

THE MUSICAL TIMES, And Singing Class Circular.

OCTOBER 1st, 1861.

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ON THE DERIVATION OF THE SCALE, TUNING, TEMPERAMENT, THE MONOCHORD, &c.

By DR. CROTCH,*

THE derivation of the scale of the major or minor key is a subject upon which many hypotheses have been framed, and which seems likely to continue a matter in dispute. Some authors derive it from that of the harmonics, but the resemblance does not seem sufficiently close to warrant such an hypothesis.

Tartini, in order to obtain the notes of the major key, takes the three notes Do, Fa, Sol, expressed by the numbers 6, 8, 9, which show the respective proportional number of vibrations of each note, as c, $\mathfrak{r}$, and g, in the key of c major; and then adds to each of them the principal or loudest harmonics which they produce, viz., the perfect chord or major third and fifth.† Thus c gives $\mathfrak{x}$ and a, $\mathfrak{r}$ gives $\mathfrak{A}$ and c, and g gives $\mathfrak{n}$ and d; thus filling up the scale, for which reason a succession of triads falling a fifth has ever been agreeable to the ear, as Sol, Do, Fa; and the numbers 6, 8, 9, and 12 (which express these notes Do, Fa, and Sol, together with the octave to Do), have ever been famous above all others among the ancients, and when tuned by the ear in the following manner, give the major scale as invented by Ptolemy.

Tune the notes a, $\mathfrak{r}$, and $\mathfrak{x}$, by the ear, respectively a perfect fifth, perfect fourth, and major third to (viz., above) c. Then make $\mathfrak{A}$ a major third to $\mathfrak{r}$, and $\mathfrak{n}$ a major third to g, and d a perfect fourth below it.

Pythagoras was the inventor of the harmonical canon or monochord, which is merely a string having a board under it of exactly the same length, upon which may be delineated the points at which the string must be stopped to give certain notes. This delineation of ratios renders them capable of being compared, and their

respective proportions accurately measured and ascertained.

Figures 1, 2, and 3, are a section plan and view of a monochord of the most simple construction.

Fig. 1.

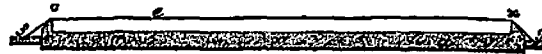


Fig. 2.



Fig. 3.

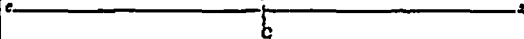


In each of these figures, $a b$ is a board made too thick to warp, having at each end $c x$, two supports for the string, of which it is required that the internal sides must be perpendicular, and the upper edge not rounded off, that the length of the string and that of the board may exactly correspond; this length is here supposed to be three feet. e is the string which is here supposed to be a steel wire called No. 11. The ends of the wire are attached to a peg at each end, f and g (the latter of which is not visible in figure 3), placed at right angles to the string. Both of these are to be turned in tuning the string, for if only one peg is used the string is apt to stretch more at that end than at the other, and consequently to be inaccurate.

The manner of using the monochord is first to place it on a table, which acts as a sound board to it, augmenting its power. Next tune the string to c, on the second space of the bass clef, by some other instrument, or by a pitch, or tuning fork. Pinch the string with the finger and thumb* of one hand, taking care not to force the string out of the straight line, and bow on the string with a violin bow in the other. The student may either mark the board according to his own discoveries of the notes produced by the string, or, which is rather recommended, he may draw lines on the board parallel to the string, and on them mark the places where he is to stop the string in order to produce the notes.

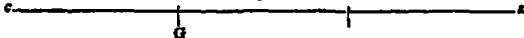
Divide the whole string $c x$ (fig. 4) into halves by pinching it at c , the half $c x$ will sound one octave above $c x$, the whole string.

Fig. 4.



Divide the whole string $c x$ (fig. 5) into three equal parts, and pinch the string at g , the remaining two thirds $g x$ will give the note g, a fifth to the whole string.

Fig. 5.



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† Let any of the lowest notes of a pianoforte, harp, violoncello, or of the diapasons of an organ, be struck and continued sounding, an ear accustomed to the experiment will distinctly hear the perfect chord of that note, and probably several of the other less audible harmonics.

