, and hence bearing a neutral stamp, so that the European ear does not know how to appreciate them. They have consequently led musicians into many errors in attempting to record them. Thus, 250 cents is neutral between a Tone 200 (just 204) and a minor Third 300 (just 316). Again, 350 cents (more accurately Zalzal's 355) lies on the boundary between the appreciation of a minor Third 300 (just 316), and a major Third 400 (just 386). The experiment is easily tried on the Dichord. At 355 cents Mr. Hipkins could not say to which Third the character of the interval approached. It was purely neutral. Observe that 350 cents is half a Fifth 700 (just 702), and the succession of 0 350 700 rapidly becomes pleasing to the ear. The interval 450 cents lies between a major Third 400 and a Fourth 500 (just 386 and 498), and is rather appreciated as a very flat Fourth. All these ambiguities are repeated a Fourth higher. Thus, 850 cents (between a minor Sixth 800, and a major Sixth 900) is precisely analogous to 350 cents, and (as 853 cents) forms part of Zalzal's scale. Observe that these intervals have no harmonic value or meaning. They could not exist in any system of music which recognised chords. Chords were an entirely European medieval discovery, of which Greece and Asia are still totally ignorant. Observe also that a solo player on a stringed instrument without frets, who is absolutely unchecked by harmony, is able to amuse himself by taking all manner of strange intervals, or occasional variations of established intervals. And this leads to the second point, the constant alteration of the normal notes in the scale, nominally by a Quarter-tone, really most probably by some indefinite but small interval at the pleasure of the performer, who consulted only his own ear at the moment, and could scarcely be checked by the ears of an audience. But these variations were reduced to a system, at least on paper, and Meshaqah is strong on "the principles and details of his *science*" of music.

(2.) *The Highland Bagpipe.*—It will seem strange to introduce this instrument among the Arabian. But the bagpipe is found sculptured at Nineveh. It was possibly brought to Europe during the Crusades, long after the deaths of Zalzal and Al Farabi, but before the introduction of the Arabic scale of 17 (or 19) notes to the octave. And it seems originally to have had that Zalzal scale already noted, viz. :—

I	204	II	151	III	143	IV	204	V	151	VI.	143
0		204		355		498		702		853	
				V	204	VI					
				996		1200					

Of which the tempered representative is the principal scale of Meshaqah just discussed. Of course, there must have been some alterations, but this Damascus scale of Meshaqah would represent the scale sufficiently well for all purposes. The Highland bagpipe has at present only nine notes, written *g' a' b' c'' d'' e'' f'' g'' a''* (*g'* being on the second line of the treble staff), and also two *drones* or deep notes which are always sounding (being the first and second octave below *a'*, that is, on the top line and bottom space of the bass staff). Now it is generally said that *g'* to *a'* is not quite a tone, and that *c'' f''* are not exactly *c''* and *f''*, or *c''* sh and *f''* sh of the ordinary notation, but in each case some intermediate sound, the consequence being that the bagpipe cannot play with any other instrument in a band, and two or more bagpipes can only play in unison. The instrument is a kind of oboe played with a bellows instead of the mouth. To determine what this scale really was, Mr. C. Keene, the well-known artist of *Punch*, who is a performer on the bagpipe, kindly brought his instrument to my house and played through the scale, while Mr. Hipkins determined the pitch by my forks. The following was the result. The first line gives the number of vibrations, the second line gives the names of the notes and the interval in cents between them, the third line gives the intervals in cents from the lowest *a'*, omitting the low *g'* which is repeated in the octave as *g''*.

OBSERVED SCALE OF THE BAGPIPE.

Obs. vib.—	395		441		494		537		587	
Notes.—	*g'*	191	*a'*	197	*b'*	144	*c''*	154	*d''*	208
Cents.—			0		197		341		495	

Obs. vib.—662 722 790 882
Notes.— e'' 150 f'' 156 g'' 191 d''
Cents.—703 853 1009 1200

This scale took us quite by surprise, and we immediately wrote to Mr. Glen, the great bagpipe seller, to make inquiry. He informed us that "the scale as regards intervals has never been altered. If the chaunter [the oboe played on] you had is one of McDonald's [it was so] or our own, it was no doubt correct. Our opinion is that if a chaunter was made perfect in any one scale it would not go well with the drones. Also there could not be nearly so much music produced (if you take into consideration that it has only 9 invariable notes), as at present it adapts itself to the keys of *A* [major], *D* [major], *B* minor, *G* major, *E* minor, and *A* minor. Of course we do not mean that it has all the intervals necessary to form scales in all those keys, but that we find it playing tunes that are in one or other of them."

Now the equal temperament of the scale just deduced would be clearly 0 200 350 500 700 850 1000 1200, or precisely the normal Damascus lute scale, just considered. For comparison, I determined the number of vibrations in such a scale, and also for Zalzal's taking the same a', with this result—

Notes	a'	b'	c''	d''	e''	f''	g''	a'
Observed vib.	441	494	537	587	662	722	790	882,
Damascus vib.	441	495	540	587	661	721	786	882
Zalzal's vib...	441	496	541	587	661	722	783	882

Mr. Keene's chaunter was not perfect (none is), and the blowing (which was difficult, as wind had to be got up in the bag for each separate note), could not be absolutely relied on. Clearly c'' was a little flat, and g'' a little sharp, the latter designedly, because the custom is to make the interval $g'' : a''$ less than 8 : 9 or a whole tone, which is an accommodation to the major scale of *A*, and is evidently a modernism. Mr. Colin Brown (Euing Lecturer on the Science, Theory and History of Music at Anderson's College, Glasgow), informs me, after diligent inquiry, that there is no scientific principle adopted in boring the holes of the chaunters, and that only about one in six made turns out useful. He himself thinks the bagpipe ought to play the major scale *A*. I should recommend reverting to Zalzal's scale, either in the pure or tempered form. In the pure form the ratios are $a' : b' = d'' : e'' = g'' : a'' = 8 : 9$, $b' : c'' = e'' : f'' = 11 : 12$, $a' : d'' = 3 : 4$, $a' : e'' = 2 : 3$. There is, therefore, only one unfamiliar interval $11 : 12 = 151$ cents, and that occurs on the trumpet. From these ratios Zalzal's vibrations were calculated above. Of course in this case *c* q and *f* q should in theoretical writing take the place of *c* and *f*.

(3.) *Northern Tambour, or that of Khorassan.*—A guitar with a circular or oval body, and a very long neck on which (formerly) the frets extending to a Ninth were placed. Of these 5 were fixed, representing the Second 204, Fourth 498, Fifth 702, Octave 1200 and Ninth 1404 cents, of the open string. The other 13 were movable, so that they could be adjusted for the different scales or *maqamat*, following the plan of the 12 scales already given. Referring to the table of the later 17 division, the notes of the tambour and lute coincided as far as 588 cents, then in place of the lute's 678 cents (our *A* ffl), the tambour had 612 cents or 498 + 114 cents (our *F* sh). Then tambour and lute again coincided till the lute's 882 *B* ffl which the tambour replaced by 816 or 702 + 114 cents our *G* sh, and then again the two coincided up to 996 *B* fl, but the remaining intervals, 1020 *A* sh, 1110 *B* and 1224 *B* sh, were different. The scale was then as follows, (*) marking the fixed, and (†) auxiliary tones :—

C	*D* fl	*E* ffl	**D*	*E* fl	*F* fl	*E*	**F*	*G* fl	*F* sh	**G*
0	90	180	204	294	384	408	498	588	612	702
†*A* fl	*G* sh	*A*	*B* fl	†*A* sh	*B*	**C*	*B* sh			
792	816	906	996	1020	1110	1200	1224			
C sh	**D*.									
1314	1404.									

Instead, therefore, of taking Fourths up from *B* to *D* ffl, this scale formed the series from *B* sh to *E* ffl, with the exception of four, marked by being inclosed in ( ) in the following list, where the subscribed numbers give the cents from *C*, subtracting 1200 where needed.

B sh	*E* sh	*A* sh	(*D* sh)	*G* sh	*C* sh	*F* sh	*B*	*E*		
1224	522	1020	(318)	816	114	612	1110	408		
A	*D*	*G*	*C*	*F*	*B* fl	*E* fl	*A* fl	*D* fl	*G* fl	(*C* fl)
906	204	702	0	498	996	294	792	90	588	(1086)
F fl	(*B* ffl)	*E* ffl.								
384	(882)	180.								

Al Farabi gives the means of tuning two strings out of the three occasionally used: first, with the strings in unison; secondly, with an interval of 228 cents, or two apotomes of 114 cents between them; thirdly, with the interval of a major Tone, 204 cents; fourthly, with the interval of a Pythagorean minor

Third, 294 cents; and fifthly, with the interval of a Fourth, 498 cents.

(4.) *Al Farabi's Flutes or Oboes.*—Professor Land calls them flutes, but his figures show that they were played with a double reed like the oboe. These were intended to play in Zalzal's scale—

0	204	355	498	702	853	996	1,200 cents,
a	*b*	*c*q	*d*	*e*	*f*q	*g*	*a'*

but the Third and Sixth varied. A double flute, figured by Professor Land from a Madrid MS. gives 9 notes, just as on the bagpipe, but having the Persian 303 and 801 cents, which are 52 cents lower than Zalzal's, thus (giving the nearly equally tempered notes written below, – 204 means an interval of 204 cents downwards)—

– 204	0	204	304	498	702	801	996	1,200.
G	*a*	*b*	*c*	*d*	*e*	*f*	*g*	*a'*

This gives the tempered form of our descending *A* minor played upwards.

(5.) *The Rabab.*—This was a two-stringed viol played with a bow. The one Professor Land figures has a finger board, the one I saw had none. It was supposed to be the custom to stop at $\frac{8}{9}$, $\frac{5}{6}$, $\frac{64}{81}$, and $\frac{32}{45}$, the lengths of the string, that is, 0 204 316 408 590 cents, or at a major Tone, minor Third, Pythagorean major Third, and Tritone, but player was really guided by ear only. It is believed, but not certain, that the two strings were stopped in the same way. Usually the interval between the strings was a minor Third 316 cents; but it was sometimes a (Pythagorean) major Third 408 cents, and sometimes a Tritone 590 cents.

This gives three scales which may be written thus, I being the open string:—

	I	204 II	112 III	92 IV	82 V
First string	0	204	316	408	590
Second string .	316	520	632	724	906
Or else	408	612	724	816	998
Or else	590	794	906	998	1180
Or say—					
First string	*C*	*D*	*E* fl	*E*	*F* sh
Second string ..	*E* fl	*F*	*G* fl	*G*	*A*
Or else	*E*	*F* sh	*G*	*G* sh	*A* sh
Or else	*F* sh	*G* sh	*A*	*A* sh	*B* sh

This gave the sharp Tetrachord *C* to *F* 520 cents, and the exact Tetrachord *E* to *A* 498 cents. But the consequent scales are not clear.

(6.) *The Southern Tambour or that of Bagdad.*—This was long-necked and two-stringed, and was used in Bagdad and to the west and south of that city. We may consider that the string was divided into 40 parts, of which only 5 were used for stopping or fretting, and the higher string was tuned in unison with the highest note on the lower string. This gave the following arrangement:—

Vib. lengths	40	39	38	37	36	35 parts.
	I	II	III	IV	V	VI
Lower string	0	44	89	135	182	231 cents.
Second string	231	275	320	366	413	462 ,,

This is a scale entirely without parallel; but Prof Land conjectures that a process of this kind may have led to the first scale of the Persian lute before Pythagorean intonation was invented. The principle is that equal divisions of the difference of two lengths of a string will give nearly equal intervals extending from one to the other. In the present case, these intervals are 44, 45, 46, 47 and 49 cents, of which the three first at least do not differ perceptibly. Then he supposes that the string may have been divided into 20 parts, and 5 of them taken; this would give—

											Parts.
Vib. lengths	20		19		18		17		16		15
	I	89	II	93	III	99	IV	105	V	112	VI
											Cents.
Sums	9		89		182		281		386		498
or say	*C*		*D* fl		*D*		*E* fl		*E*		*F*

Where *D* fl is properly 90 cents, *E* fl 281 is half a comma less than the Pythagorean *E* fl 294, and the others are exact. The alteration into Al Farabi's intervals

0	90	204	294	408	498
or *C*	*D* fl	*D*	*E* fl	*E*	*F*

does not, in any case, amount to more than a comma (22 cents).

The mode in which the Persian and afterwards Zalzal's "middle finger" was obtained, by halving the distance between the frets, shows that this plan is in accordance with the habits of the people. Compare also the 9 and 13 division in the modern Bengali string in the next section.

VII.—INDIA.

Rajah Sourindro Mohun Tagore, president of the Bengal Academy of Music, in 1875, collected and printed "for private circulation only" a number of papers and brief treatises on Hindu music by Captain N. A. Willard, Sir William Jones, Sir W. Ouseley, J. D. Paterson, Francis

Fowke and others, kindly lent me by Mr. W. S. W. Vaux, F.R.S. In 1884, he published "The Musical Scales of the Hindus," pp. 118, kindly lent me by M. Victor Mahillon, of the Conservatoire, Brussels, the only English modern native authoritative work on Indian music extant.

H.H. the Rajah Ram Pal Singh, kindly brought to me his *Sitahr*, or long-necked guitar, which has movable frets. These he set in succession for different modelets that he played to Mr. Hipkins and myself, and by registering the position of the frets after each setting, we were enabled afterwards to take the pitch of each note employed, and thus, for the first time, to determine an Indian scale as actually tuned and used by a native musician. I beg to express my great obligations to His Highness for his courtesy.

In Rajah S. M. Tagore's last book, which is my chief authority, there is a table, "by a European friend," of the frets for the primitive Indian *C*-scale compared with the European just scale and the modern Bengali division of the string. These divisions are made on the supposition that the vibrations are inversely as the lengths of the strings, which all my observations and experiments show is not the case on any practical instrument. The same measurements are given in the *Annuaire du Conservatoire* de Bruxelles, 1878, pp. 161-169, to which they were communicated by the Rajah. As this is the only attempt at measuring an Indian scale that I have met with, I give it here in a reduced form. The wire is supposed to consist of 180 parts.

Old *C*-Scale.

Vib. lengths.—180 160 144 135 120
Notes.— *C* 204 *D* 182 *E* 112 *F* 204 *G* 204
Sums.— 0 204 386 498 702
Vib. lengths.—$106\frac{2}{3}$ 96 90
Notes.— *A* 182 *B* 112 *C*
Sums.— 906 1088 1200

The modern Bengali divisions will be given afterwards.

Scale is the translation of the word defined as "a series of notes arranged according to certain rules." And the seven notes of the scale are translated as above, using the letters *C*, *D*, &c., rather laxly. These form a *septime*, which corresponds to our Octave, but it ended on the seventh note. Only 3 septimes are in use. Degrees are defined as "subdivisions of sound intervening [between] the notes." There are 22 such in the Octave. but what their precise value may be does not appear.

The Rajah gives the following as the three scales recognised by the ancient authorities, with the number of degrees in each interval, here marked by points above, the note being in olden time considered to be at the end of the interval, though in more modern times it is placed at its beginning.

C-Scale.

No.	4	7	9	13	17	20	22
Degrees	. . . .	. . .	. .	. . . .	. . . .	. . .	. .
Notes	*C*	*D*	*E*	*F*	*G*	*A*	*B*

F-Scale.

No.	4	7	9	13	16	20	22
Degrees	. . . .	. . .	. .	. . . .	. . .	. . . .	. .
Notes	*C*	*D*	*E*	*F*	*G*	*A*	*B*

E-Scale.

No.	1	4	6	10	13	16	19
Degrees	.	. . .	. .	. . . .	. . .	. . .	. . .
Notes	*B*	*C*	*D*	*E*	*F*	*G*	*A*

These seven notes are divided into two classes, which may be translated, *fixed* and *changing*. The fixed notes have their values as in the *C*-scale. A changing note is one of the fixed altered by one, two, or three degrees. There are 7 fixed and 12 changing notes, but I have failed to interpret the ancient distribution of the latter among the former. The modern musicians obtain the changing notes by making *D*, *E*, *F*, *A*, and *B*, "flat or very flat, sharp or very sharp," terms of which the only explanation given is by the 22 degrees, as follows:—

Fixed.

