THE WILLIAM HERSCHEL

(1738-1822)

TREATISE ON MUSIC

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Dominique Proust **Gus Orchard**

William Herschel (1738-1822) was one of the most notable astronomers of the 18th century. His work touched on all areas of astronomy: the Sun, Moon, Planets, Stars and Extragalactic Systems. Because of the unprecedented optical quality of his telescopes, he was the first to try and interpret certain nebulosity which he had found in the heavens; these were objects appearing in the form of a sort of stain in contrast to the precise aspect of the stars. His observations played a determining role in our current cosmology of the "Age of Enlightenment". Less well-known as a musician, he was however an oboist, violinist, organist and choirmaster but he let these activities go after his discovery of Uranus in 1781 which brought him to public attention, becoming the first Astronomer Royal of King George III.

We present here the textbook of the incomplete *Treatise on Music* by William Herschel from the scanned manuscript kept at Edinburgh University Library. Note that due to variations in the density of the text, some words are illegible. The binding frequently obscures the text in the guttering and ink in the original is occasionally badly smudged; moreover, some original pages are creased so the text is illegible. The text also contains some pagination errors.

The Musician

William Herschel was born in Hanover in Germany on 15th November 1738. His father, Isaac, played the fagotto (an old form of oboe) and directed the infantry military band at the garrison school. He taught his children the oboe, violin and organ. Blessed with a lively mind, William quickly learnt French and mathematics and showed an interest in astronomy from an early age. He discovered England in 1756 while accompanying the musicians of the guards on a musical visit, it taking 16 days (!) to make the trip. England had strong links with Hanover as George II (1683-1760) and George III (1738-1820) were descended from Sophie (1630-1714) of the line of Stuarts and from Ernst-Auguste (1629-1698), the Duke of Calenberg and Bishop of Osnabrück. When Herschel returned to Germany, the 7 Years War had broken out, marked by the battle of Hastenbeck (26 July 1757) between the forces of the Maréchal d'Estrées and those of the Duke of Cumberland (son of George II) which included Hanoverian troops. Because of his young age, and under family pressure, William and his younger brother, Jacob (1734-1792) returned once more to England, William finding work in London as a copyist. During that time, he wrote at least three concertos for the viola, which was uncommon in the middle of the 18th century. He moved to Durham where he directed the small Durham Militia Band (two oboes and two horns), whose Colonel was the Earl of Darlington, and taught music[1]. He also learnt English and Italian. He became well-known in Yorkshire giving numerous concerts including the Messiah by his illustrious compatriot, Handel, as well as some of his own compositions, all the while benefiting from the protection of the Duke of York. In 1762, William was in Pontefract to perform one of Dr Edward Miller's (1731-1807) concerts in the Town Hall, Doncaster:

[…] the first violin by Mr Herschell, a Native of Hanover, who performs one of Giardini's Solos and a Concerto on the Hautboy.

Herschel was appointed director of concerts at Leeds where he lived for 4 years but kept looking for somewhere where he could reconcile his activity as a musician to his growing interest in astronomy.

On 30th August 1766, the position of organist at the church in Halifax became available and William was one of the candidates. A document dating from 1804, an extract of "the History and Antiquities of Doncaster and its vicinity" by Dr Edward Miller informs us of the clever way that Herschel obtained the position. The German accent of the Swiss organ builder, Snetzler, is reproduced in the original text:

"At this time (1765), a new organ was built for Halifax Parish Church and was inaugurated with an oratorio by the celebrated Joah Bates. Mr Herschel was one of the 7 candidates for the post of organist. They drew lots to decide the playing order.

[1] Brown Franck.: 1990, *William Herschel, Musician & Composer*, William Herschel Society.

My friend Herschel was third. The second candidate was Mr Wainwright from Manchester, whose fingers played so rapidly that old Snetzler, the organ builder, filled the church with his exclamation: 'Te Tevel, te Tevel ! He run over the keys like one cat; he vill not give my piphes room for to shpeak!'. During Mr Wainwright's audition, I found myself with Herschel in the transept. "What chance have you got?, I asked him. He replied "I don't know, I'm sure my fingers won't go faster". He ascended to the organ loft and produced a flow of harmony of indescribable solemnity and power. After this brief introduction, he finished with the Old 100th psalm which he played better than his competitors. 'Aye, Aye !' exclaimed old Snetzler, 'tish is very goot, very goot indeed ; I vill luf tish man for he gives my piphes room for shpeak'. Having afterwards asked Mr Herschel how at the start of his audition he had succeeded in producing such a richness of sound, he replied "I told you that fingers were insufficient" and he pulled out of his jacket pocket 2 pieces of lead. "I placed one of the two on the bottom note of the organ and the other an octave above; thus in combining the harmonies, I produced an effect of four hands instead of two. However as they have a need above all for me to direct concerts as a violinist, they chose me in preference to a better organist; but I won't stay here long as I have been invited to a better position in Bath which I have accepted besides."

In spite of his nomination, Herschel quickly resigned from the post because of the better opportunities that were opening up for him as organist and director of music at the Octagon Chapel in Bath, a spa town in Somerset in the South West of England where the benefits of its waters had been known since Roman times. In addition, he was in charge of concerts at the Theatre Royal in Bristol.

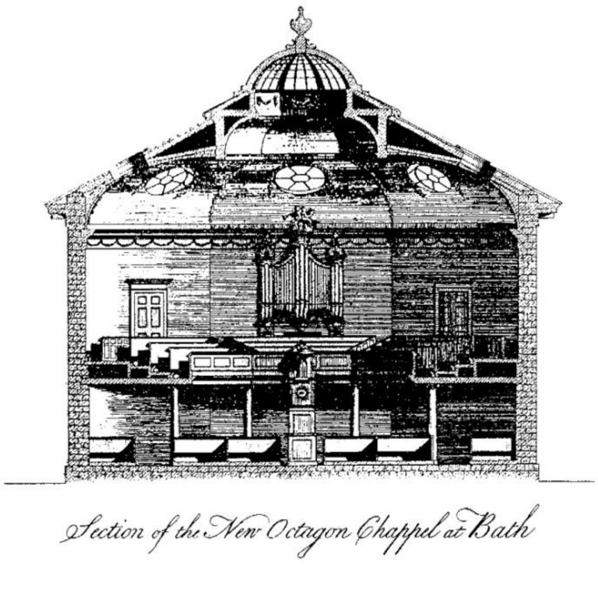


Figure 1 - The Octagon Chapel in Bath and its organ. The photograph on the right was taken before it was dismantled.

In the England of the 18th century, organ building was essentially represented by the instruments of John Snetzler who was born in Schaffhausen in Switzerland on 6th April 1710 and died in London on 28th September 1785. Like Herschel, Snetzler was friends with Charles Burney (1726-1814) who, besides his activities as organist, travelled around musical Europe and was no mean amateur astronomer. Burney was well-known for his history of music ("General History of Music") published in 4 volumes between 1776 and 1789. He was also the author of an historical didactic poem on astronomy written in 1797. Through his writings, we know that Snetzler worked with the organ-builder Edegacher in Passau between 1731 and 1733 and that he helped the builder, Christian Müller, in the construction of the organ in St Bavo in Haarlem between 1735 and 1738. However, we don't know the date of his arrival in England but once he settled here, the list of his works show his importance with more than 60 instruments built or rebuilt including St Margaret's Church in Kings Lynn where Charles Burney was organist and the 2 instruments linked to Herschel, Halifax Parish Church (1765-66) and the Octagon Chapel, Bath (1767). Snetzler was also the first person to introduce the Dulciana stop on his instruments. These "bearded Dulcianas" are narrow-scale pipes with a cylindrical bar placed in front of the mouth. Herschel frequently played the organ of St James church in Bath which had been built by Richard Seed for the sum of £250. In 1784, Seed received 30 guineas to build an organ case in walnut as well as installing some additional stops. The specification was as follows:

Great Organ: Open Diapason 8 / Stopped Diapason Bass 8 / Principal 4 / Twelfth 2 2/3 / Fifteenth 2 / Sesquialtera / Mixture / Trumpet 8.
Swell Organ: Open Diapason 8 / Stopped Diapason 8 / Principal 4 / Cornet / Hautboy 8.

In 1800, a 4 stop Choir organ was added by John Holland and in 1811 a pull-down pedal board by John Smith. In 1902, the instrument was entirely rebuilt by Griffin & Stroud who kept all the pipework for the 8, 4 and 2ft foundations stops.

Here is the specification of Herschel's organ at the Octagon Chapel (figure 1):

Great Organ: Open Diapason 8 / Stopped Diapason Bass 8 / Flute 4 / Principal 4 / Twelfth 2 2/3 / Fifteenth 2 / Sesquialtera IV / Cornet/ Trumpet 8.
Swell Organ: Open Diapason 8 / Stoppped Diapason 8 / Principal 4 / Hautboy 8.

A 2 ½ octave pedal board was added in the 19th century along with a Vox Humana by Sweetland in 1880.

The uniformity of the specification of organs at this time is notable with little imagination and a generally harsh sonority. Organ building was as homogenous as the music, doubtless with a concern for dynamic unity, from one building to another. Herschel's organ in the Octagon Chapel is no more. When the church was deconsecrated (it now belongs to the Royal Photographic Society), the organ was taken down and installed in the Freemason's Hall. In February 1898, it was put up for sale in an advertisement in the Musical Times ‘a fine-toned church organ with 827 pipes’ for £70. In the absence of a purchaser, the instrument was destroyed. The Herschel Museum in Bath is situated in the house where our musician-astronomer lived at 19 New King Street. You can see some of the organ’s pipes along with one keyboard.

Herschel is mentioned in many contemporary references as a performer of exceptional ability on many instruments. Dr Edward Miller noted:

Never before had we heard the concertos of Corelli, Geminiani and Avison, or the overtures of Haydn performed more chastely, or more according to the intention of the composers than by Mr Herschel.

John Marsh (1752–1828), an English gentleman, composer, diarist, astronomer and writer wrote:

As a true timist, Herschel would always adhere strictly to the original tempo, even when performing with the celebrated Tenducci.

As Herschel was named organist of the Octagon Chapel in 1766, he organized concerts for which he composed the music and often appeared not only as conductor but as soloist on the violin, oboe or harpsichord. These activities started gradually to take second place to his studies of mathematics and astronomy and the construction of telescopes:

All this while I continued my astronomical observations & nothing seemed wanting to compleat my felicity than sufficient time to enjoy my telescopes to which I was so much attached that I used frequently to run from the Harpsichord at the Theatre to look at the stars during the time of an act & return to the next Music.

Herschel made an instantaneous transition from being a successful musician to the most honoured astronomer of his time by discovering the planet Uranus on the 13^{th} of March, 1781.