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CROTCH,
1861



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Author(s): Dr. Crotch

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Tune the notes g, f, and e, by the ear, respectively a perfect fifth, perfect fourth, and major third to (*viz.*, above) c. Then make a a major third to f, and b a major third to g, and d a perfect fourth below it.

Pythagoras was the inventor of the harmonical canon or monochord, which is merely a string having a board under it of exactly the same length, upon which may be delineated the points at which the string must be stopped to give certain notes. This delineation of ratios renders them capable of being compared, and their

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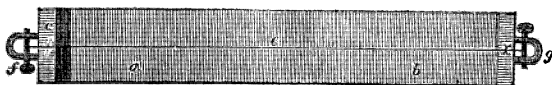


Fig. 3.

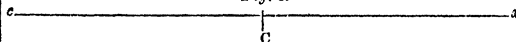


In each of these figures, *ab* is a board made too thick to warp, having at each end *c* *x*, two supports for the string, of which it is required that the internal sides must be perpendicular, and the upper edge not rounded off, that the length of the string and that of the board may exactly correspond; this length is here supposed to be three feet. *e* is the string which is here supposed to be a steel wire called No. 11. The ends of the wire are attached to a peg at each end, *f* and *g* (the latter of which is not visible in figure 3), placed at right angles to the string. Both of these are to be turned in tuning the string, for if only one peg is used the string is apt to stretch more at that end than at the other, and consequently to be inaccurate.

The manner of using the monochord is first to place it on a table, which acts as a sound board to it, augmenting its power. Next tune the string to *c*, on the second space of the bass clef, by some other instrument, or by a pitch, or tuning fork. Pinch the string with the finger and thumb* of one hand, taking care not to force the string out of the straight line, and bow on the string with a violin bow in the other. The student may either mark the board according to his own discoveries of the notes produced by the string, or, which is rather recommended, he may draw lines on the board parallel to the string, and on them mark the places where he is to stop the string in order to produce the notes.

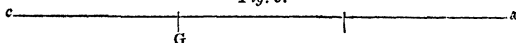
Divide the whole string *c* *x* (fig. 4) into halves by pinching it at *c*, the half *c* *x* will sound one octave above *c* *x*, the whole string.

Fig. 4.



Divide the whole string *c* *x* (fig. 5) into three equal parts, and pinch the string at *g*, the remaining two thirds *g* *x* will give the note *g*, a fifth to the whole string.

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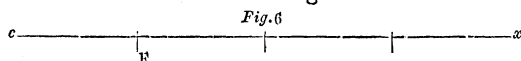


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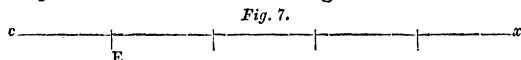
† Let any of the lowest notes of a pianoforte, harp, violoncello, or of the diapasons of an organ, be struck and continued sounding, an ear accustomed to the experiment will distinctly hear the perfect chord of that note, and probably several of the other less audible harmonies.

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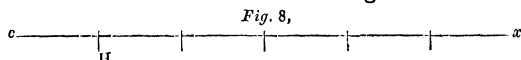
Divide the whole string $c x$ (fig. 6) into four equal parts, and pinch the string at F , the remaining three quarters $F x$ will give the note F , a fourth above the whole string.



Divide the whole string $c x$ (fig. 7) into five equal parts, and pinch the string at E , the remaining four fifths, $E x$ will give the note E , a major third to the whole string.

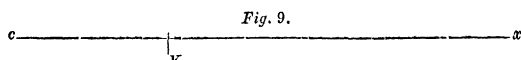


Divide the whole string $c x$ (fig. 8) into six equal parts, and pinch the string at H , the remaining five sixths $H x$ will give the note H , a minor third above the whole string.



And in the same way the octave, fifth, fourth, major third, and minor third, may be found to any given note on the monochord.