No.	1	5	8	10	14	18	21
Degrees	.	. . . .	. . .	. .	. . . .	. . . .	. . .
Notes	*C*	*D*	*E*	*F*	*G*	*A*	*B*

Changing.

No.	2	3	6	7	9	12	13	15	16	19	20	22
Notes	*D*	*D*	*E*	*E*	*E*	*F*	*F*	*A*	*A*	*B*	*B*	*B*

This arrangement would seem to imply that *D* depressed two degrees is "flat," and three degrees "very flat" (which we may write by the sign for double flat), the first corresponding roughly to a Semitone, the second to a Semitone and a half. But *E* may be depressed one or two degrees, or raised by one, written *E* ffl, *E* fl, *E*, *E*sh, the "sharp" being now only one degree. *F*, on the other hand, may be raised two (sharp) or three (very sharp) degrees, written *F*, *F*sh, *F*ssh. *A* may be depressed two or three degrees, and *B*, like *E*, may not only be depressed one or two degrees, but raised one degree. *C* and *G* remain unaltered as the backbone of the scale. Now, we do not know precisely what a degree is, and hence any representation of these differences with exactness is impossible. But we may obtain a tolerably approximate notion thus:—Suppose the fixed notes to have been those already described in the old *C*-scale, so that *C* to *D*, *F* to *G*, and *G* to *A*, have each 204 cents, and a degree of such an interval should be a quarter of that amount, or 51 cents. The interval *D* to *E*, or *A* to *B*, has only 182 cents, and but only 3 degrees, so that each degree has 60⅔ cents. Finally, the interval *E* to *F*, or *B* to *C* has 112 cents, and only two degrees, hence one of these degrees has 56 cents. The modern Bengali division gets over the difficulty thus:—The *C*-string is divided in half, giving the Octave; the half nearest the nut is again halved, giving the Fourth *F*. The part between the nut and *F* is divided into 9 equal parts, each giving one degree; and the other part, from *F* to the Octave, is divided into 13 equal parts, each giving a degree. From these indications it is possible to calculate the value of each degree and assign the notes. In the following table I give the number of degrees and the calculation of their value on both plans, *old* and *new*, with the names of the 19 Indian notes, assuming that pitch varies inversely as the length of the string, as shown by the position of *F* and the Octave, and that any errors thus arising have been corrected by ear.

INDIAN CHROMATIC SCALES.

Degrees..	1	2	3	4	5	6	7	8
Notes....	*C*	*D* ffl	*D* fl	—	*D*	*E* ffl	*E* fl	*E*
Old	0	51	102	153	204	264⅔	325⅓	386
New	0	49	99	151	204	259	316	374
Degrees..	9	10	11	12	13	14	15	
Notes....	*E* sh	*F*	—	*F* sh	*F* ssh	*G*	*A* ffl	
Old	442	498	549	600	651	702	753	
New	435	498	543	589	637	685	736	
Degrees..	16	17	18	19	20	21	22	
Notes....	*A* fl	—	*A*	*B* ffl	*B* fl	*B*	*B* sh	
Old	804	855	906	966⅔	1027⅓	1088	1144	
New	787	841	896	952	1011	1070	1135	

The only values agreeing in each are *C*, *D*, *F*, while new *E* fl is the just minor Third, a mere accident. The 9 degrees from *C* to *F* vary from 49 to 63 cents, and then there is a sudden break, after which the 13 degrees from *F* to the Octave vary from 45 to 65 cents. This is the first intelligible presentment of the Indian scale which I have been able to effect. It will be seen that *C D* fl *D E* fl *E F F* sh *G A* fl *A B* fl *B* are represented pretty well by our equally tempered notes, but that the 7 intermediate notes *D* ffl *E* ffl *E* sh *F* ssh *A* ffl *B* ffl *B* sh could only be tempered on the Quartertone system used in Syria. Hence, in the usual transcription, these 7 notes are identified with some of the others, possibly *D* ffl with *D* fl (not with *C*), *E* ffl with *E* fl (not with *D*), *E* sh with (as usual), *F* ssh with *F* sh (not with *G*), *A* ffl with *A* fl (not with *G*), *B* ffl with *B* fl (not with *A*), and *B* sh with *C* (as usual). These confusions necessarily injure the original character of the music, and give it a harmonisable appearance which is entirely foreign to Indian music.

We may now understand how on the *Vina* or native classical Indian instrument, which has frets from 7-8ths to 9-8ths of an inch high, it is considered sufficient to use 12 frets to the Octave, giving approximately our 12 Semitones (see the account of the "Vina of Madras" below), and to leave them to be corrected and the 7 Quartertones to be produced when wanted, by pressing on the string behind the fixed frets, by which an increase of tension is obtained, easily raising the pitch by a quarter of a Tone. Thus, on a *Vina*, lent by Mr. Chappell to the South Kensington Museum, Mr. Hipkins and I raised the note of fret 5 from 300 to 316 vib., or 90 cents, and that from fret 17 by much harder pressure from 539 to 573 vib., or 106 cents. On the modern Indian long-necked guitar, or *Sitahr*, which has superseded the *Vina*, the moveable frets are disposed at first so as to suit the tune for most of the half and quarter Tones, and the occasional elevation by a degree is produced by deflecting the string, drawing the finger along the fret, for which ample room is left on the fingerboard. This deflection we witnessed when Rajah Ram Pal Singh played to us, and, measuring the amount of deflection, we found that it produced an interval of 48 cents, or, say, one degree.

The number of different scales produced by selecting some of these 19 notes is very large. Rajah S. M. Tagore enumerates 32 with 7 notes each, 112 with 6 notes each, and 160 with 5 notes each, or 304 in all; but as in figuring these scales he has neglected to mark what notes were "very sharp" or "very flat," it would be useless to cite them.

These scales are of course used to produce airs. A *mode* is, according to the Rajah, "the succession of notes so arranged, according to prescribed rules, as to awake a certain feeling of the mind." In such modes four classes of notes are distinguished:—(1.) The *ruler*, "which by the frequency of its application in a certain mode, and by the length of its duration, shews to the best advantage the character and the living form, as it were, of that mode; hence it is called the *king*, that is, principal note, and by Hindust'hani musicians the life and soul of the mode." It clearly answers to the European tonic, but it does not bear to the others exactly the same relation, as Indian music seems devoid of tonality in the European sense. (2.) The *minister*, "any note lying at an interval of 8 or 12 degrees from the ruler . . . . . when, for instance, *C* is the ruler, *F* and *G* are its ministers," hence these answer to our dominant and sub-dominant. (3.) The *enemy*, the admission of which would destroy the character of the mode. (4.) The *subordinates*, the remaining notes. There are four parts or strains to each mode; and the modes are of three kinds, according as they contain 7, 6 or 5 notes, and each of these, again, are divided into three kinds, according as they are *pure* (having the characters of one mode only), *dual* (partaking of the nature of two modes artistically blended), and *mixed* (of three or more modes). The six original modes are the only instances of the pure class, and are called modes proper; the mixtures are called either modes or modelets, that is wives of the modes. It would be as impossible to go into details as into European counterpoint, but so much belongs to the scale proper. The Rajah says of harmony: "The spirit of Indian music is against the adoption of harmony in its European sense. The mode is essentially melodic in its character—it is a succession of notes artistically so arranged as to produce a certain effect, differing in the minutest particulars from that derivable from another mode."*

Now I turn to the investigations of Mr. Hipkins and myself with Rajah Ram Pal Singh. The setting of the frets was a pure matter of ear and memory. The frets were moved somewhat hastily, and perhaps were not arranged with the accuracy that would have been attained by a professional musician. Then the Rajah having played an air, I measured the position of the frets, and was thus able to put them in the same position at any time, Then the position of the frets was changed, and another air was played, and the places of the frets again recorded. In this way on one visit the Rajah changed the position of the frets three times, and at another twice, so that we obtained 5 scales, of which apparently the first and fourth, set on different days, were meant for the same. The finger-board of the Sitahr is 27 inches long and of uniform width of 3¾ inches, so that the frets can be shifted to any extent, except in so far as they are stopped by the supports of the "sympathetic" strings, namely, those which are themselves not played on but vibrate in unison with certain notes that are played. This Sitahr had 16 movable frets. The two highest and five lowest were only used when it was necessary to run into another Octave, the main part of the air being on the middle 9 frets, of which however one was always unused. The air was played on one string only, though there are 4 other strings tuned to a Tone, a minor Third and a Fourth above, and a Fifth below the speaking string. These seemed to be occasionally struck, but not to produce harmony, and they were not used with the frets. The

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* In giving the foregoing account, I have translated all the terms for the convenience of the English reader. I now append the Indian words, using ah a (in China, *u* in hut), ee i, oo u (in put), *e o* (in *there*, *note*), *ai*, *au* (as in *eye*, *how*) for the vowels, *ch sh* as in *chin*, *shot*, the small capitals for cerebrals, spoken with a reverted tongue, and *'h* for an *h* introduced after a consonant; *s'* is now pronounced *s*, but was once the palatal German *ch* in *ich*:—

Scale, *grahma*.
Septime, *s'aptaka*.
Degree, *s'ruti*.
C, *sharja* or *sa*.
D, *rishab'ha* or *ri*.
E, *gahnd'hahra* or *ga*.
F, *mad'hyama* or *ma*.
G, *panchama* or *pa*.
A, *d'haivate* or *d'ha*.
B, *nishahda* or *ni*.
C-scale, *sharja grahma*.
F-scale, *mad'hyama grahma*.
E-scale, *gahnd'hahra grahma*.
Fixed, *prakrita* or *s'udd'ha*.
Changing, *vikrita*.
Sharp tones, *tibra-suras*, the sign for them *patahkah*.
Flat tones, *komala-suras*, the sign for them *trikona*.
Very sharp, *ati-tibra*.
Very flat, *ati-komala*.
Mode, *rahga*.
Modelet, *rahginee*.
Ruler, *vahdee*.
King, *rahjah*.
Life and soul, *jahn*.
Minister, *samvahdee*.
Enemy, *vivahde*.
Subordinate, *anuvahdee*.
Seven-note scale, *sampoorNa t'haht*.
Six-note scale, *shahrava t'haht*.
Five-note scale, *oRava t'haht*.
Pure (mode), *s'udd'ha*.
Dual (mode), *ch'hahyahlaga* or *sahlanka*.
Mixed (mode), *sankeerNa*.

scale began on the Sixth fret, forming about a Fifth with the open string, which gave *E* fl 156 vib.; but the string, being an English pianoforte wire, was much too thick, and hence the pitch must not be insisted on. It is only the intervals played with which we are concerned.

In the following arrangement, I give the cents observed for each setting, the first and and fourth being, for convenience of comparison, placed immediately under one another. Then, in the next line, I give the cents in the nearest note of the *new* scale, already cited, because that must have been the one intended, though the notes played, even the Fourth and Octave, often differed from those in that scale by a comma, or even more (as for the undoubted Fourth and Octave), at which we cannot be surprised under the circumstances. Then follow the names of the corresponding notes. Accepting these, it would appear that Rajah Ram Pal Singh, for the first and fourth setting, used the notes in Rajah S. M. Tagore's 1st seven-note scale; for the second setting (supposing *E* ffl to be identified with *E* fl in the notation of those scales), the 13th; for the third setting, the 29th; and for the fifth setting, the 9th; so that all the scales are identified.

Scales set by Rajah Ram Pal Singh.

First and Fourth Setting:—

Obs. 1st ..	0	183	342	533	685	871	1074	1230
,, 4th ..	0	174	350	477	697	908	1070	1181
New	0	204	374	498	685	896	1070	1200
Notes	*C*	*D*	*E*	*F*	*G*	*A*	*B*	*c*

Second Setting:—

Obs.......	0	183	271	534	686	872	983	1232
New......	0	204	259	498	685	896	1011	1200
Notes	*C*	*D*	*E* ffl	*F*	*G*	*A*	*B* fl	*c*

Third Setting:—

Obs.......	0	111	314	534	686	828	1017	1198
New......	0	99	316	498	685	787	1011	1200
Notes	*C*	*D* fl	*E* fl	*F*	*G*	*A* fl	*B* fl	*c*

Fifth Setting:—

Obs.......	0	90	366	493	707	781	1080	1087
New......	0	99	374	498	685	787	1070	1200
Notes	*C*	*D* fl	*E*	*F*	*G*	*A* fl	*B*	*c*

At the South Kensington Museum will be found a variety of Indian musical instruments. Many of these I carefully measured, but it was sometimes difficult to determine the real vibrating length of the string. The Vinas had their frets fastened with wax. The intervals from fret to fret were measured in cents from the inverse ratios of the length of the string, which is by no means accurate, especially as this calculation takes no account of the increase of tension caused by pressing the string down on to the fret or behind the fret. One example will therefore suffice.

Vina, from Madras, dragon-headed, with a lute body broken, and a gourd; 24 frets, fastened with wax. The I, II, &c., indicate the number of the fret, O being the nut. The intervals are expressed in cents from fret to fret, and from the open string to each fret. The frets marked (*) had been broken off, and their position was restored from traces left. For the names of the notes I have been guided by the nearest number of cents in the new Bengali division, given above.

	O	89	I	89	II	91	III	104	IV	102	V	121	VI	88	VII	97	VIII	98
	0		89		178		269		373		475		596		684		781	
Notes	*C*		*D* fl		*D*		*E* ffl		*E*		*F*		*F* sh		*G*		*A* fl	

	IX	117	X	85	*XI	118	*XII	81	XIII	96	XIV	90	*XV	101	XVI	114
	879		996		1081		1199		1280		1376		1466		1567	
Notes	*A*		*B* fl		*B*		*c*		*d* fl		*d*		*e* ffl		*e*	

	XVII	95	XVIII	115	XIX	93	XX	106	XXI	97	XXII	111	XXIII	100	XXIV
	1681		1776		1891		1984		2090		2187		2298		2398
Notes	*f*		*f* sh		*g*		*a* fl		*a*		*b* fl		*b*		*c'*

Judging from the circumstance that the Rajah Ram Pal Singh began at the Fifth above the open string, it may have been more proper in this Vina to commence taking the scale from after the Seventh fret. This would make an Octave have the following intervals from the lowest notes:—

Cents...	0,	97,	195,	312,	397,	515,	596,	692,	782,	883,	997,	1092,	1207
Notes...	*G*	*A* fl	*A*	*B* fl	*B*	*c*	*d* fl	*d*	*e* ffl	*e*	*f*	*f* sh	*g*

This is very close indeed to our scale of 12 Semitones, and may be taken for it. The remaining 7 Quartertones have to be produced by pressing the string behind the fret.

The Vina is the oldest of these stringed instruments; the *Sitahr*, which is mostly used, is much more modern. Captain Meadows (Tagore collection), describing the Indian instruments presented to the Irish Academy by

Colonel French, enumerates Cymbals, Gongs, Bells, Horns, Trumpets, reed instruments (Oboes), Pipes, Four-stringed Lutes, Sitahr and its varieties, Viols, Dulcimers, Vina and Been, and one-stringed Tunteemee, Drums in great variety, Conch shell. Of these, the Oboes (*holar char soonai*) he describes as being the commonest, and to be heard everywhere. The sound is like a bagpipe, and it has no great compass, but by quarter and half covering the finger-holes great varieties of notes are introduced, and there is much execution. This must have resembled the Chinese So-na, hereafter described. Even with the assistance of a player, there would be great difficulties in recording such scales. Possibly, this oboe is an early instrument, and certainly all stringed instruments are later. But I regard percussion instruments as the most primitive, like the following:—*Balafong*, from Patna, in the South Kensington Museum—a modern harmonicon, strung over a box, which is beautifully carved, containing 3 octaves and 3 notes, or 25 bars. I give the pitch and scale of such bars as Mr. Hipkins and I measured on 6th April, 1883. The Roman II, III, &c., give the number of the bar, the pitch is written over, the cents. between and under as usual.