Herschel became friends with Johann-Christian Bach (1735-1782), the last son of Johann Sebastian, who settled in London in 1762 and also with Joseph Haydn (1732-1809) who paid him a long visit during his second visit to London in 1792. The famous musician related in his diary his meeting with the astronomer:

“ On 15th June (1791) I went from Windsor to (Slough) to Doctor Herschel where I saw the great telescope. It is 40 feet long and 5 feet diameter. The machinery is very big, but so ingenious that a single man can put it in motion with the greatest ease. Sometimes he sits for 5 or 6 hours under the open sky in the bitterest cold weather. Herschel had formerly been oboist in the service of Prussia, but left that country, and came to England, where he supported himself many years of music; but

afterwards devoted the whole of his time and thought to astronomy. There are another 2 telescopes, smaller in size, one of which is 22ft long and magnifies 6,000 times. The king had 2 built, each of 12ft, and for which he paid 1,000 guineas.

In his youth, Dr Herschel was in the service of the King of Prussia as an oboist during the Seven Years War, deserted along with his brother and came to England and earned his living for a number of years as a musician, becoming an organist in Bath before turning more and more to astronomy. After having got the necessary (astronomical) instruments, he left Bath and rented a room near Windsor, studied day and night and, his landlady becoming a widow, they fell in love with each other and she married him bringing a dowry of 100,000 florins. Moreover, the king has granted him an annuity of £500 a year and, in this year 1792, his wife, aged 45, has given birth to a son. 10 years ago, he sent for his sister who has been an enormous help in his observations."

Joseph Haydn used his contact with the astronomer to develop the cosmological theories of Thomas Wright (1711-1786), Jean Henri Lambert (1728-1777) and Emmanuel Kant (1724-1804) on the chaotic origins of the Universe. In the oratorio The Creation (Die Schöpfung) which was composed only 5 years after Haydn's visit to Herschel, the celebrated passage 'And there was light' (Es ward Licht) is marked with a double forte following a passage marked entirely pianissimo: light shone and the Universe was under way.

Herschel was well known as much for being a composer as an instrumentalist whether on the violin, oboe or organ. His pieces link the transition of musical style between the baroque and the classical using marked contrasts both in the use of thematic material and orchestral texture. His later works (concertos and sonatas) show the gallant Italianate influence of J.C. Bach with its marked lyricism whilst his symphonies conserve the typical orchestral Sturm und Drang patina of the Berlin and Dresden schools. Finally, his compositions for organ keep the freshness of the voluntary along with much less conventional works in which Herschel uses the Swell manual expression for contrasting sonorities. His fugues are developed despite the lack of a pedal board which builders would have liked to have installed. Nevertheless, organ building in England at the time, as well as music in general leaves an impression of uniformity. The instruments resembled each other and it is difficult to find any imagination or boldness in their sound. The shade of Handel is noticeable as much through his fame as through his Hanoverian links.

William Herschel ceased his activity as church organist on Whitsunday 19th May 1782 mainly due to the fame brought on by his discovery of the planet Uranus and to enable him to devote himself full time to astronomy. At the time he began a second review of the heavens; the pattern of his life was really changing. Already his commitment to astronomy was greater than that of music, and he noted in January 1779 that *I gave up so much of my time to astronomical preparations that I reduced the number of my scholars so as seldom to attend more than three or four per day*.

However, he continued to give concerts in the New Assembly Rooms as well as in the theatres in Bath and Bristol. The composer John Marsh (1752-1828) during a visit to Bath in the first half of 1782, wrote in his diary that William Herschel *applied himself to astronomy much more than music*.

Astronomy

While studying astronomy, Hershel developed a passion for constructing telescopes through reading books on optics by Bonaventura Cavalieri (1598-1647). He undertook the construction of more and more powerful telescopes, polishing the mirrors himself until they had a perfect curvature. He was rewarded for his efforts by making a number of remarkable discoveries. On 13th March 1781, observing with his telescope, that had a 16 cm aperture and a lens that magnified 227 times, a small group of stars in the constellation of Gemini, he noted that one of them had an unusual shape presenting itself in the form of a circular disc and seeming to be moving away from its neighbours. Thinking first of all that this was a comet, Herschel communicated his observations to the Royal Society on the 26th April. However, he quickly realised that the star in question was a new planet. Situated at a distance of 2,875 million kilometres and revolving around the sun every 84 years, he initially baptised it *Georgium Sidus* (George's Star) in honour of King George III, with it subsequently happily being renamed Uranus.

The impact of such a discovery was considerable because, after centuries of astronomy which had fixed at 8 the number of planets, including the Sun and the Moon, and upon which the whole concept of the cosmos was based, the Solar System had suddenly grown thanks to a new planet situated 18 times the distance of the Earth from the Sun. After the discovery of Uranus, Herschel was raised to the dignity of Astronomer Royal by King George III and thereafter progressively stopped his musical activities to consecrate himself full-time to astronomy. He continued his observations (figure 2) helped by his sister Caroline (1750-1848) and discovered the 2 largest moons of Uranus, Titania and Oberon (1787), the polar caps of Mars as well as 2 of Saturn's moons, Enceladus and Mimas (1789). However, his major interest concerned the structure of the Galaxy and the observable universe which he studied with the help of telescopes that he never ceased to perfect. By counting neighbouring stars, he was able to show that the Solar System was moving towards a point in the constellation of Hercules, the solar Apex and that the Galaxy is a flat disc of stars with 2 branches with the Sun being found close to one of them. He also showed that binary stars revolve around a centre of gravity, so following Kepler's laws.

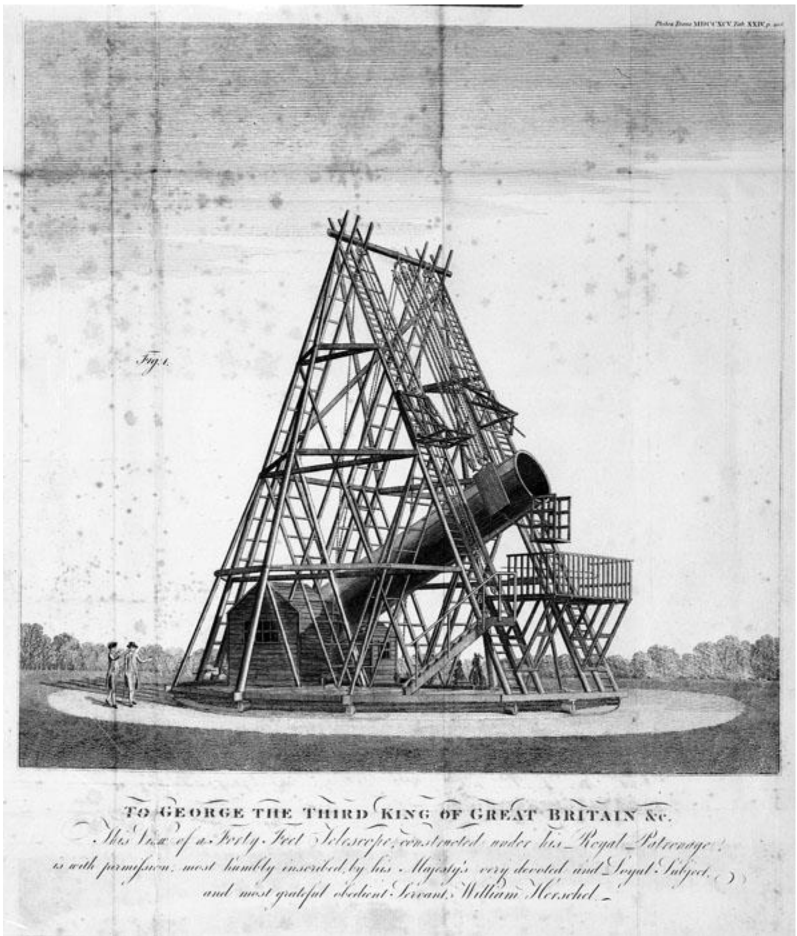


Figure 2 - The 40ft telescope built by William Herschel which was the largest in the world at that time. An exceptional document as this is a daguerreotype of this telescope taken in 1839 by John Herschel (1792-1871), William's only son.

William Herschel and the Construction of the Heavens

The new cosmology of the 18th century was developed through a series of talks and ideas which crisscrossed Europe thanks to the translations of Emilie le Tonnelier du Chatelet (1706-1749), a remarkable lady of science as well as being a muse of Voltaire. True to his course of action of interpreting the composition of the universe from a single observation, Herschel pondered over the possible "Island Universes" described by Kant. These are, as Herschel saw it, stellar systems comparable to the Milky Way and to consider that these systems were formed from huge stellar agglomeration is to admit that these Island Universes or galaxies exist far beyond the Milky Way (figure 3). In summary, the total number of nebulae, stellar clusters, distant galaxies, diffuse nebulae etc, discovered or catalogued by William Herschel amounted to 2,451. His son John (1792-1871) counted a further 1,475 during his observations in Southern Africa.

In August 1802, Herschel came to France where he was made a member of the Institut de France. He met a number of important French scientists including Pierre Simon de Laplace (1749-1827) as well as Napoleon at the Chateau of Malmaison. Napoleon, following a talk by Laplace on "The System of the Worlds" (Le Système des Mondes), asked them apropos the cosmos as a whole "who was the creator of all this?", a question to which Laplace replied by arguing that there were a number of natural causes in the origins of the construction and preservation of the "marvellous system". As Herschel later recounted, Napoleon in his turn opposed this view and, asking him the same question, Herschel replied that much could be said on this subject and that bringing the various arguments together had led man to envisage both the Natural World and the divine nature of God. Herschel's philosophical and religious views were guided by astronomy towards a natural theology of the world order.

Hershel's multiple observations, whether solar, lunar, planetary, stellar or extra-galactic, acted as reassurance to his conception of a harmony, a natural theology of a rational cosmos, the order of which is the manifestation of God the Creator. Herschel had already written in an article on the existence of space which was presented to the Philosophical Society of Bath in 1780: "I am not preoccupied with giving a full description of what space really is. It is more a question of making its existence clear…an infinitely long existence…the scale to which the Omnipotent distributes his wonders."

Along with scientific discoveries, the ideas of the harmony of the world at the end of the 18^{th} century evolved, leaving behind the narrow view of the Solar System for one of the whole cosmos. The time component completed the overview. The universe was created from where chaos reigned and order ensued. Herschel observed this harmonious and orderly universe in the same way as he played the organ, that is with the sole intention of only interpreting that which he saw (and played), only speculating on the natural history of the heavens based on the ensemble of his work. Herschel's cosmology is down to earth (or the heavens) excluding any axiom or speculation beyond the possibilities of what he saw through his telescope. Astronomic deduction only exists through interrogation linked to what is being observed in terms of the concentration and fragmentation of matter. The remarkable contribution that William Herschel made to cosmology rests on his observational tenacity, which is a long way from a dogmatic context.