Let k (fig. 9) be the given note; in order to find the octave to k , consider $k x$ as a whole string, and divide $k x$ into two parts, and pinch it so as to take off one of them.



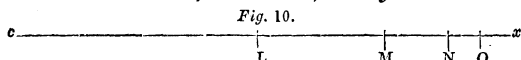
If the fifth to k is wanted, divide $k x$ into three parts, taking off one.

If the fourth to k is wanted, divide $k x$ into four parts, taking off one.

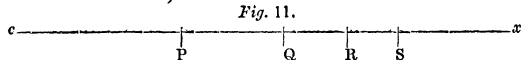
If the major third is wanted, divide $k x$ into five parts.

And if the minor third is wanted, divide $k x$ into six parts.

Thus the octave to $c x$ (fig. 10) is $L x$ the octave to L is $M x$, the octave to M is $N x$, the octave to N is $O x$, and so on, *ad infinitum*.

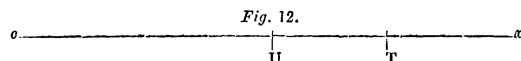


In the same way the fifth to $c x$ (fig. 11) is $P x$, the fifth to P is $Q x$, the fifth to Q is $R x$, the fifth to R is $S x$, &c.

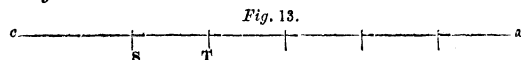


And by reversing the process, the notes below a given note may be found, provided they are not more grave or deep than the generator, or note given by the whole string $c x$.

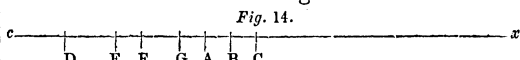
To find the octave below a given note T (fig. 12) set off U to the left of T , equal to $T x$; $U x$ will be the octave below $T x$.



To find the major third below a given note T (fig. 13) divide $T x$ into four equal parts, and set off $T s$ equal to one of them; $s x$ will be the major third below $T x$.

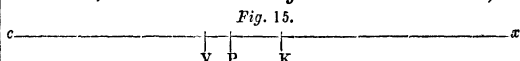


In order to tune the major key of c according to the methods of Ptolemy and Tartini, make E a major third to the whole string $c x$ (fig. 14), and G a fifth to it; F a fourth to it, A a major third to F , B a major third to G , D a fourth below G , and c an octave to the whole string.

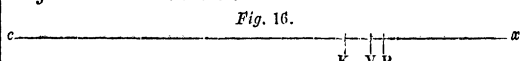


The point D will be found to be one-ninth of the whole string $c x$ from c ; or rather the note $D x$ is eight-ninths of the whole string $c x$; and this interval, from c to D , is called a major tone, and it is the difference between a fourth and a fifth; for if a fourth be subtracted from a fifth the remainder will be a major tone.

Thus to find the major tone above any given note v (fig. 15), find k a fifth above v , and p a below k ; $P x$ will be a major tone above $v x$;

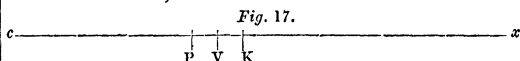


or let v (fig. 16) be the given note, make k a fourth below v , and p a fifth above k ; $P x$ will be a major tone above $v x$.

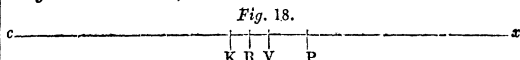


But the point E (fig. 14) will not be a ninth part of $D x$, but a tenth part; or in other words, the note $E x$ is not a major tone from D . The interval thus obtained is called a minor tone, and is the difference between a major tone and a major third; for if a major tone be subtracted from a major third, the remainder will be a minor tone, nine-tenths.

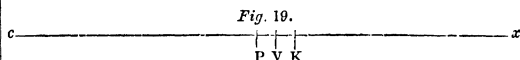
Let it be required to find a minor tone to the given note v (fig. 17), make P a major tone below v , and k a major third to P ; $k x$ will be a minor tone above $v x$, and will be nine-tenths of $v x$.