Vib.	158		176		194		214		233		259		279		321
	II	187	III	169	IV	170	V	147	VI	183	VII	129	VIII	237	IX
Cents........	0		187		356		526		672		856		985		1222
	321		355		391		434		484		531		582		
	IX	180	X	167	XI	181	XII	189	XIII	160	XIV	159	XV		
Cents (less 1222)	0		180		347		528		717		877		1036		

In the first Octave, the bars IV and VII give almost the same as the bagpipe notes; but V and VI gives a sharp Fourth and a flat Fifth, having barely three-quarters of a Tone between them. The Octaves are all sharp, as is seen by the vibrations, and by the cents when 1222 are added. But the four first notes are much alike in both octaves.

Classing Cashmere under India, I may here introduce the *Tar*, a kind of guitar, with 13 movable frets, made of three turns of waxed string, about 3 mm. in width, with two strings in unison to play with, and several sympathetic strings. The frets, on the instrument mentioned, had evidently not been shifted for a long time, and I take them as I found them. The intervals on cents are determined from the vibrating lengths, that of the open string being 676 mm.

First Octave..	O	175	I	179	II	158	III	208	IV	176	V	166	VI	175	VII
	0		175		354		512		720		896		1062		1237
Second Octave	VII	205	VIII	173	IX	150	X	195	XI	221	XII	160	XIII		
	1237		1442		1615		1765		1960		2180		2341		

The Octaves are all sharp, but as the frets were very low, they could not have been much sharpened by pressure on the string behind the fret. It would seem that this was a Quartertone scale, of the type 0 200 350 500 700 900 1050 1200, the whole Tone in the second tetrachord being placed so as to make it identical with the first.

VIII.—Singapore.

Mr. Hipkins received direct from Singapore a *Balafong*, or wooden harmonicon, supposed to have come from Java; but as the scale is totally different from the Javese, I class it under the name of the place from which it was received. It consists of twenty-four wooden bars, forming three Octaves and three notes. We measured the central Octave, beginning at bar 8, as follows:—

Vib........	312		344		382		427		470		523		569		626
	I	169	II	181	III	193	IV	166	V	185	VI	146	VII	165	VIII
Cents	0		169		350		543		709		894		1040		1205

Tempered form in Quartertones:—

Vib........	312		340		382		429		467		525		572		624
	I	150	II	200	III	200	IV	150	V	200	VI	150	VII	150	VIII
Cents	0		150		350		550		700		900		1050		1200

Comparing this tempered form in Meshaqah's 24 division, we see how close are both the number of cents and number of vibrations, assuming the same initial pitch. Hence it seems right to consider that this was, like the bagpipe, a Tone and three-quarter Tone instrument, both having 3 Tones and 4 three-quarter Tones, but differently distributed. The resemblance between this scale and that of the preceding Tar of Cashmere is very striking, and would seem to imply that they belonged to the same system of tuning.

IX.—Burmah.

The *Patala*, a wooden harmonicon, of 25 small neat bars, in the South Kensington Museum, No. 1,620, 1872, Engel, p. 16, who describes the scale wrongly. Mr. Hipkins and I commenced with bar 7 from the lowest end, here written I, and took an octave with the following result:—

Vib.	300		332		367		408		451		504		551		616
	I	176	II	174	III	183	IV	174	V	192	VI	154	VII	193	VII
Cents	0		176		350		533		707		899		1053		1246
Tempered	0		150		350		550		700		900		1050		1200

The Octave is exceptionally sharp, otherwise this scale agrees closely with the immediately preceding Singapore Balafong, the tempered forms being identical. The III 350 cents is very characteristic. Bars 15, 16, 20 were sharp octaves of bars 8, 9, 13 (or II, III, IV), the bar 16 being very sharp indeed, otherwise the Octaves were fair.

There is also a Burmese *Balafong* in the South Kensington Museum, with a box decorated with Burmese ornaments. It consists of 22 bars, and contains 3 octaves and 1 note. We measured 12 bars from the 4th to the 15th. The following gives the scale from the 8th to the 15th, numbered I to VIII:—

Vib.	353		377		432		485		525		573		641		705
	I	114	II	236	III	200	IV	137	V	151	VI	194	VII	164	VIII
Cents	0		114		350		550		687		838		1032		1196
Tempered	0		100		350		550		703		850		1050		120

And the preceding 4 bars give—

	237		258		282		318		353
	IV'	147	V'	154	VI'	208	VII'	181	VIII'
Cents	506		653		807		1015		1196
Tempered	500		650		800		1000		1200

which shows that they form the end of an octave very similar, though not identical with the other one. The tempered form seems to show that this again is a three-quarter Tone scale, though differently arranged.

The *Keay Wine* in the South Kensington Museum consists of 15 kettles or gongs, resembling Javese Bonangs, arranged in a circle. Unfortunately, one gong was cracked, and another had a very doubtful pitch, and the whole instrument seemed out of tune. I consider it best, therefore, not to record the extremely doubtful measurements.

X.—Siam.

The *Ranat* in the South Kensington Museum is another wooden harmonicon with 19 bars, which Engel (p. 316) says form the diatonic scale of *G*, but this is far from being the case. We measured 10 bars from the 6th to the 15th. The 13th was unfortunately of a different kind of wood from the rest, and had been put in as a substitute for the Octave of bar 6.

Vib.	323		348		379		433		491		504		585		666
	VI	129	VII	148	VIII	231	IX	218	X	45	XI	258	XII	225	XIII*
Cents	0		129		277		508		726		771		1029		1254
Tempered	0		150		250		500		700		800		1000		1200

	666		748		794
Vib.	XIII*	201	XIV	103	XV
Cents	0		201		304
Tempered	0		200		300

This scale is quite enigmatical. The second Octave, of which only the beginning was measured, quite disagrees with the first. The interval, 45 cents, is also unintelligible. In tempering I have therefore supposed X to be too sharp, and XI too flat, but the tempering is hazardous. Let us hope that the Siamese musicians who are to come to the Inventions Exhibition of this year, will give a better notion of Siamese music than this *Ranat* affords. If I can obtain any information, I will communicate it to the Society of Arts.

XI.—Western Africa.

A *Balafong*, No. 1080, 108a—'68, South Kensington Museum, Engel, p. 154, who makes it the diatonic scale of *C* natural, beginning at *E*. This is far from being the case. We measured 9 bars, beginning at the 8th as follows :—

1. Vib..........	327		357		386		445		497		547		596		654		714
2. Bars	VIII	152	IX	135	X	245	XI	191	XII	166	XIII	149	XIV	161	XV	152	XVI
3. Cents	0		152		287		533		724		890		1039		1200		1352
4. Ratios ...		11 : 12		25 : 27		32 : 37		9 : 10		10 : 11		11 : 12		10 : 11		11 : 12	
5. Cents of r.		151		133		251		182		166		151		166		151	
6. Sums of r.	0		151		284		535		717		883		1034		1200		1351
7. Vib. of r...	327		357		385		446		495		544		594		653		
8. Tempered.	0		150		300		550		700		900		1050		1200		

The 1st line gives the vibrations observed; the 2nd the numbers of the bars and the cents between them; the 3rd the cents from bar VIII; the 4th the nearest ratios (the product of these ratios is 500 : 999 very nearly 1 : 2); the 5th the cents corresponding to these ratios; the 6th the sum of these cents (making the Octave exact, owing to the approximate nature of the cents in line 5); the 7th the corresponding vibrations, which may be compared with line 1; the 8th the corresponding tempered intervals of the 24 divisions, showing that this is one of the Tone and three-quarter Tone systems, including in this case a five-quarter Tone. The ratios are not given as if any thought of them were present to the tuner, but merely as the nearest rational expression of the intervals.

Another *Balafong* from West Africa, belonging to General Pitt Rivers, on loan at the South Kensington Museum, consisting of 14 bars, on examination, showed that the first and last bars were too defective to have their pitch measured. The other thirteen behaved thus—

Vib. ..	280		305		332		368	
	II	148	III	147	IV	178	V	and then beginning afresh at V
Cents...	0		148		295		473	
Temp...	0		150		300		500	

Vib. ..	368		412		435		495		547		583		659		740		830
	V	195	VI	94	VII	224	VIII	173	IX	110	X	212	XI	201	XII	199	XIII
Cents...	0		195		289		513		686		796		1008		1209		1408
Temp...	0		200		300		500		700		800		1000		1200		
Say	*c*		*d*		*e* fl		*f*		*g*		*a* fl		*b* fl		*c'*		

So that bars V to XII give a very fairly correct minor scale without the leading note. Compare with the scale of *F* sh minor in French pitch, of which the vibrations are—

Vib...	366	411	435	488	548	581	652	732
Note...	*f* sh	*g* sh	*a*	*b*	*c'* sh	*d'*	*e'*	*f'* sh

Second Division.—Pentatonic Scales.

XII.—South Pacific.

To Europeans the type of the Pentatonic Scale is furnished by the black digitals on the piano. If we begin at *C* sh and play on to its Octave, keeping to the black notes, we should get a pentatonic scale. This would, however, be different if we began on *D* sh, *F* sh, *G* sh, or *A* sh. It is advisable to play these five scales from *C* only, and they then become the following varieties of our usual scales :—

1.—*C* 200 *D* 300 *F* 200 *G* 200 *A* 300 *c*.
2.—*C* 300 *E* fl 200 *F* 200 *G* 300 *B* fl 200 *c*.
3.—*C* 200 *D* 200 *E* 300 *G* 200 *A* 300 *c*.
4.—*C* 200 *D* 300 *F* 200 *G* 300 *B* fl 200 *c*.
5.—*C* 300 *E* fl 200 *F* 300 *A* fl 200 *B* fl 200 *c*.

Observe that the notes in these scales could all be obtained from the following series of Fifths, beginning for each scale with the note under its number, and continuing for 5 notes:—

5	2	4	1	3				
A♭	*E*♭	*B*♭	*F*	*C*	*G*	*D*	*A*	*E*

This also gives a method of tuning any one of them by Fifths up and Fourths *down* (tempered on the piano). All these scales sound deficient in our heptatonic ears, and in reality a scale seldom occurs in any pentatonic music. These scales seem to have originated the notion that pentatonic scales were played because the nations that used them could not appreciate Semitones. This, as we shall see, is entirely erroneous, and, consequently, the five scales just considered are by no means all. Again, it is found that intervals of three-quarters and five-quarters of a Tone, and even more, occur. Hence the real division of the Octave in a pentatonic scale is very varied. Compare also the 160 Indian forms, formed by omission, and enumerated by Rajah S. M. Tagore.

The one we commence with is not a bad specimen of the typical scale, but both the major Third, *C* to *E*, and the Fifth, *C* to *G*, are flat. It is from a balafong (labelled Jews' Harp), of 18 bars, belonging to General Pitt-Rivers, and examined, when on loan, in room L of the Science Collections of the South Kensington Museum. Only the best Octave was selected, beginning at bar VI, but all the Octaves are tolerably good:—

Vib....	332		373		411		493		559		664
	VI	202	VII	168	VIII	315	IX	218	X	290	XI
Sums ..	0		202		370		685		903		1123
Say	*C*		*D*		*E*		*G*		*A*		*c*

The *E* and *G* are, however, both nearly a comma too flat. In fact the *E* is about half-way between Zalzal's 355 cents and the just 386 cents, so that it would be difficult to say which it was meant for, had not *A* been 903 in place of Zalzal's 853 cents, which shows that probably the just major Third was meant. This is, therefore, the 3rd pentatonic scale of the above series.

XIII.—Java.

In the summer and autumn of 1882, a complete band from central Java was performing four times daily at the Aquarium. My attention was drawn to them by two articles, written, as I subsequently found, by Mr. W. Stephen Mitchell, M.A. of Gonville and Caius College, Cambridge, in the *Journal of the Society of Arts* (for Sept. 29th, 1882, vol. 30, p. 1019, and Nov. 3rd, 1882, vol. 30, p. 1072), explaining generally the nature of the scales, their names and the order of their notes. As these articles showed the genuineness of the exhibition, I felt that there was an opportunity of determining the nature of the Javese scales* which was not to be neglected. I enlisted Mr. Hipkins, to whose valuable co-operation in all these examinations the very existence of this paper is due, and Mr. Mitchell having kindly procured us admission to the instruments at the Aquarium when not open to the public, we spent many hours in determining their pitch and scales. In doing so we found the previous work of Mr. Mitchell of great service. He had determined the names of the notes, and pasted them on to the backs of the instruments; and he had determined the order of the bars in the different scales, with considerable difficulty, as the Javese players could not speak English, and the Dutch superintendent did not understand music. Drawings and descriptions of the instruments, and some airs may be found in Sir T. Stamford Raffles's "History of Java," vol. i., and in Mr. J. Crawfurd's "History of the Indian Archipelago," vol. i., the latter reprinted at the end of Rajah S. M. Tagore's collection, although the music is totally distinct from that of India. Subsequently Professor Land, of Leyden, to whose labours on Arabic music I owe so much, was kind enough to measure some Javese instruments at Leyden with a monochord, and to communicate measurements of them made by other observers, all of which greatly confirmed our results, and showed that we were dealing with genuine instruments which had not been tampered with. Professor Land also kindly communicated much information from the MSS. of a missionary in Java, and the verbal reports of a Eurasian,† from Java, then in Holland, who spoke Javese, and could himself play on Javese instruments, as well as on the European violin. This Eurasian stated that Javese instruments, especially those of wood, are apt to get out of tune. The Ethnological Museum, at Leyden, consequently ordered some

* It is usual to say *Javanese*, which I have found continually mistaken for *Japanese* in conversation. Hence as from China and Burmah, we make the adjectives *Chinese* and *Burmese*, I shall always make the adjective *Javese* from Java.

†*Eurasian* means of mixed *European* and *Asian* parentage.

of glass, which Professor Land has since informed me are actually on the way. If Mr. Hipkins and I ever have an opportunity of measuring them, I will communicate the result to the Society of Arts. In the meantime, everything concurs to give me considerable confidence in our results.

The Javese bands are called *Gamelan*, and those which were in London were composed of two distinct bands, the *Gamelan Salêndro** and the *Gamelan Pèlog*, which must be considered separately. The performers were the same for each, but the instruments and scales were so different that they could not be played together, but were ranged on different sides of the platform. With two exceptions the instruments were all of percussion, bars of wood, bars of metal, kettles, gongs. The exceptions were 1) a solitary *rabab*, the Arabic two-stringed viol, which, having no frets, could of course be played with either band, and 2) a flute or *soeling*, but I do not remember whether it was played with one band or both. Although many instruments were played together, there was no harmony in our sense of the word. Either all the instruments played in unison, or one, generally with the highest and most evanescent tone, flourished away between the notes, regardless apparently of what the other instruments were doing, but falling into unison sufficiently to show that it was playing a part in the same music. There were no written notes. Phrases were repeated till, on a given signal, they were changed.† The music was used as an accompaniment to dancing, or rather posturing, by performers of both sexes, who were supposed to convey a story in dumb show. There was occasional singing, but the singing voice was so dreadfully, and apparently intentionally, unmusical, that it could not enter into our examination. Mr. Hipkins and I overhauled the instruments of both bands, three of each, to see that they agreed, which was generally very well, or mark where they disagreed, which was seldom, and to a slight extent.