William Herschel was also at the origin of the discovery of infra-red radiation in 1800. He decomposed light through a prism, just as raindrops let us see a rainbow, and placed a series of thermometers along the different colours of the spectrum, noting that beyond red, the temperature was notably higher, thus showing that radiation existed in the domain corresponding to the wavelength beyond the visible.

William Herschel was married in 1788 to his landlady, Marie Pitt, who was a widow. John Herschel was their only son and became a renowned astronomer. As for

William, exhausted by such an active life, he died peacefully on 25th August 1822 and was buried in the church in Upton with the epitaph “he broke through the confines of the heavens”. His name was inscribed on the paving of Westminster Abbey on 8th November 1854.

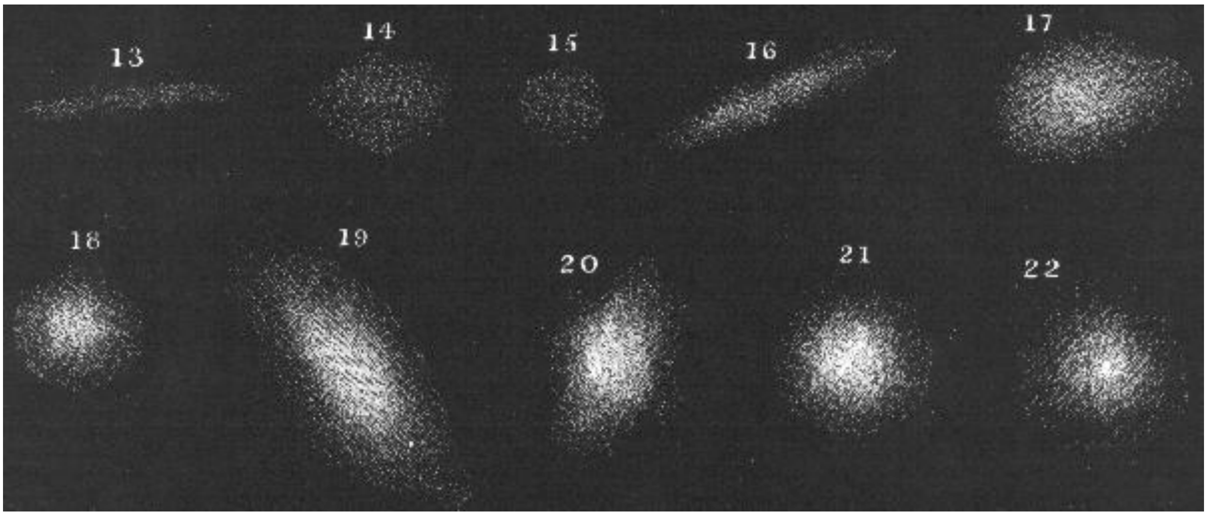


Figure 3 - Nebulae and galaxies drawn by William Herschel.

The music of William Herschel

24 Symphonies

Sei Symphonie per Duoi Violini, une Viola, uno Violoncello e Contro-Basso, obligati, Con Duoi altri Violini, duoi Fagotti e Cembalo, ripieni, composite de Fh. Wm. Herschel 1760.

- Symphony n°1, in G major. Richmond, Yorkshire, Jun 1760.
- Symphony n°2, in D major. Richmond, Yorkshire, Sep 1760.
- Symphony n°3, in C major. Sunderland, Durham, Oct 1760.
- Symphony n°4, in D minor. Halnaby, Yorshire, 5 Nov 1760.
- Symphony n°5, in F minor. Halnaby, Yorshire, 15 Nov 1760.
- Symphony n°6, in E flat major. Sunderland, Durham, 30 Nov 1760.

VI. Symphonie da F.M. Herschel 1761.

- Symphony n°7, in D minor. Sunderland, Durham, 30 Jan 1761.
- Symphony n°8, in C minor. Sunderland, Durham, 20 Apr 1761.
- Symphony n°9, in F major. Sunderland, Durham, 20 Jun 1761.
- Symphony n°10, in G minor. Sunderland, Durham, 20 Aug 1761.
- Symphony n°11, in F minor. Pontefract, Yorkshire, 1 Nov 1761.
- Symphony n°12, in D major. Pontefract, Yorkshire, 1 Dec 1761.

VI. Symphonie da F.W.Herschel 1762.

- Symphony n°13, in D major. Pontefract, Yorkshire, 24 Mar 1762.
- Symphony n°14, in D major. Leeds, 14 Apr 1762.
- Symphony n°15, in E flat major. Pontefract, Yorkshire, 3 Jun 1762.
- Symphony n°16, in E flat major, Pontefract, Yorkshire, 16 Jun 1762.
- Symphony n°17, in C major. Pontefract, Yorkshire, 1 Jul 1762.
- Symphony n°18, in E flat major. Pontefract, Yorkshire, 31 Jul 1762.

6 symphonies for Grand Orchestra: 2 horns, 2 oboes, 2 flutes, 2 bassoon, 4 string parts, 2 clarinets, timbales.

- Symphony n°19, in C minor. Symphonia per 8toStromenti… composta a Pontefratto. Augt. 6.1762. da Wm Herschel.
- Symphony n°20, in C major. Leeds, 12 Mar 1763.
- Symphony n°21, in B minor. Leeds, 30 May 1763.
- Symphony n°22, in A minor. Harrogate.
- Symphony n°23, in D major. Leeds 30 Jan 1764.
- Symphony n°24, in C major. 1 Jun 1764.
- Symphony in E minor, 1761 (extract).

Concertos and diverse pieces

- Concerto for organ n°1 in G major, 28 Oct 1767.
- Concerto for organ n°2 in D major, 29 Oct 1767.
- Andante in G major for organ and strings.
- Concerto for oboe in C major, 1750-1775 – 2 violins, viola, bass, 2 horns. Maestoso – Adagio – Allegretto.
- Concerto for oboe in C major, 1750-1775 – 2 violins, viola, bass, 2 bassoons, 2 horns. Maestoso – Adagio – Allegro.
- Concerto for oboe in C major, 1750-1775 – 2 violins, viola, cello, 2 horns. Allegro.
- Concerto for oboe in E flat major, London, 1759 – 2 violins, viola, basse, continuo. Allegro moderato – Adagio – Tempo primo.

- Concerto for the Tenor, the Oboe & Violin, 1750-1775 (unfinished). Adagio – Allegro.
- Idem in D minor, Maidstone, August 1759. Allegro moderato – Adagio cantabile – Vivace allegro.
- Idem in F major, London, Oct. 1759. Allegro – Adagio – Vivace.
- Concerto for violin & orchestra in A minor, Richmond, 3rd July 1760. s.d. – Adagio – s.d.
- Idem in D minor, Burley, 31st July 1764. Allegro – Adagio assai – Allegro assai.
- Idem in C major, Behard Castle, Durham, 16th Sept. 1762. Allegro ma non molto – Adagio molto – Allegro assai.
- Idem in G Major, Richmond, 1761 (unfinished).
- Idem in G major, 1750-1775. Allegro – Adagio assai – Allegro.
- Pieces for violin in C major, Leeds, 20th Jan. 1763. Allegro assai – s.d. – Presto.
- 25 variations on the ascending scale, 1750-1799.
- Six Sonatas (extracts), Bath, 1769.

Choral works
- Morning Service in B flat major for 4 voices.
- Morning and Evening Services in A major for 3 voices and organ.
- The 1st, 2nd, 3rd,5th, 8th, 9th, 12th and 15th verses of Psalm 51 for 4 voices and strings.
- Open Thou my lips, fugue for 4 voices and continuo, Sept. 1764.
- 4 Psalms for 4 voices
- Te Deum (Andantino n°65 – basset horn, horn, oboe, bassoon). Slough, Oct. 1803.
- Jubilate in G major. Slough, Oct. 1803.
- Eccho Catch C Maj – Bath, Summer 1779. 3 voices, voice in echo & bass (+ 2 horns, 2 oboes & 4 string parts for outdoor performance). (Published in 1780 in London as “The favourite Eccho Catch, sung at Vauxhall Gardens with universal applause”).

Sonatas
Six Sonat per il Cembalo, cogli accompagnamenti di Violino & Violoncello, Bath, 1769
- Sonata n°1 in C major: Allegro – Andante – Allegro
- Sonata n°2 in B flat major: Allegro – Andante – Allegro assai
- Sonata n°3 in G major: Allegro – Grazioso (Allegro assai) – Allegro moderato
- Sonata n°4 in D major: Allegro – Andante – Allegro spiritoso
- Sonata n°5 in F major: Moderato – Adagio – Allegro
- Sonata n°6 in A major: Allegro – Adagio assai – Allegretto spiritoso

- Sonata I (violin & continuo) Andantino, G maj, 8/8 – Allegro, G maj, 4/4 – Presto, G maj, 6/8.
- Sonata II (violin & continuo) Allegretto, F maj, 8/8 – Presto, F maj, 4/4.
- Sonata III (violin & continuo) Allegro assai, G maj, 4/4 – Adagio, G maj, 4/8 – Arioso, G maj, 2/4.
- Sonata IV (violin & continuo) Allegro assai, B flat maj, 4/4 – Adagio, F maj, 3/4 Presto, B flat maj, 4/4.
- Sonata V (violin & continuo) Allegro assai, G maj, 4/4 – Adagio, G maj, 4/4.
- Sonata VII (violin & continuo) Allegro, A maj, 4/4.
- Sonata VIII (violin & continuo) Allegro, B flat maj, 4/4 – Adagio, B flat maj, 3/4 - Presto B flat major, 4/4.
- Sonata IX (violin & continuo) Allegro D maj, 4/4 – Adagio, B min, 3/4 - Presto, D maj, 4/4
- Sonata X (violin & continuo) Allegro ma non molto, A min, 4/4 – Adagio ma non molto, A min, 3/4 – Presto, A min, 4/4.
- Sonata XI (violin & continuo) Allegro, G maj, 4/4 – Adagio grazioso, G maj, 4/8 – Allegro assai, G maj, 3/4.

Pieces for organ solo

- 6 fugues for organ n°1 in D major, n°2 in C major, n°3 in D major, n°4 in G major, n°5 in D minor, n°6 in E flat major.
- 24 sonatas for organ (10 lost) n°1 Allegro in g major, n°5 Allegro ma non troppo, n°9 Allegro in C major.
- 32 voluntary and full pieces for the organ
- 24 pieces for organ (some are incomplete).
- 12 voluntaries for organ (11 lost). Voluntary in D minor.