Or let v (fig. 18) be the given note, above which it is required to find a minor tone, make P a fourth to v , and k a fifth below P , and lastly, make R a major third to k , $R x$ will be a minor tone to $v x$.



If it be required to find the minor tone below a given note v (fig. 19), make k a major tone above it, and P a major third below k ; $P x$ will be a minor tone below $v x$.



The interval $E F$ (fig. 14) will be found to be one-sixteenth part of the distance $E x$, *viz.*, $F x$ will be fifteen-sixteenths of $E x$. The interval is called a major semitone, and is the difference between a major third and a fourth, for if a major third be subtracted from a fourth the remainder will be a major semitone. Thus, let it be required to find the semitone above v (fig. 20), make P a major third below v , and R a fourth

above *P*, *R* $\times$ will be a major semitone higher than *v* $\times$.

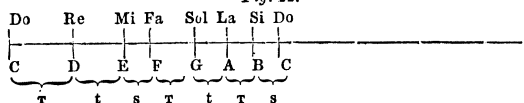
Fig. 20.

Or let *v* (fig. 21) be the given note, make *P* a fourth above *v*, and *R* a major third below *P*; *R* $\times$ will be a semitone higher than *v* $\times$.

Fig. 21.

If a major semitone is required below a given note, the manner must be reversed. Let *R* be the given note (fig. 20), make *P* a fourth below *R*, and *v* a major third to *P*, *v* $\times$ will be a major semitone below *R* $\times$. Or let *R* (fig. 21) be the given note, make *P* a major third to it, and *v* a fourth below *P*; *v* $\times$ will be a major semitone below *R* $\times$.^{*} The interval *FG* (fig. 14) is a major tone eight-ninths; *GA* a minor tone nine-tenths, *AB* a major tone, *BC* a major semitone. See fig. 22, where the major tones are marked with their usual signature *T*, the minor tones *t*, and the major semitones *s*.

Fig. 22.



It must also be understood—

That a major 3rd is equal to a *T* and a *t*, as *CE*.

... minor 3rd	... s T	... EG.
... perfect 4th	... T t s	... CF.
... perfect 5th	... T T t s	... CG.
... major 6th	... T T t t s	... CA.
... major 7th	... T T T t s	... CB.
And an 8ve	T T T t t s s	... CC.

The minor third *DF* consisting of *t* and *s*, and the fifth *DA* consisting of *T* *t* *s*, are therefore not in tune, but are both deficient by a small interval called a comma, which is the difference between a major tone eight-ninths, and a minor tone nine-tenths, and is about as 80 to 81.[†]

The note *D* combined with *F* or *A*, however, is not wanted in either of the triads, *Do*, *Fa*, or *Sol* of the major key of *c*, but in the minor key of *A* the triad of *Fa* is *D*, *F*, and *A*: hence a different tuning is required in the relative minor key to that just described. But no two major keys at all related to each other can exist, on the same keyed-instrument, perfectly in tune.[‡] Thus the

^{*} The major or diatonic semitone having been mentioned, it seems necessary to inform the student, that a minor or chromatic semitone (marked *s*) is the difference between a major semitone and a minor or major tone; as from *E* $\flat$ to *E* $\sharp$, from *c* to *c* $\sharp$, from *F* to *F* $\sharp$, &c. There are also several other intervals resulting from the combination of many keys on the same monochord, the knowledge of which is not necessary to the student.

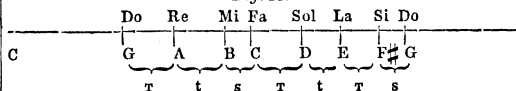
[†] The ratios of the monochord are generally expressed thus: the major tone $\frac{9}{8}$, minor tone $\frac{10}{9}$, major semitone $\frac{11}{10}$, &c.