First Band or Gamelan Salêndro.—Instruments examined:—(1.) The *Gambang Kajoe*, or wooden harmonicon of 20 bars, containing 4 Octaves, of 5 notes to the octave, ranging from 135 to 1,880 vib., so that the second Octave of the lowest note (called *bem*, evidently the Arabic *al-bamm*, for the lowest note on the lute), would have had 540 vib., the concert pitch of our English *c''* on the third space of the treble staff. The tone, produced by striking with a soft wooden hammer, was sweet, but very brief and difficult to measure. (2.) The *Sâron*, a set of metal bars, divided into three sets for convenience, each containing six bars, so that the highest note of one set was the Octave of the lowest, and was repeated in unison as the lowest note of the next set. These were played with harder hammers, and damped with the thumb of the left hand. The sounds involved dissonant upper partial tones, which rendered it difficult to determine the pitch. (3.) The *Slèntem*, an octave lower than the Sáron, made of larger metal bars with bosses on them. Prof. Land also observed a Sáron in the Museum at Leyden, and Dr. Figée had observed four notes of the same previously.*

The names of the five notes of the Salêndro Scale are I Bem, meaning "lowest," II Pengoeloe, "highest;" III. Peneloe, "third;" IV Lima, "five;" V Nenem, "six," varied as Barang, which was a Pèlog note only in the instruments we examined. It is uncertain whether there were two Salêndro Scales with a different V. or not. I am inclined to think not, and that this was only another name for the same note in other part of the country, for the names certainly varied.

* In these Javese names I adopt the orthography of Prof. Land as more exact than Mr. Mitchell's. The English reader must remember that *a°* is nearly *awe*, *oe* is *oo* in *book*, *j* is the consonant *y*.

† The above gives my own recollections. I am glad to be able to add Professor Land's account. "The musical treatment is this. The rabab plays the tune in the character of leader"; [at the Aquarium, the player of the Gambang seemed to be leader] "the others play the same tune, but figured, and each for himself and in his own way; the sâron resumes the motive or tune. All this is accompanied by a sort of *basso ostinato*, and a rhythmical movement of the drum, and the whole is divided into regular sections and subsections, by the periodical strokes of the gongs and kenongs (kettles). The variations of the same tune by the different instruments produce a sort of barbarous harmony, which has, however, its lucid moments, when the beautiful tone of the instruments yields a wonderful effect. But the principal charm is in the quality of the sound, and the rhythmical accuracy of the playing. The players know by heart a couple of hundred pieces, so as to be able to take any of the instruments in turn." He was speaking of "the gamelan band sent by the independent prince of Solo," to the Arnheim Industrial Exhibition, in the summer of 1879.

* Dr. Figée labelled them *D*, *F*, *G*, *A*, and these labels remain upon them, and would give the intervals *D* 300 *F* 200 *G* 200 *A*. But he assigned the relative pitch numbers *D* 1000, *F* 1151, *G* 1346, *A* 1520 vib., which would give the relative pitches *D* 243 *F* 274 *G* 208 *A*, in which the first two intervals are manifestly incompatible with any European scale. It is such rough and ready naming of notes which is so misleading in similar descriptions. Dr Figée, Assistant in the Physical Laboratory at Leyden, measured by means of a good monochord, and his measurements, agreeing closely with Prof. Land's, were probably correct for that particular instrument. He was also a good singer, yet he confused intervals of 243 and 274 cents, with 300 and 200 respectively, the less with the greater and conversely.

Poensen, a missionary, used I Bárang, II Goeloe, and also Penanggap or Djongga, III Tengah, IV Lima, V Nem. The very meaning of the first set of names show that they indicate a different order of the notes from that observed. Hence the Roman numerals are best used.

The following are our observations; the notes marked (*) were out of tune, as shown by the other instruments:—

Salendro Scales.

1. Gambang..............	*268		308		357		411		470		*535
2. Sáron	272		308		357		411		471		543
3. Slentem	270		308		357		411		469		540
4. Mean	270		308		357		411		470		540
5. Notes	I	228	II	256	III	244	IV	232	V	240	I′
6. Cents	0		228		484		728		960		1200
7. Lower Gendér	I	191	II	251	III	249	IV	261	V	220	I′
8. Upper Géndér	I	219	II	256	III	261	IV	223	V	288	I′
9. Land Sáron	I	270	II	200	III	266	IV	239	V	243	I′
10. Figée Sáron	I	275	II	210	III	..	IV	..	V	243	I′
11. Tempered	I	240	II	240	III	240	IV	240	V	240	I′
12. ,, sums........	0		240		480		720		960		1200
13. ,, vib.	270		310		356		409		470		540

Lines 1, 2, 3, give the number of vibrations observed in the different instruments named, the Gambang being evidently wrong in I and I′, but otherwise a very substantial agreement existing.

Line 4 gives the mean number of vibrations adopted.

Line 5 shows the intervals between the notes in cents.

Line 6 gives the intervals from I in cents.

Lines 7 and 8 give the result of Professor Land's observations on the lower and upper Octave of the Gendér (another metal harmonicon) by the monochord, made with great care and difficulty, with the assistance of Prof. Onnes of the Physical Laboratory, several times over, and not always with the same results.

Lines 9 and 10 gives Prof. Land's and Dr. Figée's observations on the Sáron, only the intervals being given; Dr. Figée's were incomplete.

Lines 11 and 12 give my own tempered account, of which more presently, and line 13 gives the vibrations which would be due to these intervals, and which agree very closely with the mean of those observed.

The great peculiarity of this scale is that it contains five intervals, each of which, by our observations, was considerable greater than a major Tone of 204 cents,* and less than a just minor Third of 316 cents or even a Pythagorean minor Third of 294 cents. Under such circumstances, a European ear would naturally hear them as a tempered Tone 200 cents or a minor Third 300, as came convenient. Hence we find Sir Stamford Raffles using the notes (which I regard as in mean tone temperament in 1817), *D* 193 *E* 193 *F*sh 310 *A* 193 *B* 310 *D*′, and Crawford (who may have thought of equal temperament) using *D* 200 *E* 300 *G* 200 *A* 200 *B* 300 *D* at one time, *C* 200 *D* 200 *E* 300 *G* 200 *A* 300 *C* at another, and at a third time *D* 200 *E* 200 *F*sh 300 *A* 200 *B* 300 *D*, which is only the equally tempered version of Raffles', the same in intervals as Crawford's second, but differing from his first. A German musician, whom I met at the Aquarium, selected *C* 200 *D* 300 *F* 200 *G* 200 *A* 300 *C* for the scale we measured, whereas V. is nearer *B* fl than *A*, so that *C* 200 *D* 300 *F* 200 *G* 300 *B*fl 200 *C* would have been nearer. But this involved going out of the key of *C*, and hence was not thought of; and even when I drew attention to it, it was not admitted. It is evident, however, that the Thirds may have been otherwise placed; but they were generally so chosen as to correct the errors arising from taking the preceding interval too small, and as they over corrected, the following interval had also to be too small. This would give 0 200 500 700 1000 1200 for 0 240 480 720 960 1200 and are the nearest round numbers of cents to take. By comparing lines 4 and 13, it is seen that it would require an exceeding small alteration in the numbers of vibrations to reduce the observed to the tempered intervals, as I found, practically, in altering a set of tuning-forks from the line 4 to the line 13 pitches.

It seems an extravagant supposition that a semi-civilised nation should have hit upon

* One of the intervals in the lower Octave of Gendèr is estimated by Prof. Land as 191 cents, and one as 200 cents; that these arose either from a faulty observation or from the notes being out of tune, appears probable, by their being opposed to all the others.

the idea of dividing the Octave into five equal parts of 240 cents each, which I call a *pentatone.* Of course no such idea occurred to them, but they only fell upon it, and as I conceive thus. They took the Octave correct, and then the Fourth a little too flat, say 480 cents, which is 18 cents or not quite a comma too flat. This gives I, I' and III. A second Fourth of the same kind from III gives V. Then working downwards from the Octave, a flat Fourth down gives IV 720 cents, and another gives II 240 cents. Of course they were never likely to take the intervals quite correctly. Thus in the case we measured, III is 484 cents, and IV is 960 cents, so that the first flat Fourth was too sharp (484 cents), and the next too flat (476 cents). Then going down from the Octave, the Fourth was taken too small as only 472 cents, giving IV 728 cents, and then the next was taken as 500 cents, much too wide giving II 228 cents. This process would succeed, but give different values to the notes whatever the Fourth chosen, for example, just Fourth 498 cents gives—

I 204 II 294 III 204 IV 294 V 204 I'
0 204 498 702 996 1200

Mean tone Fourth 503 cents gives—

I 194 II 309 III 194 IV 309 V 104 I'
0 194 503 697 1006 1200

It is clear that no supposition which does not make the Fourth flat will represent the results observed, and that allowance must always be made for taking the Fourths unequally —as is the case even with the best English tuners. It appears to me that the "tempered" scale I have suggested is much simpler than de Lange supposed (quoted by Professor Land), namely, that III was 498 cents, IV 702 cents, that is, that they made a perfect Fourth and Fifth with I, and then that the Fourth on each side was divided into $7:8 = 231$ cents, and $6:7 = 267$ cents or conversely, and it is certainly much nearer to the observed facts, while it is more conformable to habits of tuning. I therefore assume the equal division of the Octave into five pentatones of 240 cents as the probably unrecognised ideal of the Salêndro tuner.

Is this ideal also the ideal of all pentatonic scales? Certainly not, at present, as will be seen more particularly from our Chinese and Japanese results. After once a conception of a just Fourth and Fifth have been formed, then the scale just given

I 204 II 294 III 204 IV 294 V 204 I'
0 204 498 702 996 1200

probably becomes normal, and with a little trouble the positions of the 204 and 294 may be varied, III and IV or one of them remaining constant, see scales Sect. XII.

We do not, however, find these varieties in the Salêndro in Java. But there is some suspicion of cases in which one tone is replaced by another, in the information given to Prof. Land, but I have not been able to discover what the tone is. There are many other Pentatonic scales in Java, as we shall see presently, but they are decidedly not Salêndro in character.

This simple scale is capable of much variety of melody, varied greatly by rhythm, strict time being necessarily kept when many instruments play in music. The three airs given by Raffles and the six* by Crawford are all for the Salêndro scale.

It however appeared not to be the favourite with the Javese at the Aquarium, who more frequently played in the kind of scale next described.

The Second Band or Gamelan Pèlog.— In the first band we had five notes in a scale, and the interval between the consecutive notes was always greater than a whole Tone, but less than a minor Third. In the second band we have seven notes, with intervals between consecutive notes, varying from a Semitone of 100 cents to just over a minor third of 300 cents. But of these seven notes, only five are selected to form the scale used at any time, and each different set of five notes forms a new scale, so that the intervals between consecutive notes may vary from a Semitone of 100 cents to a sharp Fourth of 550 cents. The two bands are, therefore, widely distinct. As the case in which the Gambang is fixed will only accommodate five notes to the Octave, any unused bar has to be thrown out and replaced by another, and sometimes the order of those retained has to be changed. Hence the scales are called *sòcòggan* or extra bars. The instruments examined were the *Gambang*, the *bonang*, or collection of kettles with bosses, resting in square holes left by pieces of crossed girth on a frame, and a *Sáron*. The Sáron had all 7 bars in order of sharpness, and there was no more shifting than there is on a piano when we select different sets of 7 notes to an Octave out of the twelve on the instrument. In the *bonang*, where the kettles take up much room, this would be inconvenient. All are left on the framework,

* Crawford gives seven airs, but the seventh is Malay, not Javase, and not pentatonic, but, as noted, heptatonic.

but the kettles not in use are put at a distance, and those employed brought near. Of these "shifts" or scales, four were made out by Mr. Mitchell, and two others (Miring and Menjoera) have been conjecturally added by me from Professor Land's notes, but the indications furnished to him were too indistinct and imperfect for me to feel sure that I am right in my conjecture.

The names of the notes are partly the same as those of the Salêndro and partly different, but those having the same name have not the same pitch. Indeed, no note of one band exactly coincided in pitch with any note of the other band. When it is necessary to distinguish the Salêndro and Pèlog numbers of notes, s. or p. will be added, thus, Ip, Is. The names are Ip Pengoeloe = IIs. IIp Peneloe = IIIs. IIIp Pèlog. IVp Lima° = IVs. Vp = Nenem = Vs. VIp Barang. VIIp Bem = Is.

The *Gambang*, or wooden harmonicon, had 19 bars, or three complete octaves and four notes of the fourth octave, and because Pengoeloe was its lowest note, I have made all the Pèlog scales begin with it, but I have no other reason for so doing. Two of the notes of this instrument marked * in the following table, are shown by a comparison with the other instruments to have sharpened.

The *Bonang Pelog* had two rows of kettles forming octaves with each other and beginning with Barang and not Pengoeloe. These are struck on the boss at top with two padded wooden sticks, called *tapoes*, which are also used to damp the sound.

The *Sáron Pelog* consisted of metal bars like those of the Sáron Salêndro, but of a very different shape and quality of tone. It consisted of three octaves all but one note, distributed on three sets of seven bars, the octave above lowest bar being on the next highest instrument, and the higher octave of the lowest note of the highest set being missing. Each set was played by a different performer.

Pèlog Notes and Scales.

1. Gambang ..	*283		*311		365		391		416		448		*532		566
2. Bonang	278		302		361		390		417		448		526		556
3. Sáron	279		302		360		387		414		447		524		558
4. Adopted. ..	279		302		361		389		415		448		526		558
5. Notes	I	137	II	309	III	129	IV	112	V	133	VI	278	VII	102	I'
6. Cents	0		137		446		575		687		820		1098		1200
7. Pelog	I	446	—		III	129	IV	112	V	414	—		VII	102	I'
8. Dangsoe ...	I	137	II	550	—		—		V	133	VI	278	VII	102	I'
9. Bem. E ...	I	137	II	438	—		IV	112	V	411	—		VII	102	I'
10. " L ...	I	147	II	416	—		IV	96	V	429	—		VII	112	I'
11. Barang E...	I	137	II	438	—		IV	112	V	133	VI	380	—		I'
12. " L ...	I	151	II	426	—		IV	111	V	179	VI	333	—		I'
13. Miring	I	446	—		III	129	IV	245	—		VI	278	VII	102	I'
14. Menjoera...	I	137	II	309	III	129	IV	523	—		—		VII	102	I'

Line 1.—The pitch numbers as determined from the Gambang, the notes marked (*) being evidently out of tune.

Line 2.—The pitch numbers from Bonang.

Line 3.—The pitch numbers from Sáron.

Line 4.—The pitch numbers adopted as most probable.

Line 5.—The seven Pélog notes with the intervals between them in cents.

Line 6.—The intervals in cents of each Pélog note from the lowest. It should be remembered that these seven notes do not form a scale, but that the scales which follow consist of five notes selected from them, and that these intervals hold for those notes selected over the numbers of which they stand.

Line 7.—The five notes in the scale Pelog with the intervals in cents between them.

Line 8.—The five notes in the scale Dangsoe, with the intervals between them. The interval II 961 VII which occurs in this, the Bem (line 9), and the Menjoera (line 13) scales, is the same as the Salêndro interval II 960 V, and approaching closely to that of the 7th harmonic 4 : 7 = 969 cents, has a very sweet effect, especially in descending from VII to II. This Dangsoe is said, by Prof. Land, not to be mentioned by the missionary Poensen, and only the Eurasian Rhemzev was able to tell him that it was probably an importation from China, and was used by the Chinese dancers in Java. It was certainly much used by the Aquarium Javese, and had a very pleasing effect.

Line 9.—The five notes of the Bem scale according to our determinations.

Line 10.—The Bem scale as determined from another set of instruments, with the aid of a monochord, by Dr. Loman, in 1879, as kindly communicated by Prof. Land. Although there is throughout a disagreement, amounting at II to a comma, 22 cents, and elsewhere to 18, 14, 10 cents, yet the differences are not all in the same direction, and there is a substantial agreement which is confirmatory.

Line 11.—The five notes of the Barang scale, according to our determinations.

Line 12.—The Barang scale according to Dr. Loman. The disagreements here are greater, Dr. Loman is 14 cents sharper for I to II, 12 cents flatter from II to IV, and 46 cents, nearly a quarter of a Tone, sharper for V; but 47 cents, or nearly the same amount, flatter for VI. These may have been original differences, or have come on through circumstances. Still there is a substantial agreement throughout.