- Treatise on Harmony (incomplete).
- Capricii per il Violino Solo, Leeds, 1763: A major, 4/4 – A major, 2/4 – G major, 3/8 – G major, 2/4 – G major, 2/4 – G major, 3/4 - 20 Jan. 1763. G major, 4/8 – C major, 3/4 – E mineur, 3/8 – E major, 8/8, E flat minor, 6/8 – B flat major, 2/4 – G minor, 4/4 – F major, 3/4 – F minor, 4/4 – G sharp minor, 4/4 – G major, 4/4 – A major, 4/4 – B flat minor, 3/4 – F major, 2/4 – A major, 4/4.
- Ensemble of Glees, Catches and Madrigals for mixed voices (soprano, counter-tenor, tenor, bass, chamber ensemble (2 violins, viola, cello, 2 oboes, 2 horns) – performed at the Spring-Garden Concerts in Bath): 1/ The spring garden concert (glee). 2/ We sing of love (glee). 3/ I lov'a nymph. 4/ To be or not to be (recit). 5/ When shall we three met again (glee). 6/ With thee my Daphne ever could I stray (duet). 7/ Come, let us sing a roundelay. 8/ You're tipsy Tom. 9/ Ah wherefore should a frozen heart (madrigal). 10/ By love so firm am thine (madrigal). 11/ Let all with mirth and joy abound (glee). 12/ When dolefull thoughts the mind propels. 13/ Shall I soft cupids laws obey (catch). 14/ The Eccho. 15/ Suppose we sing a catch. 16/ Lets humble faithless France (song). 17/ To be drunk is horrid (catch).

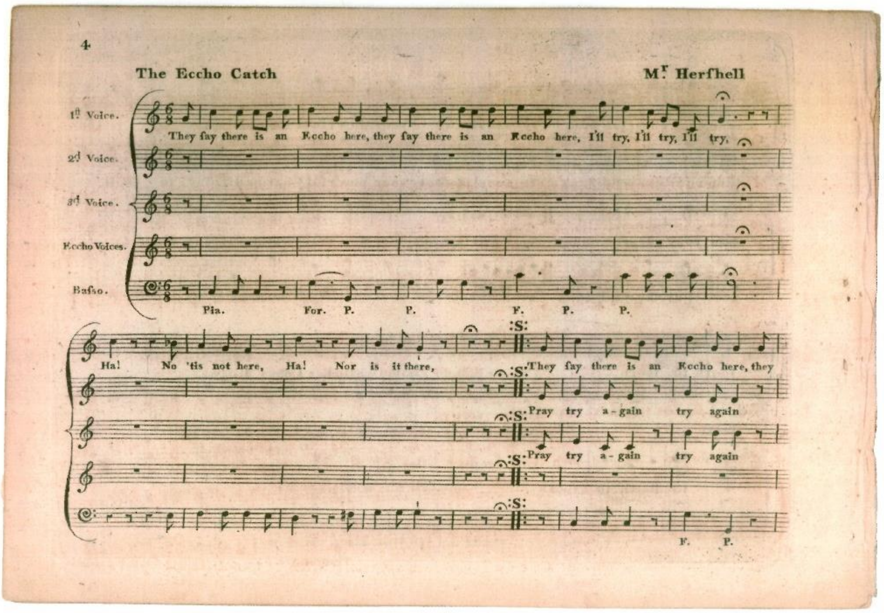


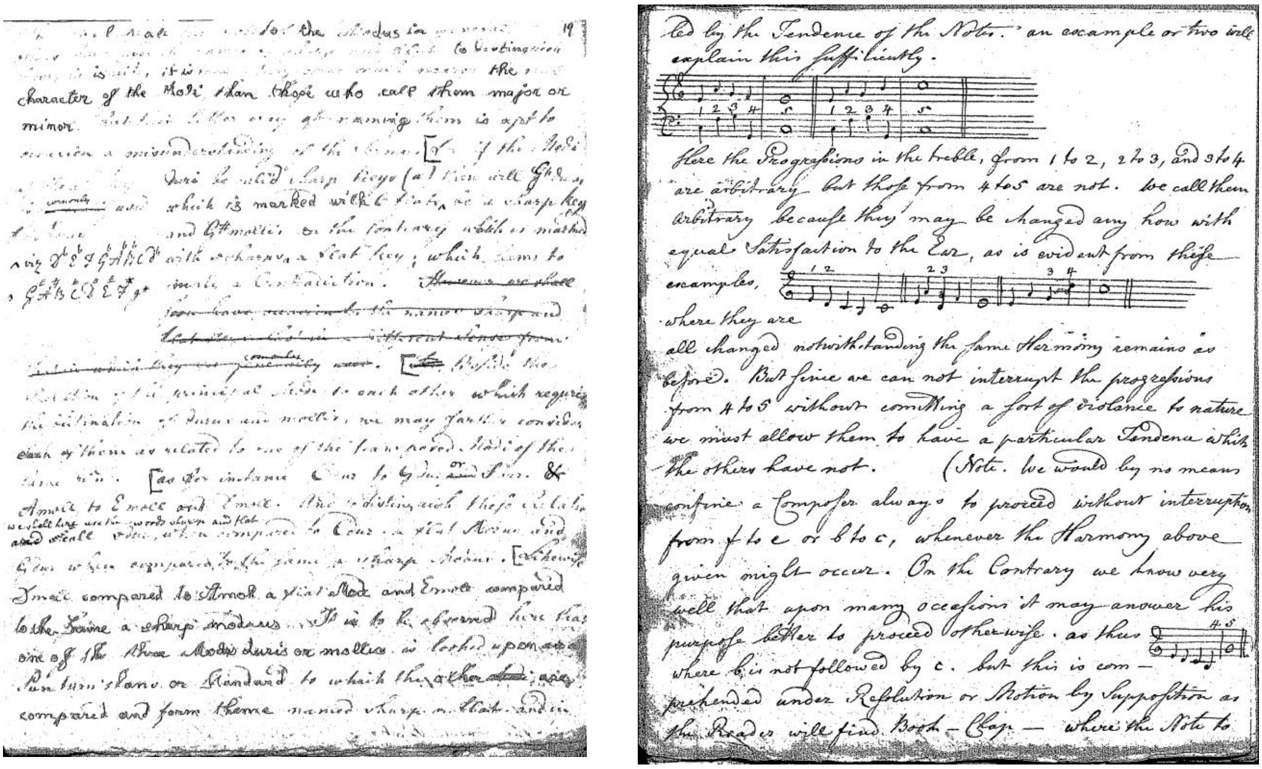
Figure 4 - The original score of *The Eccho Catch* by William Herschel.

As an example, the figure 4 shows the original score of *The Eccho Catch*. The term *catch* refers to a round or a canon at the unison for three or four male voices, very popular in England in the sixteenth, seventeenth and eighteenth centuries. Like all rounds, catches are indefinitely repeatable. Note that there are often double meanings (or more) created by the juxtaposition of the words[2].

[2] Whitson, B.: 2008, *William Herschel's "Eccho Catch"*.

The treatise on Music

For a long time, William Herschel intended to write on the theory of music. In a letter to his brother Jacob in 1764, he gives details upon his *Treatise on Music*:
I have actually begun my Treatise upon music. I will give you a general idea of it and reserve particularities till a further opportunity as I intend to communicate the whole to you when I have got a little forward with the work.



led by the Tendence of the Notes. an example or two will explain this sufficiently.

Here the Progressions in the treble, from 1 to 2, 2 to 3, and 3 to 4 are arbitrary but those from 4 to 5 are not. We call them Arbitrary because they may be changed any how with equal Satisfaction to the Ear, as is evident from these examples, where they are all changed notwithstanding the same Harmony remains as before. But since we can not interrupt the progressions from 4 to 5 without committing a sort of violence to nature we must allow them to have a particular Tendence which the others have not. (Note. We would by no means confine a Composer always to proceed without interruption from f to e or b to c, whenever the Harmony above given might occur. On the Contrary we know very well that upon many occasions it may answer his purpose better to proceed otherwise. as thus where b is not followed by c. but this is comprehended under Resolution or Motion by Supposition as the Reader will find Book – Chap. — where the Note to

Figure 5 - Two pages of the manuscript of the treatise; on the left, the most illegible and on the right, the last page.

The treatise was to fall in six parts:

1. Melody, wherein Herschel intended to discuss the different modes, the degree of sharpness, times and accents.
2. Harmony, wherein the theory of intervals was to be expounded, together with their combinations, progressions and resolutions. Inversion and the diminution of intervals were also to be discussed here.
3. Modulation.
4. *Under relation I explain the characters A,B,C,D, treat of all sorts of motion of the Parts, of Imitations points and fugues &c and all other sorts of Rapports. Shew how several faults are to be avoided*.
5. Invention would treat of the different styles and expression of music.

6. Under composition: *I shew wherein consists the perfection of all sorts of Music – and treat of all sorts of Pieces and performances in General*[3].

This treatise was never finished and never published. The manuscript is conserved at the Edinburgh University Library. We reproduce it in the next pages.

[3] Turner, 1977.

Treatise

As early as the year 1758 I intended at some convenient time to write a Treatise on Harmony and Musical composition, and began to collect materials for that purpose. The enclosed papers show the design and extent of the intended work.

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I shall not at present interrupt our subject with an explanation of them, but it may be inquired why we have rather chosen the notes A^b D^b and G^b than $G^\#$ $C^\#$ and $F^\#$, to form a modus upon. For the 12 semi-tones in one octave, as we have given them somewhere before, are C, $C^{\#,}$ D, E^b, E, F, $F^\#$, G, $G^\#$, A, B^b, B. In answer to this we say the preference is given to A^b, D^b, and G^b in order to avoid the inconvenience of too great a number of sharps, for the most simple method of performing the same thing is always the most eligible, but the modus of D^b, could not have been formed upon $C^\#$ without introducing 7 sharps, $C^\#$, $D^\#$, $E^\#$, $F^\#$, $G^\#$, $A^\#$, $B^\#$, $c^\#$, whereas upon D^b the same is done with only 5 flats D^b, E^b, F, G^b, A^b, B^b, C, d^b. For the same reason A^b is preferred to $G^\#$. But the number of sharps and flats being equal in forming a modus either upon $F^\#$ or G^b, to wit, $F^\#$, $G^\#$, $A^\#$, B, $C^\#$, $D^\#$, $E^\#$, $f^\#$ and G^b, A^b, B^b, C^b. D^b, E^b, F. g^b. The composer is left as liberty to choose which he pleases.

Yet, since in a course of a Piece of music, the modulation proceeds generally most towards the sharp side, the flats are on that account preferable. For if we add one or two sharps to fix the number, they will increase to 7 or 8 but when we add one or two to 6

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flats, the number remaining will only be 5 or 4, because adding a sharp is the same thing as taking away a flat.