[‡] In a lecture on this subject, the author of the present work caused the keys of *E* major with four sharps, and *E* $\flat$ major with three flats, to be tuned perfectly on the same pianoforte, viz., first the triads of *B* *E* *F* $\sharp$

c $\sharp$, *d* $\sharp$, *e* $\sharp$. And then having two notes, *c* $\sharp$ and *d* $\sharp$ already tuned, *e* $\sharp$ *A* *B* which would serve for *A* $\flat$ and *E* $\flat$, *c* was added to them, and lastly triads of *G* and *D*, *e* $\flat$ *B* $\flat$

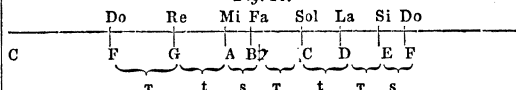
dominant key of *c* is *G* major with one sharp; *G* will be *Do*, and *A* *Re*, &c., but from *Do* to *Re* in a major key ought to be a major tone, see fig. 22; whereas in the major key of *c* from *G* to *A* is a minor tone. Compare figures 22 and 23, the latter of which is the major key of *G*.

Fig. 23.



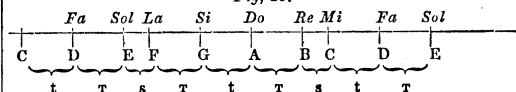
And thus in the subdominant of *c*, *F* major with one flat, from *c* to *D*, viz., from *Sol* to *La* should be a minor tone, but in the major key of *c*, from *c* to *D* is a major tone. See fig. 24, and compare it with fig. 22.

Fig. 24.



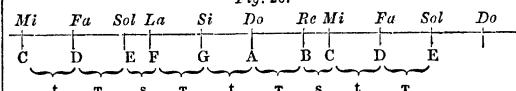
The minor key may be tuned likewise in the same way as the major, only making the thirds to *Do*, *Fa*, and *Sol*, minor instead of major. There is some difficulty, however, in choosing the first note *Do* of the principal minor key of *A*. Some authors make it the same as the note *La* of the relative major key, viz., *A* in the key of *c*, a minor tone above *G*. In which case all the natural notes excepting *D* correspond with those of the major key of *c*. Compare figures 25 and 22.

Fig. 25.



If the major thirds to *Fa* and *Sol*, *F* $\sharp$ and *c* $\sharp$, be added to this scale, they will be different from those notes in the keys of *A* major. The author of the present work, therefore, prefers making the key notes of *A* minor and *A* major the same; viz., a whole tone from *G* in the key of *c* major, see fig. 26, in which case only one natural note of the key of *A* minor, viz., *D*, will be the same with those of the major key of *c*; but the key note, the fifth, and the fourth, will be the same with those of the key of *A* major, three sharps; as also the *F* $\sharp$ and *G* $\sharp$; and also the *c* $\sharp$, which is sometimes used in a close.

Fig. 26.

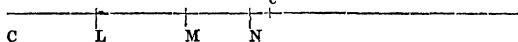


Having seen the impossibility of perfection on an instrument which has any limited number of sounds in an octave, the student may next proceed to the study of temperament, viz., of the distribution of the unavoidable imperfection resulting from the limited number of sounds.

On keyed instruments containing only twelve notes in an octave, three major thirds (as *CE*, *EG* $\sharp$ or *A* $\flat$, *Abc*, or as *GB*, *BD* $\sharp$ or *E* $\flat$, *E* $\flat$ *D* *G*) make an octave; but three major thirds tuned perfectly

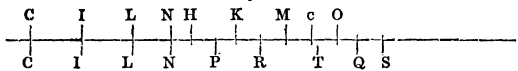
to each other, as *c L M N*, fig. 27, fall considerably short of the true octave *c*. Hence in tuning, one, two, or all of the three major thirds, which constitute every octave, must be tempered too sharp; and the nearer perfection any of them are made, the worse will the others become. *n c* is the unavoidable imperfection which must be added either to one or more of the thirds, and if equally divided between them will, *upon the whole*, be least offensive to the ear.

Fig. 27.



Again, twelve fifths, or, which is the same thing, six major tones, on a keyed instrument, constitute an octave; but on the monochord it will be found that they exceed it by a small portion, fig. 28, where *H I K L M N O P Q R S T* represent twelve sounds so obtained, the latter whereof does not coincide with the true octave *c*: *c T* is the unavoidable imperfection which must be subtracted from one or more of the twelve fifths which compose an octave.