Line 13 contains the five Tones which I conjecture to have belonged to the scale Miring, which means "half-and-half." As thus conjectured, it begins like Pèlog, line 7, and ends like Dangsoe, line 8. The information is from the Missionary Poensen, as interpreted by Prof. Land.

Line 14 contains the five tones which I conjecture may have been meant by an impossible indication of Mr. Poensen's. But it is, first, a merely conjectural alteration of the intervals given as 1, $\frac{1}{2}$, $\frac{1}{2}$, $2\frac{1}{2}$, $\frac{1}{2}$ Tones, which contain only 5 Tones, and is therefore impossible, into 1, $1\frac{1}{2}$, $\frac{1}{2}$, $2\frac{1}{2}$, $\frac{1}{2}$ Tones, which is possible; secondly, taking the nearest Pèlog intervals; and thirdly, identifying it with the lost Menjoera, as it is the only scale containing so large an interval as $2\frac{1}{2}$ Tones, or 500 cents.

The first four scales were determined at the Aquarium by Mr. Mitchell, so far as the names or order of the notes were concerned and verified by us, and I think we have succeeded in giving substantially the intervals employed. The following are observations of Mr. J. A. Wilkens, from Solo, Java, a first-rate authority upon native speech and manners, according to Prof. Land, from whom I obtained them:—"Not all gamelans, even of the same style, agree as to the relations of the notes. A difference of a quarter of a tone makes no dissonance to the Javese ear, for instance the *manis* [which Prof. Land identifies with VII of pèlog] of one gamelan will be (say) *F*, and that of another between *F* and *F* sh, whereas in both the note before was E." This must be considered a mere illustration, but ought to refer to some Pèlog scale; a difference of a quarter of a tone in the Barang scale has been pointed out in the observations on line 12. Mr. Wilkens continues:—"People would put these differences to the account of personal taste; I think they must be a defect in the instruments themselves," and proceeds to give his reasons, which I omit. Mr. Poensen (1872) in quoting these remarks says:—"Observe that the writer is talking about instruments which he has examined at the residences of native noblemen and princes in Middle Java. Now, what must be the condition of such instruments as we find among tradesmen and peasants, which are played upon continually, often badly preserved, and incessantly transported from place to place." Unfortunately, Mr. Wilkens is no authority on music, for he gives us a scale of *six* notes, and $5\frac{1}{2}$ Tones to the Octave, both impossible in Java, and the second everywhere, and Mr. Poensen is also unsatisfactory as a musical authority. But Mr. Rhemzev, the Eurasian, who can play Javese instruments, told Prof. Land, before he had seen these passages, that "tuning of a gamelan, even of the copper and gongsa (copper and tin alloy) instruments, suffers terribly from transporting and even from a few weeks of disusage." The former ill-effects may have happened to the Aquarium instruments (if the musicians could not retune them), and the latter to those preserved unused for years in the Dutch Museums. At any rate this fact may partly account for the discrepancies observed. The difference of observing by forks and monochord in a case of such difficulty would account for the rest, even if, as we have no right to assume, Javese tuners were much more accurate than English tuners.

I think, then, that we are justified in assuming some tempered form, as we did for Salêndro, round which to group the various determinations of the intervals. This I have found very difficult to do satisfactorily, but the following approximates very closely to observations. I take three kinds of interval, the Semitone 100 cents, the well-known three-quarter Tone, 150 cents, and the minor Third 300 cents which is double the last interval, and

instead of observed........	I	137	II	309	III	129	IV	112	V	133	VI	278	VII	102	I'.
Sums	0		137		446		575		687		820		1098		
I propose tempered	I	150	II	300	III	100	IV	150	V	100	VI	300	VII	100	V.
Sums	0		150		450		550		700		800		1100		1200
Tempered less observed ..			13		4		—25		13		—20		2.		

that is, only in one case does the difference exceed a comma of 22 cents, and only in one other case does it come near to a comma.

We then get the following results for comparison :—

EFFECTS OF TEMPERING.

1. Obs. vib.	279		302		361		389		415		448		526		558
2. Tempered vib.	279		304		362		383		418		443		527		558
3. Tempered notes	I	150	II	300	III	100	IV	150	V	100	VI	300	VII	100	I′
4. Tempered sums	0		150		550		700		700		800		1100		1200
5. Obs. sums	0		137		446		575		687		820		1098		1200
6. Tempered less obs.	0		†13		† 4		—25		*13		—20		* 2		0
Tempered scales :—															
7. Pèlog	I	450	—		III	100	IV	150	V	400	—		VII	100	I′
8. Dangsoe	I	150	II	550	—		—		V	100	VI	300	VII	100	I′
9. Bem	I	150	II	400	—		IV	150	V	400	—		VII	100	I′
10. Barang	I	150	II	400	—		IV	150	V	100	VI	400	—		I′
11. Miring	I	450	—		III	100	IV	250	—		VI	300	VII	100	I′
12. Menjoera	I	150	II	300	III	100	IV	550	—		—		VII	100	I′

With the exception of those involving quarter tones, which are not many, these intervals would certainly please a European ear better. We have the Fifth in the first four scales nearly pure, in place of flat. We have a Fourth very good between V and I′ in the same. We have a major Third between V and VII in the first three scales, and also between II and IV in the third and fourth scales, and between VI and I′ in two, perhaps three scales, and a minor Sixth between I and VI. We have the minor Third in Dangsoe between VI and VII, and possibly in Miring. We have the three-quarter Tone between I and II in three, perhaps four, scales, and between IV and V in three scales. But we have not a tone anywhere. The Semitone is found between III and IV in one scale, between V and VI in two scales, and also between VII and I in three, perhaps five scales. There is also an approximate subminor or harmonic Seventh (950 for 969 cents) between II and VII in two, perhaps four scales.

We should not go wrong more than a quarter of a Tone, and that only in the first two notes, if we assumed I 100 II 300 III 200 IV 100 V 100 VI 300 VII 100 I′, which would give us the tempered *C Csh E Fsh G Gsh B C* for the 7 Pèlog notes, and this would give the scales, PELOG *C E Fsh G B C*, DANGSOE *C Csh G Gsh B C′*, BEM *C Csh Fsh G B C′*, and BARANG *C Csh Fsh G Gsh C′*. And although these are bad imitations, especially as regards the *C Csh E*, when they come together, yet they are the best imitations of the Pèlog scales, which our radically different scale can produce. No one seems to have ventured on giving Pèlog airs in European notation.

The Pèlog scales of Java quite dispose of the notion that Pentatonic scales are confined to intervals of a Tone and a minor Third, for we do not find a Tone in them anywhere, and the minor Third is rare, while the Semitone is frequent.

XIV.—CHINA.

There is a long description of Chinese music in Amiot, and shorter ones in Barrow Williams, and Dennys, and another in the catalogue of the Chinese court at the Health Exhibition of 1884, the last having numerous airs in European notation.* All of these books seem to assume as undoubted that the Chinese musical intervals are the same as the European. Amiot begins by giving the relative lengths

* *Père Amiot's* account occupies the whole of vol. vi. of "Mémoires concernant l'histoire, les sciences, les arts, les mœurs, les usages, etc., des Chinois, par les Missionnaires de Pe-kin," Paris, 1780.

John Barrow, (late private secretary to Lord Macartney and his suite as Ambassador from the King of Great Britain to the Emperor of China). "Travels in China," 4to, 1804, pp. 314.

S. Wells Williams, LL.D. of Yale, "The Middle Kingdom," 2 vols; the edition I saw was 1883.

N. B. Dennys, M.R.A.S., "Short Notes on Chinese Instruments of Music, read before the North-China Branch of the Asiatic Society on October 21st, 1873," with numerous illustrations, and the Chinese characters for each instrument named.

China Imperial Maritime Customs Illustrated Catalogue of the Chinese Collection of Exhibits for the International Health Exhibition, London, 1884. Published by order of the Inspector-General of Customs, pp. 143—180. The short essay there given is merely an abridgment of an elaborate quarto treatise of 84 pages, with plates and music, and all the Chinese characters, by J. A. van Aalst, forming No. 6 of the "Special Series," published by the Chinese Imperial Maritime Customs, entitled "Chinese Music," to be had of P. S. King and Son, Canada-buildings, King-street, Westminster, easily procurable, and very complete.

of the string and names for the principal five tones, to which I give the corresponding English names, and the implied intervals in cents.

Relative Lengths of string	81		72		64		54		48	
Names.—Koung		chang		kio		tsché		yu		
Solfeggio...	fa		sol		la		ut		re	
Notes	*F*	204	*G*	204	*A*	294	*C*	204	*D*	294 *F*
Cents	0		204		408		702		906	1200

Then on p. 28 he develops this into a series of twelve notes forming perfect Fifths or Fourths, that is completely Pythagorean, as *F C G D A E B F*sh *C*sh *G*sh *D*sh *A* sh which give the 12 *lu*. These, with the Octave of the first *C* he found in the *cheng* of 13 tubes. If so, his cheng (the *shêng* of the catalogue and pronounced *shung* rhyming to *sung*) was entirely different from the one we examined. In the second part, fig. 18, he gives the calculation in the 12 *lu*, by a modern Chinese, as ratios to 10 figures, and these give the equally tempered scale exactly.

The catalogue says that at B.C. 1300 the scale had only five notes *C D E G A*, the scale on the black notes of the piano beginning with *F*sh (No. 3 of sect. XII). About B.C. 1100 two more notes were introduced, so that the scale corresponded to *C D E F*sh *G A B c*, which is a tempered form of the *F*-mode of Sect. V., and differs from our scale in having a Tritone *C* to *F* sh, instead of a Fourth *C* to *F*. This remained the scale till the invading Mongols introduced *C D E F G A B c*, and it is curious to note that, if the first scale is begun on *G*, thus, *G A B C D E F*sh *G*, the intervals are precisely the same as the second scale. Kublai Khan (A.D. 1259) endeavoured to reconcile the two by making the scale *C D E F F*sh *G A B C c*, which in modern language allowed of the modulation from the scale of *C* to its dominant *G*. But in the thirteenth century the Ming dynasty excluded all notes producing Semitones, and employed only the notes *C D F G A C*, which gives the scale of the black notes on a piano beginning with *C*sh. But the present Tsing dynasty, which has existed from A.D. 1644, reverted to the former scale excluding *F*sh, and hence retaining only *C D E F G A B C*, which is said to be "the Chinese gamut of the present day." But it is added that though "present Chinese theoretically admit seven sounds in the scale," they "practically only use five." It is pointed out however that whereas the ancient five were *C D E G A C*, the modern are *C D F G A C*, which puts the first minor Third nearer the commencement. Now, turning to the specimens in the catalogue, I find No. 1, which is *harmonised* in the key of *B* fl (for the use of the pianofortists, I suppose, as it is quite contrary to all Chinese habits), has, taking the melody only, all the notes *B* fl *C D E* fl *E F G A*, and once uses *C* sh in the harmonies (in a chord of the diminished Seventh). We may, therefore, pass it by as not Chinese music at all, though it is called the National Anthem. Of the following Nos. 2, 3, 4, 5, 7, 10, 11 use the scale *C D E G A*, which was said to be superseded by *C D F G A*, a form found only in No. 12. A different pentatonic scale *D E G A B* occurs in No. 14, but the intervals are the same as in No. 12. In Nos. 9, 15, 16, we find a hexatonic scale *C D E G A B*, and in No. 8 only we find the full heptatonic *C D E F G A B*.

Referring to van Aalst's treatise, for further particulars of this, I proceed to our own investigations respecting the actual notes actually played by native musicians. These may have been quite false, but they were at any rate satisfactory to the ears of natives. There were six musicians attached to the Chinese Court at the International Health Exhibition, and they gave vocal and instrumental performances several times daily in the tea-room and restaurant attached. By the politeness of Mr. J. Duncan Campbell, one of the Commissioners of Chinese Customs, representing China at the Exhibition, and of Mr. Neumann, the secretary, Mr. Hipkins and I were enabled to "interview" the musicians on four mornings in July and August, 1884, for two hours at a time, with the help of an interpreter, in the large dining-room of the Chinese contingent of thirty-one natives, close to the houses erected for their use, near the Queen's-gate exit. We were thus enabled to get the musicians to play us the scales of their instruments and take the pitch of the individual notes by means of my forks. We met the utmost readiness to oblige from the Chinese musicians, who were extremely good-natured. But there was great difficulty in taking the pitches, and two instruments had to be revised. There was present on two occasions an English violinist, who was engaged to teach the musicians English tunes, and he said that he had the utmost difficulty with passages involving semitones. We heard also one of the Chinese on his fiddle attempting to play a Scotch air, and the difficulty he had in hitting the intervals—although, of course, on the violin, however rude, there is no material impediment to taking any intervals—was a sufficiently convincing proof that the modern Chinese intervals are not the same as ours. Similarly for their version of "God save the Queen."

The following is the result of our investigations, which would have been prolonged had Mr. Hipkins's business engagements allowed him to come oftener. As it is they present, I believe, the first attempts to record, with some degree of accuracy, the scales actually used. I say with some degree of accuracy only, for it is very possible—and, indeed, probable—that many modifications of the notes, due to difference of blowing and half stopping holes of pipes, are made in playing, which would not occur in merely sounding the scale. Indeed we had reason to suspect our flute player of involuntarily following our fork, so that we had to contrive that he should not hear it, by holding it close to Mr. Hipkins's ear instead of pressing the handle on the table.

Besides these instruments, we examined a duplicate in the South Kensington Museum, and I measured the vibrating lengths of strings on several fretted instruments. We also took the pitch of a small set of bells lent by Mr. Hermann Smith.

1. *Transverse Flute*, or *Ti-tsu* (Mr. Dennys's No. 52, van Aalst's No. 33, p. 71), a modern instrument having 7 holes besides the embouchure, open at both ends, so that the mouth hole was twice as far from the end as in ordinary English flutes; no keys.

1. Vib.	240		266		292		311		352		401		454		479
2. Notes	I	178	II	161	III	109	IV	214	V	226	VI	215	VII	93	I'
3. Sums	0		178		339		448		662		888		1103		1196
4. Pentatonic	I	178	II	270	—		IV	214	V	226	VI	308	—		I'

Line 1.—Observed vibrations.

Line 2.—Notes with the intermediate intervals in cents.

Line 3.—Intervals from lowest note in cents.

Line 4.—The intervals selected for the pentatonic scale.

This approaches an ordinary major scale, and may possibly have been intended for it, but the first two Tones are much too small, and the last three Tones much too large, so that the only notes decently in tune are VI and VI. It was an orchestral instrument, by which the stringed instruments were tuned.

2. The *Oboe* or *So-na* (Dennys, No. 56, "copper clarinet," but his figure corresponding to it is Fig. 38 of the *hsiang ti* called a "flageolet," it is No. 35, p. 72, of van Aalst, and it seems to be the Indian *Soonai*.) I use the term *oboe*, because it is played with a double reed, which is very short, so that there is a disk below the reed to protect the lips; then come two small pierced copper spheres, then a pipe with 7 finger holes in front and 2 thumb holes behind. A loose brass cone of considerable size covered the lower end, and was attached to the upper by a string. Dennys says it is a modern instrument, which agrees with its coming from India. It requires much force of breath, and the sound is very like a bagpipe, of which it seems to contain the intervals differently distributed. But it is an orchestral instrument, and is played with the flute, so that the intervals must be much "humoured" by the performer. The measurements of the pitch numbers of the notes in both this and the flute were revised.