The following are, the modus mollis, transferred upon the 12 semitones

					$F^\#$	$G^\#$	
A	B	C	D	E	$F^\natural$	$G^\natural$	a
					$C^\#$	$D^\#$	
E	$F^\#$	G	A	B	$C^\natural$	$D^\natural$	e
					$G^\#$	$A^\#$	
B	$C^\#$	D	E	$F^\#$	$G^\natural$	$A^\natural$	b
					$D^\#$	$E^\#$	
$F^\#$	$G^\#$	A	B	$C^\#$	$D^\natural$	$E^\natural$	$f^\#$
					$A^\#$	$B^\#$	
$C^\#$	$D^\#$	E	$F^\#$	$G^\#$	$A^\natural$	$B^\natural$	$c^\#$
					$E^\#$	F^x	
$G^\#$	$A^\#$	B	$C^\#$	$D^\#$	$E^\natural$	F^x	$g^\#$

					$B^\natural$	$C^\#$	
D	E	F	G	A	B^b	$C^\natural$	d
					$E^\natural$	$F^\#$	
G	A	B^b	C	D	E^b	$F^\natural$	g
					$A^\natural$	$B^\natural$	
C	D	E^b	F	G	A^b	B^b	c
					$D^\natural$	$E^\natural$	
F	G	A^b	B^b	C	D^b	E^b	f
					$G^\natural$	$A^\natural$	
B^b	C	D^b	E^b	F	G^b	A^b	b^b
					$C^\natural$	$D^\natural$	
E^b	F	G^b	A^b	B^b	C^b	D^b	e^b

in which the sharps and flats are again employed to the same purpose, namely to render the interval of one modus similar to those of another, for as A is to $G^\#$ so are B to $A^\#$, C to B, D to $C^\#$, E to $D^\#$, $F^\#$ to $E^\#$, $F^\natural$ to $E^\natural$, $G^\#$ to $F^\#$, $G^\natural$ to $F^\#$, and a to $g^\#$, that is: as the modus of A is to its prima, or fundamental so are the other modi to their respective primas or fundamentals.

In transferring the modus mollis upon the 12 semit[ones] we have preferred $F^\#$,$C^\#$ and $G^\#$ to G^b, D^b and A^b that we might avoid too great a number of flats. For G^b mollis would have no less than 7 ascending and 9 descending *viz.* G^b A^b B^{bb} C^b D^b

E^b F g^b
E^{bb} F^b

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whereas $F^\#$ mollis has but 5 sharps ascending and no more than 3 descending.

The number of sharps in $G^\#$ mollis being equal to the number of flats in A^b mollis, we have here preferred the sharps, because this modus is so nearly related to B durus (which carries sharps) that in the sequence of a piece of music the modulation naturally leads us to it for which reason, it ought to be placed among those marked with sharps, as we have done.

(To return to the modi duri) this likewise is a reason why G^b dur ought to be placed among the modi marked with flats, for in the modulation of a piece of music in that modus, we generally pass to E^b mollis with carried flats. The whole business of choosing either one or other depends upon this proposition, which we look upon as a maxim; that we ought to avoid superfluity of signs, and that the lesser number is always preferable to the greater.

We shall not detain our reader with a transcription of the modi inferiors as they always follow their principals. Whatever number of sharps or flats we are led to by them, must be used in this likewise for, since they depend intimately upon

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the former, it is necessary they should be in the same situation of sharps or flats with them. Thus the modus durus of the 5^{th} to $G^{\#}$ mollis is marked with sharps

$E^{\#}$ $B^{\#}$ C^{x}
$D^{\#}$ $E^{\natural}$ F^{x} $G^{\#}$ $A^{\#}$ $B^{\natural}$ $C^{\#}$ $d^{\#}$ although the same might be done by a lesser number of

F C D
flats E^{b} F^{b} G A^{b} B^{b} C^{b} D^{b} e^{b}, for a change of sharps into flats would be far worse than the inconvenience of a few additional sharps can be.

Hitherto we have supposed our readers already to be in the same measure acquainted with the general use of sharps, flats and naturals, but here we intend to give them a more perfect idea of their different properties and powers. As long as we kept to the diatonic scale of the modus durus there was no occasion for sharps flats & naturals but when, by adopting the tertia minor, we were under the necessity to introduce both the 6^{th} and 7^{th} majors & minors in the same modus, we then found there wanted some certain signs by which they might be distinguished from one another. Now the 6 and 7 majors being a semitone above the same minors this sign # was annexed to them, to which a power was given of raising or sharpening

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them as much as they wanted. But the introduction of one sign rendered it necessary to introduce another, for to avoid a useless repetition of the same sign, it was thought necessary to extend its power to all notes of the same kind by being only annexed to the first. Thus $F^{\#}$ *F F &c* is equal to $F^{\#}$ $F^{\#}$ $F^{\#}$ *&c*. Therefore if the composer thought proper to change the same note from a major to a minor, he was obliged to annex to it another sign to denote that the power of the first should cease. To this end a $\natural$ was introduced, which reduces the note it is annexed to to its former state in which it again continues till a second change alters it, and so on. Thus $F^{\#}$, *F*, *F*, $F^{\natural}$, *F*, *F &c* is equal to $F^{\#}$ $F^{\#}$ $F^{\#}$ $F^{\natural}$ $F^{\natural}$ $F^{\natural}$ *&c* or to $F^{\#}$ $F^{\#}$ $F^{\#}$ *F F F &c.*

Next, when the composer changed the modus durus into a modus mollis, by adopting the tertia minor, he found occasion for a third sign to distinguish it from the former, for instead of wanting an addition, the tertia major already exceeded the tertia minor by a semitone which therefore was to be taken away, and the sign *b* was hence invested with the power of depressing or lowering that note, to which it is annexed, a semitone.

To take away the effect of a *b*, the $\natural$ is used in the same manner as it is after a #. Thus B^b *B B* $B^\natural$ *B B &c* is

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equal to B^b B^b B^b $B^\natural B^\natural B^\natural$ *&c* or to B^b B^b B^b *B B B &c*. Hence we may observe that the # and *b* have but one power, *viz* of sharpening or flattening a semitone the notes to which they are annexed; but the $\natural$ has a double capacity, it flattens again a sharpened note and sharpens again one that was flattened before.

Time however has made some final alteration in the use of these signs, for as the # and *b* were first invented for the sake of sharpening or flattening particular notes not belonging to the principal modus of a piece of music, so now they are likewise used for several and sometimes all the notes of the principal modus itself. For since the correction of the modi and their transposition has been better understood, it has been found necessary to extend the use of these signs, and a modus with 5 or 6 sharps or flats is known to be as natural a modus as one without any at all, for, as we have proved that all the notes of the transposed modi are to their respective fundamentals as those of C durus are to C, it follows from thence that they are alike natural, and that the manner of marking them is a mere accident, not all material to the nature of the modi thus differently marked. Those who are not thoroughly acquainted with this

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subject are apt to be misled by name, for there is no real difference, in the nature of these three modi G^b A^b B^b C^b D^b E^b $F^\natural$ g^b $C^\natural$ $D^\natural$ $E^\natural$ $F^\natural$ $G^\natural$ $A^\natural$ $B^\natural$ $c^\natural$

$B^\natural$ $C^\#$ $D^\#$ $E^\natural$ $F^\#$ $G^\#$ $A^\#$ $b^\natural$

Each of them carries 7 signs to denote the particular situation of its 7 gradies, for each note to which a # or *b* is not annexed is thereby marked with a $\natural$, but to avoid useless repetitions it never is expressed unless particular occasions required. The names sharp, flat and natural, when applied to the signs, should not be looked upon as signifying anything more than #, *b*, $\natural$, for they might with as much reason have been called *1*, *2*. *3*, or *a*, *b*, *c*, as sharp, flat & naturals. According to the literal signification of the word, G^b is a natural note because the fundamental of a modus must certainly be deemed as much so as any can possibly be. Likewise, in relation to the modus, $F^\natural$, in G^b durus, is a sharp note, and $F^\natural$ in *C* durus, is a flat note, as we shall have an opportunity to show hereafter. It is, therefore, necessary in treating of sharps flats and naturals, to take those words as void of their common signification & as standing for no more than #, *b*, $\natural$.

When time had discovered the use of the transposed modi, it was found that some of them could not be completed without introducing a fourth sign. Thus, in <u>$G^{\#}$ mollis</u> it was required to sharpen a note already sharpened,

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which is the 7 minor $F^{\#}$. The composers therefore found it necessary to invest a sign with a power of raising that note two semitones. This, some performed by doubling the # thus ## and others by the sign × which latter is now most generally received.

This sign has the same power of continuing till it is contradicted like the others. The method used to return a double sharpened note to its single sharpened state is to annex to it a # which here has the same power as a ♮ has when used after a #. The ♮ could not have been used on this occasion without confusion, for the note $F^{\times}$ returned to $F^{\#}$ by a ♮ would be equal to $F^{\#}$ returned to $F^{\natural}$ by the same sign, and consequently the necessary distinction between these two notes would have been lost.

To these 4 must still be added another sign namely a double flat, which in some extensive modulations is required, to the end of double flattening the note it is annexed to, and as a # before was used to return a double sharpened note to its single sharpened state so a *b* is employed when the occasion requires to return a double flattened note to its former single flattened condition, for the same reason we gave before: because the distinction between B^{bb} returned to B^{b} by a ♮ and B^{b} returned to $B^{\natural}$ by the same sign would otherwise be taken away.