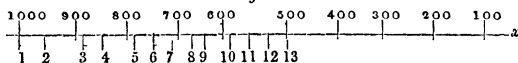
Fig. 28.



If equally distributed, this imperfection will be scarcely perceptible; when the fifths are all equally too flat, the thirds will all become, of their own accord, equally too sharp, and this will render all keys equally imperfect, which is called the equal temperament, and may be obtained on the monochord as follows. Divide the whole string *c x* into one thousand parts, beginning from right to left, as in fig. 29:

Place the note 2 at 943	
..	3 .. 890
..	4 .. 840
..	5 .. 793
..	6 .. 749
..	7 .. 707
..	8 .. 667
..	9 .. 629
..	10 .. 594
..	11 .. 561
..	12 .. 529
..	13 .. 500, the true octave.

Fig. 29.



Tune any one of the twelve notes of a keyed instrument to the whole string *1 x*, then *2 x* will give the next note, *3 x* the next, &c., to *13 x*, which will be an octave to *1 x*. If the note *1 x* be *c*, then *2 x* will be *c#* or *db*, *3 x* will be *d*, *4 x* will be *d#* or *eb*, &c. The fifth *8 x* will be only one thousandth part of the whole string too flat; but the third *5 x* will be seven such parts too sharp.

Unequal temperament is that wherein some of the fifths, and consequently some of the thirds,

are made more perfect than on the equal temperament, which necessarily renders others less perfect. Of this there are many systems, which the student is now capable of examining for himself.

He will also find much amusement in studying the various attempts to improve the scale by increasing the number of notes in the octave, such as that of the two additional notes at the Temple organ, of the five additional notes in Mr. Hawke's instruments, and of the twelve additional notes in those by Mr. Löeschman. In all these the bulk, expense, and complication of the instrument are increased in proportion to the number of notes added, and the consequent approach to perfection.

The author, in conclusion, cannot but regret that the preference of English organists for the old method of tuning is (as he is informed) hitherto so strong and determined, as to have resisted and repelled the attempts made to introduce the equal temperament into our Cathedrals and Churches. He has for many years uniformly recommended that this system should have a fair trial, upon the principle that as all tempered fifths and thirds offend the ear, those systems which contain such as are most tempered and most discordant cannot be preferable; especially in an age when the keys which have four sharps and three flats can no longer be excluded from general use. It has at length been fairly tried, and, having carefully examined it, he feels convinced that its practicability and superiority are as unequivocal on the organ as they are allowed to be on the piano-forte, and on all other instruments which contain only twelve different notes in each octave. He continues to press these opinions, not merely because they are his own, but because, in so doing, he is contending for the far higher 'authority of the judgment and practice of one whom, he trusts, his opponents must venerate and admire,—the greatest of all composers for this sacred instrument—

SEBASTIAN BACH.

TO CORRESPONDENTS.

We cannot undertake to return offered contributions; the authors, therefore, will do well to retain copies.

We would request those who send us country newspapers, wishing us to read particular paragraphs, to mark the passage, by cutting a slip in the paper near it.

Colored Envelopes are sent to all Subscribers whose payment in advance is exhausted. The paper will be discontinued where the Subscriber neglects to renew. We again remind those who are disappointed in getting back numbers, that only the music pages are stereotyped, and of the rest of the paper, only sufficient are printed to supply the current sale.

Notices of concerts and other information supplied by our friends in the country, must be forwarded as early as possible after the occurrence, otherwise they cannot be inserted. Our correspondents must specifically denote the date of each concert, for without such date no notice can be taken of the performance. All communications must be authenticated by the proper name and address of the writer.

Brief Chronicle of the last Month.

ABINGDON.—On the 18th ult. the Musical Association engaged the Brousil Family to give a Concert and contributed several vocal pieces themselves, which were well received. The performance of the Brousil children was received with every appearance of gratification.