1. Vib.	400		435		475		516		578		640		719		808
2. Notes...........	I	145	II	152	III	143	IV	197	V	176	VI	201	VII	202	I'
3. Sums...........	0		145		297		440		637		813		1014		1216
4. Tempered notes ..	I	150	II	150	III	150	IV	200	V	150	VI	200	VII	200	I'
5. Sums...........	0		150		300		450		650		800		1000		1200
6. Vib.	400		436		476		519		582		635		713		800

The tempered form which, as is seen, agrees very closely with the observed, gives the character at once, as an instrument with the same intervals as the bagpipe (whence another cause for its close resemblance to that instrument) but differently distributed. There is no approach to a major scale here. But van Aalst gives the scale as f' (on the last space of the treble) g' a' b' fl c'' d'' e'' f'' g'', 9 notes as in the bagpipe.

3). *Reed Mouth Organ*, the *Shêng* (rhymes *sung*, and often so called, van Aalst, No. 46, p. 79), a gourd with its top cut off, and then a flat cover cemented on, into which a series of bamboo pipes are inserted, each provided with a "free reed" of copper, something similar to the harmonium reed (which is said to have been borrowed from it), but really different, because it will sound either by blowing or suction. The lengths of the tubes are ornamental, the actual length being determined by a "slot" or long hole turned from view, as on the "show pipes" of an organ. Each sounding pipe (there are two dummies for convenience of construction) has a ventage near the bottom, which must be stopped with the finger for the note to sound. The semigourd is provided with a mouthpiece or short spout, through which the performer can blow, or out of which he can suck wind (the latter is the proper method), which passes through all the pipes, so that there is a great loss of power, as only the one pipe stopped will sound.

First Octave—

1. Vib ...	450	508	547	600	680	760	820	899
2. Notes	I 210	II 128	III 160	IV 217	V 193	VI 132	VII 159	I′
3. Sums.	0	210	338	498	715	908	1040	1199

Second Octave—

1′. Vib ...	899	1017	1110	1232
2′. Notes.	I′ 214	II′ 151	III′ 182	IV′
3′. Sums..	0	214	365	547

Tempered—

4. Notes	I 200	II 150	III 150	IV 200	V 200	VI 150	VII 150	I′
5. Sums.	0	200	350	500	700	850	1000	1200
6. Vib ...	450	505	551	601	674	757	825	900

There were only 11 notes in the particular instrument examined, which was blown (or rather sucked) for us by one of the Chinese musicians. This seems, therefore, to have the bagpipe intervals, very slightly altered in distribution. According to Mr. Hermann Smith's measurements, a Shêng in his possession should produce a series of Fifths (reduced to one Octave), which would agree with Amiot. The Shêng, I understand, very readily gets out of tune. We selected it because it is well known, and its tones are fixed.

4). *First Chime of Gongs* or Pien-lo, Wan-lo (in Dennys, No. 38, van Aalst, No. 14, p. 57,) or *Yan-lo* as called at the Chinese Court and in South Kensington Museum, from both of which we had specimens, which differed greatly. That from the Chinese Court is given here, the other in 5). A series of 10 small cheese-plate-shaped gongs in a frame, one at the top, and then three rows of three in each, here numbered as seen from behind, where they projected, and were struck by the wooden hammer, I at the top, II III IV in first row, V VI VII in second row, VIII IX X in bottom row. In the table, however, I arrange them in order of pitch. They were struck in this order, omitting IX and I. I am quite unable to give any theory for this scale, and especially for the notes IX and I omitted by the player. But I give a tempered form, which seems to suit when these are left out. We are told by van Aalst that "it has become exceedingly difficult to find a *yün-lo* capable of giving a satisfactory gamut; besides the pitch is not uniform, so that two *yün-los* rarely agree. The scale is ordinarily *C D E F G A B c d e*." It will be seen that this is nothing like the scales of those we examined.

1. Vib.	449	495	555	568	630	663	703	712	830	902
2. Notes....	VIII 169	V 198	II 40	IX 179	IV 88	VI 101	X 22	I 265	VII 144	III
3. Sums	0	169	367	407	586	674	775	797	1062	1208
4. Placed ..	VIII 169	V 198	II 219	—	IV 88	VI 101	X 287	—	VII 144	III
5. Temp. ..	0	150	350	—	600	700	800	—	1050	120

5). *Second Chime of Gongs* or Yan-lo or Yünlo from the South Kensington Museum, see 4). Engel p. 193 makes the value of the gongs in order of number to be *c*, *d a f*, *b b*fl *g*, *f* sh *e* fl *e*, out of which he says 4 peutatonic scales can be formed, *f g a c d*, *c d e g a*, *d e f* sh *a b*, *b* fl *c d f g*. I can only suppose that he was describing some other set. Neither the copy in the Chinese Court or the South Kensington Museum bears the remotest resemblance to this ingenious arrangement. Gong V was unsound, and gongs V and IX were almost identical in pitch to the ear, while gong VIII was very little sharper than gong VI. The compass of the whole scale is less than a Pythagorean minor Sixth of 792 cents. The notes in the table are in order of pitch.

1. Vib......	794		818		912		926		1011		1022		1114		1116		1198		1216
2. Notes....	I	52	II	188	III	26	IV	152	VI	19	VIII	149	V	3	IX	123	X	26	VII
3. Sums.....	0		52		240		266		418		437		586		589		712		738

Possible Scales :—

4. Fifth sharp	I	240	—		III	178			VI		171		—		IX	123	X		
5. Fifth flat..			II	188	III	178			VI		168		V		152				VII
6. Sums.....			0		188				366				534						686
7. Another Fifth flat..			II	214	—		IV		171		VIII	152			IX	149			VII
8. Sums.............			0				214				385				537				686
9. Fourth...........					III	197	—				VIII	152	—		IX	149			VII
10. Sums.............					0						197				349				498

Line 1 gives the vibrations observed. Line 2 the notes of the gongs in order of pitch with their intermediate intervals in cents. Line 3 their intervals from the lowest in cents. Then I show that three scales of a certain sort may be formed from the notes, but whether they were intended or not it is impossible to say. Line 4 goes to a slightly sharp Fifth 712. Line 5 goes to a slightly grave Fifth 686, only 16 cents flatter than the true Fifth which does not occur on the chime. Line 7 gives another scale up to the same. Line 9 gives a tetrachord, going to a perfect Fourth, and divided practically into a Tone and two three-quarter Tones, 200, 150, 150 cents as on the bagpipe. Two others of these three-quarter Tones are IV 152 VI and V 152 VII.

There are several other remarkable intervals. VI 19 VIII may have been meant for a comma 22, and III 26 IV and I 52 II are nearly one-eighth and one-quarter of a major Tone 204 cents.

II 188 III and III 178 VI may both be meant for the minor Tone 182 cents.

I 240 III is the exact pentatone of the Javese Salêndro scale.

II 385 VIII is an excellent major Third 386 cents. I 586 V, or I 589 IX may represent the 588 or zaïd on the second string of the Arabic lute, I 738 VII is the 49th harmonic reduced to the same octave, which cannot be more than a curious coincidence. The great difference between the two Yan-los suggest the possible existence of many other varieties.

6. *Dulcimer*, or *Yang-chin* (the "copper wire harmonicon" of Dennys No. 65, van Aalst's No. 28, p. 67), is exactly like the ordinary dulcimer (see "Grove's Dictionary of Music," p. 49), with 4 wires to each note forming two octaves, the longer set of wires passing under the bridge which limits the shorter set. It is struck by two elastic hammers. The instrument being out of tune was tuned for us by the player of the *tamboura*, 7) below, according to the Chinese names of the scale in Dr. Williams's "Middle Kingdom," namely I ho, II sz', III í, IV chang, V ché, VI kung, 7 fan, 8 liu, which are there interpreted as the major scale of *E* fl. If the conjectural restoration I have made be correct, it is rather a major scale beginning on its Second note, which may be considered as the justly intoned scale of *B* fl commencing on *C*, thus *C D E* fl *F G A B* fl *C*, but that this is "the" Chinese scale I doubt. The instrument was evidently not quite in tune, but it had the peculiar character of the *D*-mode described in Sect. V. The oboe player played us a tune upon it after the tamboura player had tuned it. The tuner had great difficulty with the semitones II 105 III, and VI 118 VII, that is with notes III and VII. He accomplished the second more easily than the first. In pentatonic playing both these notes are omitted.

1. Vib.............	205		226		240		272		300		340		364		409
2. Notes	I	169	II	105	III	217	IV	170	V	217	VI	118	VII	202	I'
3. Sums	0		169		274		491		661		878		996		1198

Conjectured Just—

4. Notes	I	182	II	112	III	204	IV	182	V	204	VI	112	VII	204	I'
5. Sums	0		182		294		498		680		884		996		1200
6. Vib.............	205		228		243		273		304		342		364		410
7. Pentatonic Notes	I	182	II	316	—		IV	182	V	204	VI	316	—		I'

Such a scale would of course be harmonisable, but of that I suppose no Chinese would think.

7). The *Tamboura* or *Sien tsu* (Dennys' *San-hsien*, van Aalst's No. 24, p. 66), or three-stringed guitar, No. 75, Fig. 53. The one played to us had no frets. The strings were tuned to 239, 266, and 400 vib., making the interval of 185 or say 182 cents, a minor tone, between the two first, and 706, or say 702 cents, a just Fifth between the Second and Third, much better tuning than might be expected. The string lowest in pitch was, as as usual, highest in position when playing. The strings were plucked by two plectrums of bone, looking like claws tied to the first joints of the thumb and forefinger, and projecting beyond their ends. The tone was good, and very like a banjo, which it resembled in shape. The following pentatonic scale was the only one played to us:—

1. Vib	320		357		400		480		536		642
2. Notes	I	189	II	197	III	316	IV	191	V	312	I′
3. Sums	0		189		386		702		893		1200
Just—											
4. Notes	I	182	II	204	III	316	IV	182	V	316	I′
5. Sums	0		182		386		702		884		1200
6. Vib	320		356		400		480		535		640
Transformed—											
7. Sums	498		680		884		1200 = 0		182		498

Lines 1 to 3 as usual. Then in lines 4 and and 5 I conjecture a just scale which is, in fact, *C* 182 *D* 204 *E* 316 *G* 182 *A* 316 *C′*; where line 5 agrees very closely with line 3, and on calculating the vib. on line 6, they agree almost exactly with those in line 1. Now I transform the scale by beginning it with IV = *G*, and get *G* 182 *A* 316 *C* 182 *D* 204 *E* 316 *G*, where the intervals are identical with those of the Dulcimer in its pentatonic just form, or *C* 182 *D* 316 *F* 182 *G* 204 *A* 316 *C*. Hence these two instruments practically furnish different modes of the same scale, that is, the same succession of notes begun in different places. But then it was the same man who played and tuned both.

8). *Balloon Guitar* or *P'i-p'a* (Dennys' No. 76, Fig. 52; van Aalst's No. 22, p. 64).—This was tuned by the same musician who furnished the two last scales. It has 4 strings, the lowest having 234 vib., and then its Fourth, its Fifth, and its Octave, but we did not test the accuracy of these intervals. Near the nut were 4 large. round backed, semielliptical frets, which the player did not use, and then there were 12 frets on the body of the instrument. On these frets a pentatonic scale was played, but not all on one string. The frets were indeed fixed, but the player might have easily sharpened some of the notes in the Indian fashion, for the frets were pieces of wood, rather roughly glued on, and fully a quarter of an inch high. But the top was broad enough for him to press thereon; we were, however, so fully occupied in taking the pitch, that we did not notice.

1. Vib.	320		348		392		465		530		638
2. Notes	I	145	II	206	III	296	IV	227	V	321	VI
3. Sums	0		145		351		647		874		1195
Tempered—											
4. Notes	I	150	II	200	III	300	IV	250	V	300	VI
5. Sums	0		150		350		650		900		1200
6. Vib.	320		349		392		466		538		640

This scale is like nothing I have yet met with. The quarter Tone tempering agrees very well, except in V, which is 26 cents and 8 vib. in 530 too sharp.

This completes the observations made with the help of the Chinese musicians at the Health Exhibition. But, in addition to these, I measured the lengths of strings in several instruments at the South Kensington Museum. The very great uncertainty of the scales deduced from such measurements induces me to pass over the results. I may mention, however, that these measurements show, in a second P'i-p'a, that the four large round frets already named probably gave a Fourth, divided into a Tone and three Semitones of some sort; that one "Moon Guitar" seemed intended to give 12 equal Semitones, the only trace of Amiot's scale which I have found, and another Moon Guitar seemed to divide the Octave into 8 Threequartertones of 150 cents each.

9). *The Scholar's lute*, or *Chin* (van Aalst, No 10, p. 59, Dennys, No. 70). Dennys quotes the method of tuning from Dr. Williams ("Middle Kingdom," vol. 2, p. 168), which amounts to this:—

1. Notes	I	204	II	294	III	204	IV	204	V	294	VI	204	VII
2. First Oct...	0		204		498		702		906		1200		
3. Second Oct.			0		294		498		702		996		1200
4. Say	*D*		*E*		*G*		*A*		*B*		*D′*		*E′*

This would give two pentatonic scales of whole Tones and minor Thirds differing in the position of the minor Thirds. The tuning begins at the central string *A*, and the extremes are *D*, a Fifth below, and *E′*, a Fifth above. Again, a Fourth below *A* gives *E*, and a Fourth above, *D′*. Finally, a Fourth above *D* gives *G*, and a Fourth below *E′* gives *B*. As this instrument was not played at the Health Exhibition, I had no opportunity of measuring the pitch of its notes, and give the above indications with considerable hesitation. But it did not seem right to omit all mention of it, as Dennys says that it "stands at the head of the Chinese orchestra, occupying, to native eyes, the position taken by the violin in our own."

10). *A chime of bells*, such as I do not find named in Dennys, or in van Aalst, consisting of four small bells on a stem, so as to be struck by a hammer, were lent me by Mr. Hermann Smith. The diameters of the bells are only 43, 39, 37, 36 mm, and their heights about 10 or 12 mm, forming little shells. The sound was very shrill. Mr. Hipkins and I measured their pitch, as well as we could, as follows.—

1. Vib.	761		912		1004		1156
2. Bells	I	313	II	167	III	244	IV
3. Sums ..	0		312		480		724

These intervals are rather remarkable. I 313 II is a very good minor Third. I 480 III is exactly the theoretical flat Fourth of the Javese Salêndro, and I 724 IV is almost precisely the theoretical sharp Fifth of the same, 720 cents would be exact. Hence III 244 IV is a pentatone. As the interval II 167 III is then rather inexplicable, I feel inclined to suppose that II had been tuned much too sharp, and that we ought to have I 240 II 240 III 240 IV, part of a Salêndro scale. This would make II 874 vib. in place of 912, a difference of 73 cents, which is very great.

No theory of Chinese music can be deduced from such indications, but they serve to show that the representations by European notation usually given are utterly misleading, and require reconstruction from a detailed examination and record of what is actually heard from Chinese musicians.

XV.—Japan.

The Rev. Dr. Veeder, when Professor of Physics in Japan, gave an account of tuning the Japanese Koto, in the "Transactions of the Asiatic Society of Japan," first in 1877, and then in 1879; together with the pitches of a set of old Japanese pitchpipes, taken by the help of a siren. He also gave the pitches of notes obtained from ancient Japanese flutes, but remarked that these were certainly not those obtained by natives, who by the way of blowing and half covering finger holes could make them speak very differently. Mr. Hermann Smith lent me a set of Japanese pitchpipes (less three), but they differ materially in pitch from Dr. Veeder's indications. Both sets were in all probability much out of order. Dr. Veeder also says that the modern pipes differ from the ancient. Hence I do not give either his or our determinations.

In the Japanese Section of the Educational Division of the International Health Exhibition of 1884, there was a considerable display of Japanese musical instruments, but unfortunately no one who could play them, or who knew anything of music. Among others was a Biwa, or four-stringed lute, a handsome well-made instrument, to all appearance like Al Farabi's Arabic lute, the strings being almost in contact at the nut, but spreading out at the bridge so as to allow of being played with a wooden plectrum. This we tried first by measuring the vibrating lengths from the nuts and five frets, and then, after screwing up the open strings to convenient pitches, by taking the pitch number for each string and each fret. I give the results of the intervals from fret to fret only, as the variations are rather remarkable.