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With the assistance of these 5 signs #, ♮, *b*, ×, *bb* we presume all modi as well as modulations may be completely noted, and as it is the main business of a composer to render his music plain and legible, it was soon discovered that the number of sharps and flats in the transposed modi were a great obstruction to the readiness of the execution. To remedy this inconvenience, they left out all sharps or flats annexed to the diatonic notes of the modi. Thus <u>*B* durus</u> was written

and the sharps annexed to *F*. *C*. *G*. *D*. and *A* were put at the beginning upon the lines and spaces where these notes or these octaves are placed. Ex:

By their means the whole scale was at once cleared from a number of perplexing signs, and the transposed modi became as plain and legible as the modus of *G*. Here we must take notice of a neglect some composers are guilty of, in not placing all the signs of a transposed modus at the beginning of the lines, for if <u>*B* durus</u> be only marked with 4 sharps instead of 5, the composer is obliged to repeat the 5^{th} sharp upon *A* as often as *A* is used, whereas he might have himself and his readers that trouble by putting it at the beginning. Moreover it takes away that regularity so much valued in music, of noting all modi the same way; for things that are alike ought to be treated alike,

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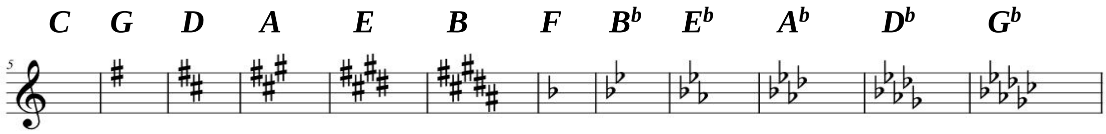
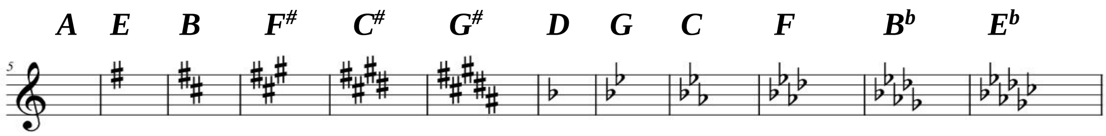
and if all the sharps and flats of *D*, *A*, B^b or E^b durus are put at the beginning upon the lines why not likewise all those of *B* or G^b durus, the 12 modi duri therefore should be marked thus



Concerning the modi molles, composers are still more inconsistent and divided, marking them sometimes one way sometimes another. The generality however seems to espouse the right method, which is that of putting upon the lines all the signs which occur in these modi, the 6 and 7 majors being excluded. Thus <u>*A* moll</u> is marked like <u>*C* dur</u>, because without the 6 & 7 majors, there will be no sharp in that modus. Experience will show that those who mark the 6 major upon the lines are oftener obliged to use a sign to render it minor, than those, who mark it minor, are, to render it major. But a very material reason against marking the 6 major upon the lines, rather than the 6 minor, is, that it is no ways entitled to that preference, for the latter is more essential to the modus mollis than the former, as may be gathered from what we have already said in our chapter on that modus, and will still appear more evident in the sequel.

The 12 modi molles then, we presume are most naturally marked thus,



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by which means their marks correspond with those of the modus duri, *C* with A, *E* with *G* and so on, according to the order of relation between them, but of this more hereafter.

To clear music as much as possible from superfluous signs, the composers were not content to have rid themselves so happily of all those which are annexed to the diatonic scale of the transposed modi, but they endeavoured likewise to cast off as many as possible of the accidental marks, but here their endeavours were not equally successful; for some of them employed means which rather puzzled than assisted the performance. The first of these is that they gave a power of continuance to the signs annexed to accidental notes, in any part of a piece equal to that of those put upon the lines. Hereby the memory of the executor is too much taken up, for as nothing can be easier than to recollect the signs upon the lines, because they leave all the notes in the diatonic, that is, the most natural situation; for nothing can be more burdensome than to carry in memory, the continuance of a sign superadded which puts the note it is annexed to out of the diatonic order. Accordingly most composers have discovered this

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inconvenience, and repeated the sign whenever they would have a note to be otherwise than it is marked at the beginning of the lines.

Here again, some thought it sufficient to extend the power of accidental signs to the length of one bar only and made it a rule never to repeat them [un]til at the expiration of that [bar], when the **|** (bar line) was to put an entire stop to their effect and renew the whole power of the signs upon the lines. They extended moreover this power to all octaves above and below so that *F* marked **#** was to imply *f* to be so likewise. But this method is subject to almost as many inconveniences as the former, for, an accidental sign can neither be a sufficient mark for all the notes and octaves in one whole bar especially if it be a long one, nor can the **|** be a sufficient mark to take off the effect of one, two, three or more signs used in the bar before. The ear of an executor requires some more satisfactory notation.

Some again did not extend the power of accidental signs but thought it sufficient, after having made use of them, to omit them without employing another sign to contradict them. But as it often leaves the performer in doubt whether he should continue or

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discontinue them, others with more justice made it a rule not only to repeat an accidental sign to denote its continuance, but likewise to contradict it to signify its omission.

To sum up the whole, the following is the most judicious and most generally received method of notation.

1/ the power of the signs upon the beginning of the lines, extends throughout the whole piece, except in those places where they are contradicted by accidental marks.

2/ whenever the accidental sign is not repeated after having been used some moderate while before, the power of the signs upon the lines takes place again.

3/ the power of accidental signs extends no further than the very note to which they are annexed, except first, in notes of the same denomination when they immediately follow one another; in which case it continues to any length whatsoever. Secondly in similar passages often repeated, for these are sufficiently marked by the signs of the first or second repetition, thus $g^{\#}$ $f^{\#}$ *e*, *g f e*, *g f e*, *g f e*, in *A* mollis is equal to $g^{\#}$ $f^{\#}$ *e*, $g^{\#}$ $f^{\#}$ *e*, $g^{\#}$ $f^{\#}$ *e*, $g^{\#}$ $f^{\#}$ *e*, [and] lastly in those passages where the notes marked are very frequently used, for in that case some of the signs may be left out, according as the composer thinks will best answer the end of notation.

4/ whenever the power of the signs upon the lines is to take place again after having used an accidental mark,

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it is necessary to contradict the same by a contrary, except first, in those places where a considerable time is past since it was used, secondly in passages where the accidental signs were only used upon passing notes & graces, for here the impression made by them is very inconsiderable and hardly deserves contradicting.

Lastly in all those places in general, where the impression of the accidental marks may be supposed to be destroyed by the harmony of the piece, for as the intention of all signs is only to render the performance easy to the executor without burthening the memory there can be no farther occasion for any when these ends are obtained.

Before we leave this subject we must still add one observation concerning the particular manner in which some composers use the signs.

To raise a note a semitone above the situation it is in, by the signs upon the line, they employ the # and to lower it the *b*, whereas in our way of notation both may often be done by a ♮. In B^{b} durus for instance the B^{b} and E^{b} may be sharpened by a ♮ and in *D* durus the $F^{\#}$ and $C^{\#}$ flattened by the same, in $G^{\#}$ mollis likewise the # cannot be employed to raise the 7 minor to $F^{\times}$. The difference consists in this, that they regard the signs relatively to the modus of the piece in which they are used. We on the contrary treat them positively and give them

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always identically the same signification. Thus, B^{bb} always makes an interval of 9 semitones to G, B^{b} one of 10 and $B\natural$ of 11. $F^{\#}$ likewise makes an interval of 5 semitones to $C^{\#}$ and $F^{\times}$ one of 6, so that the pitch of a note with a sign annexed to it, is as positively signified, as that of one without it, or in short all notes are alike in this respect; for when a note has no sign annexed to it, it is understood to be marked with a $\natural$.

It has been inquired, and not without some appearance of reason, why the lines and spaces we use are not equidistant. It seems to be irregular and inconsistent with the order we might expect in a musical scale, that, for instance from the lowermost line of the  cliff to the next space should only be a semitone and from that space to the next line a whole tone. But a little reflexion will soon clear up this point; for when we consider the nature of the modi and recollect that their 7 gradus are not of equal magnitude, we shall soon find there was a necessity of admitting this apparent irregularity. It was proper, for the sake of readiness and distinction, that each gradus should have a particular line or space to itself by which it might be distinguished from the other the distance of lines and spaces, therefore, could not consist of whole tones throughout the scale, because the gradus of the modi are not all of that magnitude.

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Likewise it was inconsistent with the order of the modi that any one should take up more than one line or space, for that would destroy the uniformity of notation, and therefore they could not all be at the distance of a semitone only, since some of the gradus are of a greater magnitude.

If each line or space had been at a distance of a tone, an octave would have taken in 6 only, or if otherwise at the distance of a semitone, it would have taken in 12, but in both cases the regularity of noting the gradus of the modi must have been neglected, whereas, by the adopted inequality, it is preserved not only in C durus but with the assistance of the signs likewise in all the transposed modi.

According to what we have said before each modus consists of 7 notes and as many intervals. Now when we compose a piece of music, in which it is required to express various sentiments, we find that some of the notes of the modi are more suitable to expressions of one kind than another; and that, in general, there is a great difference in their effect; from hence we may account for that pleasing variety of expression, so beautiful and so much to be admired in music. If there was no difference in the quality of notes, in vain would the composer call the power of sounds to his assistance, in vain would he endeavour to express different sensations. All the aids he might draw from loudness or softness, quickness or slowness

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would not amount to more than the expression of a drum or the reports of various firearms in an action. The time undoubtedly contributes greatly to the clearness of the expression, as without rythmus and metre no music would have a power of moving the passions in any great degree, but the qualities of sound determine especially the particular kind thereof, as whether we choose to express grief and sorrow or joy and content.

5/ Now these powers of expression are not essential to the notes considered by themselves, but depend on certain relations they have to one another; thus when $G^\#$ and *f* are used in consonance (the last being a septim (7th) as diminuta to the first) we are naturally affected with certain soft sensations of a sorrowful plaintive kind for that is the particular power of the relation there in between those two notes. But if either of them be heard in consonance with another note, so that the relation be thereby changed, we then soon perceive that the effect is likewise changed. Thus the *f*, in *G, f* (being a minor 7th) and the $G^\#$ in $G^\#$, $D^\#$ ([being] a [major] 5th) have none of that particular softness we observed in them, as they were related before, and this is a sufficient proof that the power of expression depends not on the pitch of a note but only on the relation it bears to those sounds with which it is used in consonance or sequence.

6/ Before we go to an examination of the particular powers of the notes which constitute the modi we

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shall find it necessary to explain the nature of the relation on which they depend, which we call **gravity**, for without this be well understood it will be impossible to lay down any general rules concerning the power of expression of particular notes.

The modi, we find, are divided into duri and molles or soft and hard, which words are here taken in a very extensive signification, for under the word soft are here comprehended all kinds of expression of a tender nature such as love, grief, sorrow, compassion, pity, benevolence, gratitude and so forth, and under the word hard likewise all kinds of expression of a stronger nature such as fortitude, magnanimity, joy, devotion, obstinacy, anger, wrath and so forth, and as the modus durus is more suitable to expressions of the latter kind so the modus mollis is more adapted to those of the former. Instead of the words hard and soft some have made use of the names major and minor to distinguish the modi, but as these terms are only taken from the tertia [third] which is major in one and minor in the other, they are not so capable of denoting the character of the modus to which they are applied, whereas on the contrary the epithets durus and mollis regard that only

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the ··· so the modus in general ··· the real character of the modi than those who call them major or minor that this later way of naming them is apt to occasion a misunderstanding of the name. So if the modi ··· duri be called sharp keys (a) then will G^b dur be commonly used, which is marked with *6* flats (*viz* D^b E^b F G^b A^b B^b C D^b) be a sharp key ··· and *G#* mollis on the contrary which is marked with 6 sharps (*viz* $G^\#$ $A^\#$ B $C^\#$ $D^\#$ $E^\#$ $F^\#$ $g^\#$) a flat key; which seems to make a contradiction. Besides the relation of the principal modi to each other which requires the utilisation of durus and mollis, we may further consider each of them as related to one of the transposed modi of the same kind, as for instance *C* dur to *G* dur or *F* dur & *A* moll to *E* moll or to *D* moll, and to distinguish these relations we shall use the words sharp and flat and call F dur when compared to *C* dur, a flat modus and *G* dur when compared to the same a sharp modus. Likewise *D* moll compared to *A* moll a flat mod and *E* moll compared to the same a sharp mod ··· since it is to be observed here that one of the three modus duris or mollis is looked upon as a punctum stans or standard to which the others are compared and from thence named sharp or flat and in

(note that many words on the original of this page are illegible)

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this case we are at liberty to choose for a standard which of them we please. Thus suppose we choose *G* dur for the punctum stans, then will *C* dur be a flat modus in comparison to it, for as *F* is to *C* so is *C* to *G* and as the notes of one modus are to its fundament, so are those of the others likewise to their fundamentals. Therefore the modi are to one another to their fundamentals, and since *C* is to *G* as *F* to *C*, *C* dur is to *G* dur as *F* dur to *C* dur, and *C* dur is consequently a flat modus when compared to *G* dur. This ought not to form contrary to what we have said of the manner of noting the modi with sharps or flats upon the lines; for tho' *C* dur is not marked with flats, yet we should consider that, as it has no sharps which *G* dur has, it must be flatter than the same since the absence of a sharp stands often instead of a flat.

But having resolved to treat of the relation of the modi for another chapter, let us now apply this to present purpose. It being thus settled that *G* dur is a sharp modus when compared to *C* dur; and this again, a flat modus in comparison to *G* dur, let us suppose that the gravity of the sharp modus *G* dur (for so we call that particular relation of sharpness and flatness between the modi and notes compared to each other) be to that of the flat modus *C* dur as 2 to 1 and from thence it will follow that every note of the one is to every respective note of the other in the same ratio of gravity. For since the fundamentals

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are to each other as the modi, *G* must be in the ratio of 2 to 1 sharper than *C*·, that is, if the gravity of *C* be 1 that of *G*· will be 2, and since all the notes of one modus are to all those of another as their fundamentals, not only *G* but likewise all the other notes of *G* dur must be in the same ratio of sharpness to *C* and all the notes of *C* dur, and consequently from both modi together we may collect the following series of degrees of gravity, which, as we shall afterwards prove are equal to each other, *F, C, G, D, A, E, B,* $F^{\#}$, *C* being the quarta of *G* dur according to the supposition is in the ratio of 2 to 1, sharper than *F*, which is the quarta of *C* dur: *G* the fundam than *C* the fundam, *D* the quinta of *G* dur than *G* the quinta of *C* dur, *A* the secunda than *D* the secunda, and so on to the end of the series. Therefore as the gravity of *C* is to that of *F*, so is the gravity of *G*· to that of *C*·, *D* to *G*, *A* to *D*, *E* to *A*, *B* to *E*· and $F^{\#}$ to *B*.

That this is the true order of the degrees of gravity will equally follow, whatever we suppose to be the ratio thereof between *C* durus and *G* dur, for if it be 3 to 1, 6 to 1, or any other ratio, the same argument will give us the series *F C G D A E B* $F^{\#}$ as before.

It remains now only to prove that the degrees of gravity of this series are equal to each other, and

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this will be very easy to conceive when we consider that musical intervals are as the logarithms of continual proportionals, where the notes which make the intervals are put for the terms. Thus for example let 1, 2/3, 4/9, 8/27, 16/81, 32/243, 64/729, 128/2187 be a series of continual proportionals for as 1 is to 2/3, so is 2/3 to 4/9, 4/9 to 8/27, 8/27 to 16/81 and so on, and let the same be represented by the letters or notes *F, C, G, D, A, E, B,* $F^{\#}$, for as *F* is to *C*, so is *C* to *G*, *G* to *D*, *D* to *A*, and so on, and let the logarithms of the letters or numbers be 0, 1, 2, 3, 4, 5, 6, 7, which will be in the following manner

1.	2/3.	4/9.	8/27.	16/81.	32/243.	64/729.	128/2187.
F.	*C*.	*G*.	*D*.	*A*.	*E*.	*B*.	$F^{\#}$.
0	1	2	3	4	5	6	7

Now since a musical interval is the difference between the sounds, it will be found here to be as the logarithms, for *C′* to *F* is one quinta, *G*:*F* is 2, *D*:*F* is 3, *A*:*F* is 4 quintas and so on (the fifths here are all taken extended or one above another).

Likewise take the logarithm of which *D* which is 3 and the logarithm of *A* which is 4 and there remains one, and take the interval *D* to *F* from the interval *A* to *F* and there remains one quinta, which is the interval between *D*:*A* and so with the rest, for as the common difference of the logarithm is one, so the common difference of the intervals is a quinta.

Now as the intervals answer to the logarithms of the series, so likewise the degrees of gravity answer thereto. As a proof of this we must desire our readers

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to recollect what we have said in Chap V concerning unisons and octaves, where it is proved by experience that the latter have to each other the same relations which the former have, for which reason the gravity between *c* and *g* is equal to that between *C* and *G*, for should it be different, they could never join in the execution of a piece of music, as gravity is the very principle on which all musical expression chiefly depends.

Since then the gravity between *c* & *g* is equal to that between *C* and *G*, we conclude from thence that it is as the logarithms, and not as the proportionals, for let *g* be to *c* as 6 to 4, and *G* to *C* as 3 to 2. Then if the gravity were as the proportionals that of *g* would be 6, that of *c* 4, of *G* 3 and of *C* 2, consequently the difference of gravity between *C* and *G* would be 1, and that between *C* and *g* 4. But this is contrary to what we have proved for since *g* may be joined to *G* in the execution of the quinta *C:G*, the gravity between *C* and *G*, and *C* and *g* cannot be different, and consequently it cannot be as the proportionals. From whence it follows that it must be as the logarithms, for the given series of the degrees of gravity, is already proved to be in continual progression which, if it be not

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geometrical, must be arithmetical, or the same as the logarithms of the letters representing the terms.

Hence it follows that those degrees are equal to each other, that is: the difference of gravity of the interval *F*:*C* is equal to that of *C*:*G*, of *G*:*D*, *D*:*A* and so on.

To extend this series to any length required we need but add so many degrees, which may be done by adding so many fifths. For as the intervals are so are the degrees of gravity, because they are both as the logarithms, and by forming a series of fifths we shall consequently form a series of the degrees of gravity, the above being extended both ways gives us the following

G^{bb} D^{bb} A^{bb} E^{bb} B^{bb}. F^{b} C^{b} G^{b} D^{b} A^{b} E^{b} B^{b}. *F C G D A E B*.
$F^{\#}$ $C^{\#}$ $G^{\#}$ $D^{\#}$ $A^{\#}$ $E^{\#}$ $B^{\#}$. $F^{\times}C^{\times}G^{\times}D^{\times}A^{\times}$&c:

Whenever we call some of these degrees flat and others sharp, it is proper that we should mention that particular degree to which are them rest & this is what we can call the standard or punctum stans, according to which the others will be denominated degrees of flatness or sharpness. To distinguish this let us mark it with a cipher the degrees of sharpness with the arithmetical progression increasing 1, 2, 3, 4, 5, &c and the degrees of flatness with the arithmetical progression decreasing -1,-2, -3, -4, -5, &c:

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for example, let *D* be the punctum stans, and the whole series will thence be in the following order of gravity:

&c:	G^{bb}	D^{bb}	A^{bb}	E^{bb}	B^{bb}	F^{b}	C^{b}	G^{b}	D^{b}	A^{b}	E^{b}
&c:	-15	-14	-13	-12	-11	-10	-9	-8	-7	-6	-5
B^{b}	*F*	*C*	*G*	*D*	*A*	*E*	*B*	$F^{\#}$	$C^{\#}$	$G^{\#}$	$D^{\#}$
-4	-3	-2	-1	0	1	2	3	4	5	6	7
$A^{\#}$	$E^{\#}$	$B^{\#}$	$F^{\#\#}$	$C^{\#\#}$	$G^{\#\#}$	$D^{\#\#}$	$A^{\#\#}$	*&c*			
8	9	10	11	12	13	14	15	&c			

where G^{bb} has 15 degrees of flatness and $A^{\times}$ 15 degrees of sharpness. If G^{bb} be taken for the standard the whole will become 30 degrees of sharpness, and if $A^{\times}$ be taken for the same they will become 30 degrees of flatness, and so on with the rest.

The degrees of gravity as well as the intervals, according to what we have proved follow the order of the logarithms, but with this difference, that the measure of the intervals must be taken from the logarithms of one continued series of proportionals, that of the gravity on the contrary from those of different series. As, suppose it be required to find the logarithm of the interval of the secunda *F:G*, then, because in the series here before given *G* is 2 fifths or a 9th to *F*, the logarithm of *G* in that place cannot be a measure of the interval of a secunda, but we shall be obliged to extend the series & to produce more terms, for which purpose we must

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choose an arithmetical progression of a greater common difference for the logarithms of the series of 5^{ths} before given, in order to have room, to express the smaller intervals, the following will be sufficient where the common difference is 31.

1	2/3	4/9	8/27	16/81	32/243	64/729	128/2187
F	*C*	G	D	A	E	B	$F^{\#}$
0	31	62	93	124	166	186	217

The logarithm of the secunda *F:G*, will be 9, which is the measure of its interval and in the same manner any other term required being produced will measure by its logarithm the interval of the same as *F*, $F^{\#}$, A^{b}, $A^{\natural}$, B^{b}, $B^{\natural}$, which are a semitone, a third minor & major a fourth minor & major, and are measured by their logarithms

1	15/16	8/9	5/6	4/5	3/4	32/54	2/3	4/9	8/27
F	$F^{\#}$	G	A^{b}	A	B^{b}	B	C	G	D
0	5	9	14	17	22	26	31	62	93

and so on.

But the case is different with the logarithms of the gravity, for suppose it be required to find that of the secunda *F*:*G*, here we are to form a different series of proportionals for this purpose, as thus

1/2 1/3 2/9 4/27 8/81 96/243 92/729 64/2187

whose logarithms must be the same with those of the others: for octaves as we have proved before

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differ not in gravity. Next, taking the *f* of this last series, and comparing it with the *G* of the former, which makes the interval of a secunda we may then find its gravity. The logarithm of *f* being 0 and that of G' 2 we have two degrees of gravity which is what was required, in the same manner we must proceed with other octaves or double octaves, only remembering to give the same letters, the same logarithms.