Biwa.—

Vibrating lengths	843		750		709		673		637 mm.
Cents from lengths	I	202	II	79	III	90	IV	95	V
Cents from pitch of									
Lowest string ... diam. 1·65 mm.	I	225	II	107	III	84	IV	96	V
Second lowest .. diam. 1·37 mm	I	223	II	115	III	91	IV	71	V
Second highest... diam. 1·06 mm.	I	195	II	125	III	87	IV	89	V
Highest string ... diam. 0·88 mm.	I	212	II	109	III	93	IV	89	V
Mean from pitch...	I	214	II	114	III	89	IV	86	V
Sums of mean	6		214		328		412		498
Assume	I	204	II	114	III	90	IV	90	V
Sums	0		204		318		408		498
Pythagorean notes	*C*		*D*		*D* sh		*E*		*F*

The *D* sh of 318 cents would be indistinguishable from *E* fl of 316 cents, a perfect minor Third. This tetrachord was repeated on each string, the scale played would, therefore, depend upon the methods of tuning of the string of which six were assigned, and are given later on.

There was also a *Sho*, the same sort of instrument as the Chinese Shêng, and we tried to blow it. But our results disagreed so thoroughly with what was assigned, that it must have been out of tune, or else we blew it wrongly. Hence I do not cite it.

My principal assistance came from a MS. at the Japanese Educational Section, entitled "Extracts from the Report of *S. Isawa*, Director of the Institute of Music, on the result of the investigations concerning Music, undertaken by order of the Department of Education, Tokio, Japan, translated by the Institute of Music." The original Japanese was printed, but the extracts in English were only in MS., and Mr. Tegima, the commissioner, politely allowed me to have a copy of the parts I asked for, and said I might make use of them as I liked. The Institute of Music at Tokio was founded in October, 1878. For some time it had the assistance of Mr. Luther Whiting Mason, from Boston, as teacher of music, and after he left it, has had Mr. Eckest, a German bandmaster. The first object was to determine the difference, if any, between the Japanese and European notes. The method of procedure was as follows (abridged from the report):—

"Mr. L. W. Mason, after attentively hearing Japanese popular and classical pieces of music for the purpose, said there was no difference as to tonality [meaning evidently *intonation*], but only a little difference in the mode of the tonal combinations. Several inquiries have been put also to the best Japanese musicians, whether they thought the European intonation dissimilar to their accustomed tones. They all say there is no difference to be detected by their ears. The most striking instance to be mentioned here is that when Yamase Shoin, the best Koto musician, who had never heard European tones before, touched the pianoforte keys, he detected at once the deviations of some tones, of which he expressed his opinion that such tones could not be true according to his ear, and these tones criticised by him were indeed found by Mr. L. W. Mason to be out of tune. Students who entered the Institute, and had been most skilled in popular and classical music, made such remarkable progress [in European, having nothing to unlearn] as quite surprised Mr. Mason."

In addition to the information contained in Mr. Isawa's report, he politely wrote me a long letter in answer to my inquiries, and Mr. ——, another Japanese gentleman, who is studying physics in Europe, and is acquainted with the European violin, to whom I was introduced by Mr. Tegima, has most kindly answered a long string of questions that I sent him on the subject, but, considering himself only an amateur, he desires to remain anonymous. He represents, therefore, the views of the intelligent non-professional native gentleman.

As ro the 12 notes acknowledged by the Japanese pitch pipes, Mr. Isawa writes, that they are obtained from the lowest note by taking Fifths up and Fourths down, as in tuning the piano, but that if the Fifths and Fourths were taken perfect, the 13th note instead of being an Octave of the First, would, as is well known, be sharper by a Pythagorean comma of 24 cents, and that this "difference is equally distributed to all tones, or rather more to the tones which are not frequently used." The first would give the equal temperament, the second an accommodation temperament, such as some pianoforte tuners are said to affect. Professor Ayrton, when my paper on non-harmonic scales was read to the Royal Society (20 Nov, 1884, Proc. R.S vol. 38, p. 368), remarked, that his experience in Japan led him to conceive that the Japanese intervals were often very different from the European. Mr. —— says guardedly, that "the intervals are the same musically, but not mathematically. . . . As we have no harmony, no one can discover, by hearing, any slight deviation from the mathematical." This is an important observation, and may account for numerous discrepancies. It is evident that Japanese ears have not been cultivated for an accurate appreciation of melodic differences, and they have, properly speaking, no means of controlling their results by the beats of imperfect consonances. Mr. —— says further, that the twelve pitch pipes "give nearly the same notes as the European chromatic tones." "I had occasion," he adds, "to compare one of these series of pipes in possession of a celebrated court musician, with a series of tuning forks used by European musicians, and I found that the corresponding ones did not give beats of more than 3 in one second." Mr. Isawa, however, judged it expedient not to send me a new set of pitch pipes, because he thought they would be misleading. In fact, as I suppose, the set of pipes is not very evenly tempered, and secondly, Japanese intervals generally differ from each other considerably according to the player.

The first conclusion is confirmed by the intervals on the Biwa, which, notwithstanding their material differences, are assumed to be on each string a Tone and three Semitones, and any two of the latter taken together are considered to make the same interval as the Tone itself. The second conclusion is con firmed by two observations on native Japanese players coming from country districts, and hence certainly unprejudiced by scientific research, who performed at the Japanese Village, at Knightsbridge, where Mr. Buhicrosan, the proprietor, kindly allowed Mr. Hipkins and myself to take down their scales. The first was a female player (and Mr. ——— says that music is generally left to the women in Japan), the second was her music master, and both were supposed to be tuning the *Koto* in the method called *hiradio-shi* (Isawa) or *hira-joshi* (———).

The Koto is the national instrument. Over a sounding board, about 6 feet long, are stretched 13 strings all of the same length (about 61 inches = 1549·4 mm.) and thickness (diam. 1·16 mm.), and, intentionally, with the same tension. Their vibrating lengths are limited by high movable bridges, which, on being inserted, necessarily increase the tension to some extent. These bridges serve to tune the strings, and they leave a considerable length of string behind them, the use of which will appear hereafter. There are several ways of tuning the Koto, but in the Japanese Village, the *hiradio-shi* alone was known. Of the 13 strings, only 5 give different notes, the remainder are unisons, or Octaves of these. It is, therefore, only necessary to consider the first 7 strings, of which the fifth is in unison with the first, and the seventh is the octave of the second. The scale is comprised between the second and seventh strings, and for convenience I reckoned from the second, or lowest note, which Mr. ——— considers to be the fundamental tone.

Mr. Isawa's Report..	I	702	II	204	III	112	IV	386	V	112	VI	386	VII
Sums....	702		0		204		316		702		814		1200
Female Player.......	I	719	II	193	III	164	IV	362	V	82	VI	398	VII
Sums........	719		0		193		357		719		801		1199
Music Master........	I	683	II	185	III	152	IV	346	V	107	VI	410	VII
	683		0		185		337		683		790		1200

Now these show great discrepancies, and those between the woman and her master are curious, for the woman used a sharp and the man a flat Fifth (with 36 cents between them). But both seemed to aim at a Semitone and a major Third as the final intervals, and at a Tone (almost a minor Tone with the man) to begin with (II to III). So far they agree in intention with Mr. Isawa. But the next two intervals in his report are 112 and 386, while the woman had 164 and 362, and the man 152 and 346 cents. The sums of these pairs of intervals are 498, 526, and 498 cents, respectively, so that the second pair (the woman's) must have been in error. But is it possible that the intervals were all meant for 112 and 386? Or were the last two intended for 150 and 350, two intervals of the 24 division being $\frac{3}{4}$ and $\frac{7}{4}$ tone? Mr. ——— has never heard of such intervals. He thinks the player may have hit on them unconsciously. That would imply that he aimed at 112 and 386, but did not succeed. That, however, they were not accidents of the moment was shown by the fact that the man reproduced the same intervals on his Siamisen (as was proved by my forks), and he showed us marks on the finger-board of that instrument which guided his fingers, though there were no frets. Moreover, in tuning Mr. Hipkins's Koto for the purpose of showing it this evening, it was treated in the same way, with the neutral Third of about 350 cents, IV to V, and no attempt at a major or minor Third, and a Semitone from V to VI. On this occasion the music master tuned his own Koto, and the lady teacher of the Siamisen tuned Mr. Hipkins's to it. Hence this method of tuning clearly exists, although not acknowledged by either Mr. Isawa, or, as we shall see, Mr. ———.

Mr. ——— agrees with Mr. Isawa's report, so far as strings I, II, III, V, and VII are concerned. He does not believe in tuning a major Third down from I or V to IV, although Mr. Isawa says in his letter that "the older style [of tuning] has really a natural major Third [386 cents] in an interval between IV and V in hiradio-shi." Mr. ——— agrees that there is something like the interval, but that it is obtained indirectly, by tuning III to IV and V to VI, "not by consonance, but by a certain melodical intuition," and admits that it is "as nearly as possible a diatonic semitone," though "it is impossible to pronounce it so, as even the ablest musicians do not always give precisely the same tones when required to tune separately. It is important," he adds, "to remark that the interval IV to V and VI to VII are *not* tuned by major Thirds, to which they are very nearly equal. I rather doubt whether the Japanese have an idea of the perfect consonance of the Third, and so of the Sixth. They use generally the Octave, the Fifth and the Fourth in tuning." We may, therefore, probably assume that the two tunings of the woman and her master resulted only from their having taken bad shots at the Semitones, the major Thirds being left to shift for themselves. It is interesting to observe that this hiradio-shi scale, which consists of a tone and two conjunct tetrachords, each divided approximately into a Semitone, and its defect from a Fourth, presents us with a survival of the oldest Greek tetrachord. Perhaps Olympos himself tuned no better, and it is only theorists who have rendered his intervals exact, precisely as Mr. Isawa, in his praiseworthy efforts to raise Japanese music, has defined the intervals with a mathematical precision, which the ordinary musician, whether Japanese or European, fails to appreciate. I know in England the extreme difficulty of getting a major Third exactly tuned, and am not surprised that the same difficulty occurs in Japan.

The above discussion has been given at considerable length; not only because it is interesting and novel in itself, but because it serves to explain many similar confusions recorded above. For what follows, then, I shall assume the equal temperament as sufficiently correct. "I can assure you," says Mr. ——, "that when you play any Japanese air on the piano, no Japanese musician will pronounce it wrong."

There were 12 popular tunings of the Koto, which were given, in staff notation, on charts at the Health Exhibition of 1884. We may now write them thus, using *c c' c''* to indicate the tenor *c* on the second space of the bass, *c'* the Octave above it, or middle *c'*, and *c''* the Octave above the last, or treble *c''* respectively, and omitting or adding accents in a similar manner to the names of all the notes in the Octaves beginning with *c*, *c'*, *c''*. The notes in ( ) constitute the pentatonic scales to be considered. As equal temperament is adopted; the number of equal Semitones between the notes are, for brevity, used in place of cents. The Japanese name is prefixed.

1. Hira-dioshi :—
   d (*g* 2 *a* 1 *b* fl 4 *d'* 1 *e'* fl 4 *g'*) *a' b* fl *d'' e''* fl *g'' a''*.

2. Akebono I :—
   d (*g* 2 *a* 1 *b* fl 4 *d'* 2 *e'* 3 *g'*) *a' b'* fl *d'' e'' g'' a''*.

3. Akebono II : –
   d' g 2 (*a* 1 *b* fl 4 *d'* 2 *e'* 1 *f* 4 *a'*) *b'* fl *d'' e'' f'' a''*, which contains an extra note *g*, not having any Octave in the pentatonic part.

4. Kumoi I. :—
   d' (*g* 1 *a* fl 4 *c'* 2 *d'* 1 *e'* fl 4 *g'*) *a'* fl *c'' d'' e''* fl *g'' a''* fl.

5. Kumoi II. :—
   d' (*g* 1 *a* fl 4 *c'* 2 *d'* 1 *e'* fl 4 *g'*) *a'* fl *c'' d'' e''* fl *g'' a''*, which differs from 4 only in having an extra note *a''* on the 13th string.

6. Han-Kumoi (*i.e.*, a variant of Kumoi) :—
   d' (*g* 2 *a* 3 *c'* 2 *d'* 1 *e'* fl 4 *g'*) *a' c'' d'' e''* fl *g'' a''*, which differs from 5 in having *a*, *a'* for *a* fl, *a'* fl.

7. Kata-Kumoi :—
   d' (*g* 2 *a* 1 *b* fl 4 *d'* 1 *e'* fl 4 (*g'*) 1 *a'* fl 4 *c''* 2 *d''* 1 *e'* fl 4 *g''*) *a''*. This has two different pentatonic scales, *g'* ending the first, and beginning the second. The first is the same as No. 1, and the second the same as No. 5, including even the final *a''*.

8. Sakura :—
   d' (*g* 1 *a* fl 4 *c'* 2 *d'* 1 *e'* fl 4 *g'*) *a'* fl *c'' d'' e''* fl *g'*; *c''*.

9. Iwato :—
   c' (*g* 1 *a* fl 4 *c'* 1 *d'* fl 4 *f'* 2 *g'*) *a'* fl *c'' d''* fl *f'' g'' c'''*.

10. Han-Iwato :—
   d' (*g* 1 *a* fl 4 *c'* 2 *d'* 3 *f'* 2 *g'*) *a'* fl *c'' d'' f'' g'' a''*; this has *d'* for *d'* fl in 9.

11. Kata-Iwato :—
   d' (*g* 1 *a* fl 4 *c'* 1 *d'* fl 4 *f'* 2 (*g'*) 1 *a'* fl 4 *c''* 2 d' 1 *e''* fl 4 *g''*) *a*. This, like 7, contains two pentatonic scales, the first ending and the second beginning with *g'*. The first is the same as No. 9 and the second as No. 8.

12. Kumoi-Hen :—
   d' (*g* 1 *a* fl 4 *c'* 2 *d'* 1 *e'* fl 4 *g'*) *a'* fl *c'' d'' e''* fl *g'*, *a''*. This seems to be precisely the same as 5.

Now, these scales seem to imply the existence of a pentatonic system and that only. But this would be an error, for the Koto player, by pressing upon the string behind the bridge, can casily raise the pitch of any note, either slightly or as much as half a tone,* and in

* Mr. —— says, "usually IV and VI," this would change the division of the tetrachords in pentatonic *hiradio-shi*, from a Semitone and a major Third to a Tone and a minor Third, and thus reduce it to a usual form (No. 3 of Section XII), but not render the scale heptatonic. To get Mr. Isawa's classical Riosen scale, given presently, we should require first that the original tuning should be what is thus obtained, II 200 III 200 IV 300 V 200 VI 300 VII, and nex that IV & VI should be raised a whole Tone, as Mr. ——

point of fact he is constantly manipulating the strings in this way with his left hand, to an extent which seems to suit the fancy of the moment. "The amount of raising is rather obscure, as it depends on the degree of pressure. Sometimes we flatten the notes by pulling the string on its other part than that plucked," that is, I suppose, practically raising the string from the bridge, and for the moment making a new bridge of the finger, thus lengthening, and therefore flattening, the string. (This flattening was also noticed by Dr. Veeder.) Mr. —— therefore hesitates about saying that the Japanese scale is pentatonic. "The two complementary tones are not due to modern addition, but are insignificant from having no representation on the Koto. With our musicians, this is not of much interest, as they do not greatly care about the construction of scales. These complementary tones play no important *rôle*, but are generally used as passing tones of a melody"—a circumstance which seems to show the original pentatonic construction of the scale, as has been remarked in so many Scotch airs. Mr. Isawa appears to assume a pentatonic origin derived from the original five Chinese notes or *Gosei*. There seem to be two entirely different kinds of music—the classical and the popular. Of the classical, or "old Chinese school," as Mr. —— calls it, he says it "is only played in the Imperial household, or Shinto temples, and is entirely unappreciated by the whole people. It, therefore, does not contribute anything towards the musical cultivation, or towards the pleasures of the people." Mr. Isawa's report distinguished strictly between them. The preceding Koto tunings are all popular. In the classical, two forms of scale are distinguished — Riosen (corresponding to, but also not identical with, our major scale) and Ritsusen (corresponding to, but also not identical with, our minor scale). The notes marked (*) are considered as variable; that is, no doubt, produced by pressure on the strings beyond the bridge. I give notes and intervals as before—

CLASSICAL RIOSEN.

Names..........	kin		sho		kaku		*henchi		chi		oo		*henkin		kin
	D	2	*E*	2	*F* sh	2	*G* sh	1	*A*	2	*B*	2	*c* sh	1	*d*

CLASSICAL RITSUSEN.

Names..........	kin		sho		*ei sho		kaku		chi		oo		*ee oo		kin
	D	2	*E*	1	*F*	2	*G*		*A*	2	*B*	1	*c*	2	*d*

These differ from European *D* major, by having *G* sh for *G* (but *G* is generally used in descending, at least, sometimes), and from European *D* minor (descending form) by having *B* for *B* fl. Observe that Riosen is the Greek *F*-mode, and Ritsusen the Greek *D*-mode. Mr. Isawa gives 4 Riosen and 3 Ritsusen Koto tunings, all classical, and having this peculiarity that their tetrachords consist of a Tone and a minor Third, and not, as in the popular case, of a Semitone and a major Third.

Ichikotsu-Chio (Riosen).

d′ d′ (*a* 2 *b* 3 *d′* 2 *e′* 2 *f′* sh 3 *a′*) *b′ d″ e″ f″* sh *a″*

Lio Dio (Ritsusen).

b′ (*e′* 2 *f′* sh 3 *a′* 2 *b′* 2 *c″* sh 3 *e″*) *f* sh *a″ b″ c‴* sh *e‴ f‴* sh.

Thus taking one example of each.

It is remarkable, that although these two scales have different pitches, and are differently classed, the intervals in the pentatonic part in parenthesis are identical.

Mr. Isawa also gives two popular heptatonic scales.

I. *D* 1 *E* fl 2 *F* 2 *G* 2 *A* 1 *B* fl 2 *C* 2 *d*.

II. *D* 1 *E* fl 2 *F* 2 *G* 1 *A* fl 2 B fl 2 *C* 2 *d*.

These differ from each other only in the Fifths, which reduces to a Tritone in II. Observe that I is the Greek *E* mode, and II is the Greek *B*-mode (see Sect. V.). Mr. Isawa says "there is no scale in the Japanese classical or popular music which is not found in the scales of Greek music;" that is to say, when the Japanese intervals have been rendered precise.

The next important instrument to the *Koto* is the *Siamisen* (Isawa) or *Shamisen* (———), a long-necked guitar, or tamboura, with three strings and no frets, often played with the

observes, but does not seem to have met with. After reducing the tetrachord to this form, however, we could, by sharpening IV and VI by a Semitone where necessary, obtain a real heptatonic scale, II 200 III 200 IV 100 IV sh 200 V 200 VI 100 VI sh 200 VII, the Greek *G*-mode (Section V), which, however, does not seem to be known in Japan.

Koto, already referred to. The three strings are tuned in three ways:—1. *honcho sai, D G d*, an Octave with a Fourth inserted; 2. *niagari, D A d*, an Octave with a Fifth inserted; and 3. *sansagari, D G c*, giving two Fourths. These were well tuned at the Japanese Village. Having no frets, it could follow all the alterations of the Koto.

The Biwa, already mentioned, is simply a classical instrument, and its four strings are tuned in six ways: —3 riosen (open strings, as *a d' e' a'*, or *g a d' g'*, or *a b e' a*), and 3 ritsusen (open strings, as *e b e' a'*, or *a c' e' a'*, *or f* sh *b e' a'*), so that nearly any Semitones could be taken. The charts of Mr. Isawa also described (1) the *Riuteki fuye*, or transverse flute, with a scale given as *D d*sh *E F*sh *G A B c c* sh; (2) the *siaku hachi*, or vertical flute, with a scale given as *D F E D*sh *G F*sh *G*sh *A c b a* sh *c* sh *d*, in this order; (3) the *hichi riki*, or oboe, with the scale, *G A B c d e f* sh *g a*. All, therefore, have a pentatonic scale and additional notes.

Mr. Isawa distinctly claims a species of harmony for Japan, and gives an arrangement of the Greek "Hymn to Apollo" (Chappell, p. 174), which he had directed "a Court musician, and a member of the [Musical] Institute [at Tokio] to harmonise purely according to the principles of Japanese classical music." It was set for 5 instruments, the Riuteki (fuye), Hichiriki, Sho, Koto, and Biwa. I have seen the setting. Though much was in Octaves, the Koto played a figured form, with dissonances, followed by consonances. Mr. —— says, "anything like European [harmony] cannot be heard in Japan. If it exist, it is of the rudest possible description. We have certainly *ensemble* playing with many instruments of different sorts; but it seems to me that we have no idea of such things as chords. . . . . We go generally parallel in Octaves and in Fifths, rarely in Fourths, but there are cases where two different tones, not belonging to the three consonances, are sounded, but they are not *harmonic*, but what Helmholtz calls *polyphonic*. We have many *figures* for accompaniment. . . . . In popular music, we meet with cases where two instruments play Octaves or Fifths. With singing this would also hold, but it is very rare that people ever sing chorus."

My warmest thanks are due to Mr. ——, for his very important remarks on Japanese music, and to Mr. Isawa, for his connected exposition and his letter. Together they have enabled me to give an entirely novel, though still incomplete, account of Japanese music. In conclusion, I am sure that all will heartily join in wishing success to the infant Musical Institute at Tokio in improving and extending Japanese music, under the leadership of its able director, Mr. S. Isawa.

XVI.—Conclusion.

In this hasty review of the musical scales of some of the principal and some of the minor nations of the world, we find the following facts. First, the relation of the Octave, naturally given by the voices of boys and men, is naturally recognised, although not always correctly tuned on the instruments examined. At this we must not be surprised, for it is often incorrectly tuned even on modern pianos. The next interval most generally appreciated is the Fourth. All Greek music, and hence all modern European, as well as all old and medieval music, is founded on this interval. The Fifth seems to have been rather appreciated as the defect of the Fourth from the Octave, though modern tuners find the Fifth much easier to appreciate than the Fourth. The Tone was appreciated only as the difference between two Fourths and the Octave, or between a Fourth and a Fifth. But, in very early times, in the tetrachord of Olympos, the just major Third of 386 cents made its appearance, and with it the just diatonic Semitone of 112 cents, as the difference between it and a Fourth. Unless, indeed, as in Japan, the Semitone was tuned by a kind of guess, and the major Third obtained as the defect from a Fourth, and this seems to be a very likely hypothesis. At any rate these intervals (assumed by Helmholtz as 15 : 16, or 112 cents, and 4 : 5, or 386 cents) were soon ousted by the strict system of Fourths, on which the later Greek scale was formed.

In Arabia and Persia, however, other distinctions came in. The old division of the Fourth into *C D E*fl *E F* was disliked, the *E*fl of 294 cents from *C* was felt to be too flat. The Persians raised it to 303 cents, as nearly as possible to our equally tempered minor Third, but retained the old *E* 408 cents. The division was then practically our equal one of 0 100 200 300 400 500 cents. But there was a lutist called Zalzal, who evidently disliked these 300 and 400 cents, and introduced the halfway-house or neutral 355 cents, where the ear is unable to determine whether the interval is major or minor. This practically employed the trumpet scale 8 : 9 : 10 : 11 : 12, for 10 : 11 is 167 cents, and 11 : 12 is 151 cents. An entirely new interval was thus introduced, and seems to have struck deep root, the interval of three-quarters of a Tone. The medieval Arabic system drove it out of classical musical scales, by continuing the number of Fourths to 16, using therefore 17 notes, which gave very artificial scales, generally bordering on the old Greek, but often greatly diverging from them, occasionally employing even eight notes in a scale. The later Arabic forms, by dividing the Octave into 24 equal Quartertones, sufficiently reconciled Zalzal and the medieval musicians. But the normal scale was Zalzal's of 0 200 350 500 700 850 1000 1200 cents, and this scale we imported into England, and still possess in the Highland bagpipe, which has not yet been harmonised. The attempt, however, to conform to the other Arabic scales led to sharpening or flattening any of these notes by a quarter of a Tone, which was one of their degrees. thus producing a large number of varieties.

Now did India draw upon Arabia, or conversely? In India we have a remarkably complex system. First a scale very like our major, but with a sharpened Sixth of 906 in place of 884 cents There was consequently a separation of the scalar intervals into three kinds, major, minor, and half Tones, and these were supposed to be divided into four, three and two equal parts respectively, which I have called degrees. Practically these, being produced by shifting frets, pressing on strings behind the fret, or deflecting them along the edge of the fret, were never precise, but were always about or slightly exceeding a quarter of a Tone. Then came the habit of altering the intervals by a degree, which is extremely like the Arabic Quartertone system; although it must have been generated independently, yet it certainly frequently produced in the different modes, and modelets, those three-quarter Tones which in Arabic music we owe to Zalzal.

China and Japan introduced nothing new beyond the original limitation of the scale to five notes, which arose in fact from the divisions of tetrachords into two parts only, for example, a Semitone and major Third, like those of Olympos, whose very division we find in the popular music of Japan, or else into a Tone and a minor Third, the Thirds arising in each case as defects of the first intervals from a Fourth. Such tetrachords were then either conjunct or disjunct. But they were always capable of being completed into Greek scales, as has been actually done in Japan, and possibly in China. On the instruments as tuned or played by natives, China offers many examples of the three-quarter Tone interval. But neither China nor Japan, any more than Europe, have reached the complete Quartertone system, which we find in Arabia and practically in India. On the other hand, Japan at least, and China also, according to Amiot, have attained to a system of twelve, more or less exact, equal Semitones.

The double pentatonic system, as developed in Java, is, however, something new and entirely different from the Chinese and Japanese. The first system seems to be formed by taking the Fourth flat enough to give, practically, a division of the Octaves into five equal Pentatones. Remarkably enough, the fourth note of the scale thus becomes very nearly indeed the natural harmonic Seventh of the first note. But upon this system, if I am correct, both Fourth and Fifth are defective, the Fourth being flat, and the Fifth sharp. Whatever be the theory of the scale, this fact is certain, and it entirely destroys the assumption of the necessity of founding a scale upon the Fourth or Fifth. This is further confirmed by the second class of pentatonic scales in Java, for which I have not been able to find any satisfactory principle, although they adopt intervals of very nearly 100, 150, and 300 cents, that is nearly Semitones, three-quarter Tones, and minor Thirds. This system has a fund of seven notes to the octave, and out of this fund it selects different sets of five to form a scale. Whereas, then, in the first system no interval between consecutive notes is so small as a Tone, or so large as a minor Third; in the second system, differences of 100, 150 (rarely or never 200), 300, 400, 450, and even 550 cents occur. The first set of scales are therefore remarkably uniform, the second as remarkably diverse. Another singular difference is that in the first system the Fourth is flat, and the Fifth sharp; but in the second the Fourth is very sharp, almost a Tritone, and the Fifth is nearly a comma flat. In the first system, and on at least two scales of the second (Dangsoe and Bem), the harmonic Seventh is developed.

The final conclusion is that the Musical Scale is not one, not "natural," nor even founded necessarily on the laws of the constitution of musical sound, so beautifully worked out by Helmholtz, but very diverse, very artificial, and very capricious. At the same time the contributions I have been able to offer towards the study of this vast subject, are, notwithstanding the inordinate length of my paper, relatively very small and manifestly extremely imperfect in observations. They really require completion by the long and careful observation and study of many physicists who have some notion of music, rather than of musicians whose ears are trained to particular systems with but slight knowledge of physics. At my time of life I must feel satisfied with having shown that such an investigation is possible.

The CHAIRMAN said that it was his pleasing duty to propose a hearty vote of thanks to Mr. Ellis for the most interesting communication he had made, which would repay the greatest amount of study when published in full, and even the short *resumé* just given showed what an immense amount of research Mr. Ellis had devoted to the subject. They could only hope that he would still have much time and opportunity before him to pursue this subject, which was evidently to him, one of increasing interest. He hoped that in the musical department of the forthcoming Inventions Exhibition there would be opportunities for judging of the scales of different nations, as illustrated by their different instruments. The Siamese would, he knew, be represented by an efficient band, and probably there would be some others.

The vote of thanks was carried unanimously, and the proceedings terminated.

Miscellaneous

SILKWORMS OF ASSAM.

The following particulars are obtained from a Report on Silk in Assam by Mr. E. Stack, Director of Agriculture in Assam, which contains a complete description and account of the rearing of three domesticated silkworms, two of which have been erroneously considered by English silk-spinners as wild silkworms; these are the *Muga* and *Eri*, which, although they may, like other species, be found in a wild state, are not found in sufficient quantities to be called wild silkworms of Assam; they are cultivated worms.

The wild silk worms of Assam occur so sparingly, that no silk could be supplied in large quantities from the collecting of the cocoons. Silks in Assam are, therefore, obtained by the cultivation of three domesticated worms, and not from the wild silkworms. Mr. E. Stack says that in treating of the silks of Assam it is desirable to make it clear that, from the wild silkworms of Assam, as they now exist, nothing whatever is to be expected, and that it is very doubtful whether by the most strennous efforts one hundred weight of wild cocoons of all sorts could be collected in the whole of the Assam valley.

Domesticated Silkworms of Assam.—There are three kinds of domesticated silkworms in Assam. These are the *Pát*, or mulberry worm (*Bombyx textor*); the *Muga*, or *sum*-feeding worm (*Antheræa assama*) whose cocoon, like that of the *Pát*, can be reeled; and the castor-oil worm (*Attacus ricini*), yielding a silk which is spun by hand.

Pát, or mulberry silkworm.—Of this there are two species cultivated in Assam; the univoltine *Bombyx textor*, called *bor polu*, or large worm, and the multivoltine *horn polu*, or small worm, *Bombyx cræsi*. Both species are reared indoors on the leaves of the mulberry (*Morus indiça*).

Attacus recini.—*Eri* worm, or *Attacus ricini*. This is reared principally on the castor-oil plant (*Ricinus communis*), called *eri* in Assamese, but it feeds also on the *Keseru* (*Heteropanax fragans*), and there are several other trees, as *gulancha* (*Jatropha curcas*), the *gomári* (*Gmelina arborea*), and even it is said, the common *bogri* or *ber* tree (*Zizphus jujuba*), which the worm can thrive on in its later stages, if other food is not procurable in sufficient quantity. The *Eri* worm is multivoltine, and is reared entirely indoors, and as many as eight broods can be obtained in twelve months. Large numbers of worms are lost by disease during these indoor rearings, which is not to be wondered at, as the excreta and even the dead worms are not removed. The *Eri* worm is cultivated, to a greater or less extent, in every district of the province of Assam.

The number of moultings of the *Eri* worm is four, and the following description of it is given by Mr. Thomas Hugon in a paper which he contributed to the Proceedings of the Asiatic Society of Bengal for 1837:—"The caterpillar is first about a quarter of an inch long, and appears nearly black. The colour is, perhaps, more exactly described as a blackish-yellow. As it increases in size, it becomes of an orange colour, with six black spots on each of the twelve rings which form its body. The head, claws, and holders are black; after the second moulting, they change to an orange colour; that of the body gradually becomes lighter, in some approaching to white, in others to green, and the black spots gradually become the colour of the body. After the fourth or last moulting, the colour is a dirty white, or a dark green. On attaining its full size, the worm is about 3½ inches long." According to one series of observations, it would appear that in the hot months, the first change of skin occurs three days after hatching, and the rest follow at intervals of three days, while the worm begins to spin on the fourth day after the final change, or the fifteenth day after hatching. In the cooler months, the period between each moulting is four or five days, making twenty to twenty-five