But this may be much easier performed, by making one series stand for all, for as the logarithms there of are all alike. *F*, *C*, *G*, *D*, *A*, *E*, *B*, $F^{\#}$ may stand for any one of them and its logarithms will sufficiently denote the gravity of any interval required thus the logarithms of *F* and *A*, 0 & 4 give us the gravity of a tertia, a decima, a septimadecima and so on. And likewise of all those intervals inverted, as a sexta, a tredecima and so on, but with this difference only that as before *F* was taken for a punctum stans, [since] from *F* to *A* were 4 degrees of sharpness, but now *A* being chosen for the same *F* is four degrees of flatness to it. And herein lies partly the cause of the difference in the effect of fundamental and inverted harmony but of this more hereafter.

When ever we hear a piece of music performed we find that the notes thereof are continually changing and shifting in this series expressing their gravity, some

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times to the sharp side, sometimes to the flat, then back again and so on, but in general this motion does not exceed a certain number of degrees either one way or the other and according as the shift is great or small the expression is found to be great and small likewise. So that whenever we perceive any great expression in the melody or harmony, we need best look on this series where we shall soon discover the cause thereof to lie in some considerable shift just then made therein either to one side or the other. From this and some other experiences we may draw several useful observations, as

1/ that the transition or shifting of the gravity is limited to a certain number of degrees.

2/ that a transition to the flat side is of a hard expression.

3/ that a transition to the sharp side is of a soft expression (note it must be here remembered that the words hard and soft are taken in the extensive signification explained page --).

4/ that those notes and intervals whose gravity is the greater are the more expressive, e.g. from $G^{\#}$ to *F* being 9 degrees of flatness is more expressive than from *B* to *F*, which is but 6, and

5/ vice versa those notes and intervals whose gravity is less are less expressive e.g. from *C* to *G*, being

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but one degree of gravity is less expressive than from *B* to *F* which is 6.

6/ that a piece of music which contains the greater and more frequent transitions, is the more expressive, and

7/ vice versa, a piece of music containing but few and moderate transitions, is of a calm and composed nature, for

8/ all violent expressions in general are caused either by the great extent and opposition of gravity or by the frequent changes and transitions thereof.

Chapt^{r}-

We have seen that the gravity of a piece of music is limited to a certain number of degrees which it never or seldom exceeds. The extent thereof in a piece which is in a modus durus comprehends generally about 6 degrees. These are in *C* dur

F	*C*	*G*	*D*	*A*	*E*	*B*
0	1	2	3	4	5	6

and taking *C*, the fundamental of that modus for a punctum stans we shall have 5 degrees of sharpness and one of flatness, the indices being fixed accordingly

F	*C*	*G*	*D*	*A*	*E*	*B*
-1	0	1	2	3	4	5

the fundamental will neither be sharp nor flat the secunda will have 2 degrees of sharpness, the tertia 4 degrees of sharpness, the quarta one degree of flatness, the quinta one degree of sharpness, the sexta 3 degrees of sharpness and the septima 5 degrees of sharpness. But this supposition does not seem to agree with experience, for the fundamental is in

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regard to all the notes of the modus, except *F*, a flat note and if it actually were the punctum stans, it could not appear so flat as we find by experience it does, it seems therefore reasonable that we should remove the standard some degrees further to the sharp side in order to give some flatness to the fundamental.

Let us then remove it to *D*, for beside the above reason, it seems to be more agreable to the nature of a puctum stans, to be fixed in the middle of the series, than near the extremes of it.

When the index of *D* is a cipher, the modus will be

C	*D*	*E*	*F*	*G*	*A*	*B*	*c*
-2	0	2	-3	-1	1	3	-2

as may be seen from the series thus marked

F	*C*	*G*	*D*	*A*	*E*	*B*
-3	-2	-1	0	1	2	3

and that this is the best and most natural way of fixing the indices may be proved from an experiment which is taken from the essential harmony of the modus: generally called the common chord.

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For if we take the chord of *C* namely *C*, *E*, *G*, we find that its flattest note *C* has two degrees of flatness & its sharpest note *E*, two degrees of sharpness, from which it is plain that it is placed as much at rest as a chord can possibly be placed since its sharpness and flatness are equal, and, as it were, balance each other. Moreover if the gravity of all the notes be added together, which will give the gravity of the whole chord, we shall have (C_{-2}) two degrees of flatness, (E_2) two degrees of sharpness and (G_{-1}) one degree of flatness equal to three degrees of gravity, which is the least any chord can possibly contain. And being thus perfectly at rest and having the least gravity, it answers in every respect the idea of the essential chord of a modus, which ought to be and, according to this supposition is, the standard of the different gravities of all other chords.

As we have thus seen that experience agrees to prove that in *C* dur, *D*, is the punctum stans, we shall thence draw this general conclusion, that the Nona of each modus durus is respectively its punctum stans, or that their essential chords are the standards of their harmony.

Chapt^r-

The modus mollis differs greatly in its gravity from the modus durus, not only in the number of degrees but likewise in the disposition thereof. For here we cannot fix the punctum stans in the middle of the

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series as we have done before, nor are 6 degrees sufficient for the extent of this modus.

We have seen [chapt^r-] that it admits the 6th and 7th minores as well as majores; but these cannot be introduced without admitting 9 degrees of gravity, they are

F	*C*	*G*	*D*	*A*	*E*	*B*	*F*#	*C*#	*G*#
0	1	2	3	4	5	6	7	8	9

The method of fixing the punctum stans must be taken from the modus durus, for as we have observed before (a) the modus mollis is in fact nothing else than a modus durus: with the 3rd minor as it were grafted upon it by the assistance of the 6th & 7th minores. If here then, we follow the same rule as we do with the modi duri, and take the Nona for a punctum stans we shall have the whole modus of *A*m: whose Nona is *B*, thus, ascending and descending

A	*B*	*C*	*D*	*E*	*F*#	*G*#	*a*	*G*♮	*F*♮	&c:
-2	0	-5	-3	-1	1	3	-2	-4	-6	

as may be seen from a series of degrees of gravity where the index of *B* is a cipher.

F	*C*	*G*	*D*	*A*	*E*	*B*	*F*#.....		*G*#
-6	-5	-4	-3	-2	-1	0	1	2	3

But to render the difference of the gravity between the modi duri and molles more conspicuous, let us instance in two of the same denomination *viz.* *C* dur and *C* moll, the first is as we have given it before, the latter thus

$$\begin{array}{cccccccccc} C & D & E^b & F & G & A^\natural & B^\natural & c & B^b & A^b \ \ \&c: \\ -2 & 0 & -5 & -3 & -1 & 1 & 3 & -2 & -4 & -6 \end{array}$$

Here all the notes have respectively the same gravity, they have in the

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modus durus except the tertia, the sexta & septima minores and these being all much flatter than the same majores it is easily supposed that this must proceed from their gravity since between a natural and a flat note of the same name there are no less than 7 degrees difference, as

$$\begin{array}{cccccccc} (AEB)^b \cdots & \cdots & \cdots & \cdots & \cdots & \cdots & (AEB)^\natural & \\ 0 & 1 & 2 & 3 & 4 & 5 & 6 & 7 \end{array}$$

In a modus durus the tertia sexta and septima majores constitute the sharp part of the modus, *viz*

6th	IIIrd	VIIth
A	*E*	*B*
1	2	3

but in a flat modus they make out the flattest part thereof *viz*

6th	3rd	7th
A^b	E^b	B^b
-6	-5	-4

As to the essential chord of this modus, it is neither in its lowest degrees of gravity, nor as it were balanced by the sharpest and flattest note thereof. But this is the particular nature of the modi mollis, and here again we find our manner of fixing the punctum stans confirmed by experience; for the gravity of the chord of *C*m, is (C_{-2}) two degrees of flatness ($E^b{}_{-5}$) five degrees of flatness and (G_{-1}) one degree of flatness. *C* and *G* are equal, in both therefore the difference lies in the tertia and is 7 degrees as we have observed before. However when we hear only the essential chord of *C* moll, and some other chords in the same modus we do not perceive so great a flatness in the chord of *C* moll as seven degrees would infallibly produce.

This is owing to our looking upon *A*m, in that case in a different light, for it is then no longer relative to *C* dur but becomes a standard of its own modus, and the flatness we perceive in it is owing to its being placed

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in the flat part of its own modus, whereas in the chord of *C* dur no such flatness can be perceived, it being placed in the middle of the series. The two following examples will show this more evidently.

Fund 5th							IIIrd		
F	*C*	*G*	|*D*|	*A*	*E*	*B*	
-3	-2	-1	|0|	1	2	3	

3d			Fund 5th								
A^bC	E^bG	B^bD	*FA*	*CE*	*GB*	|$D^\#$|	*A* to *B*		
-6	-5	-4	-3	-2	-1	|0|	1	2	3

From this experiment, it is plain that we should offend against the nature of the modus mollis if we placed its essential chord in the middle thereof, as thus for instance

3d						Fund 5th					
A^b	E^b	B^b	|*F*|	*C*	*G*	*D*	*A*	……	*B*
-3	-2	-1	|0|	1	2	3	4	5	6

for since we clearly perceive a great flatness in this chord it ought to be placed to the flat side as we have done.

Notwithstanding this eccentricity, if one may so call it, of the essential chord, it may still be a standard of the gravity of other chords pertaining to this modus, for as numbers may be called great or small, not only when they are referred to unity as a common centre, but likewise in comparison to any other number greater or less than unity; so chords may be denominated flat or sharp, in reference to other chords not exactly placed in the centre of gravity. Moreover although several ancient composers often had recourse to the essential chord of the modus durus, when they finished a piece in a modus mollis, in order to let

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the gravity be perfectly balanced and the ear no longer suspended. Yet, we find by experience that this is not necessary, and that the ear is very well satisfied with the flatness, or eccentricity of the essential chord of a modus mollis, which now our composers use without any further hesitation as a perfect principal chord.

Chapt^{r}-

After having fixed the standard of gravity in the principal modi we shall find no difficulty to do the same in their inferiors or subordinates. These are only parts of the former differently taken and rendered more melodious by the addition of one two or more notes. Their gravity therefore must coincide with that of their principals. Thus in the modus durus of the quinta to *C* dur, the gravity is

G	*A*	*B*	*C*	*D*	*E*	$F^{\#}$	*g*	$F^{\natural}$	*&c*:
-1	1	3	-2	0	2	4	-1	-3	

ascending and descending which is the same as in *C* dur, but with the addition of $F^{\#}_{4}$ as the reader may find in comparing it with its principal.

Having thus far explained the nature of gravity we may now assign a reason for the imperfection of this subordinate modus, from the gravity of its essential chord G_{-1} B_{3} D_{0} , which is not equally balanced and therefore not at rest. For whenever a chord is not placed as much in the centre of gravity as it can be, it will tend to form other more perfect harmony, and accordingly

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we find that B_{3}, which is most distant from the punctum stans tends to the flat side, *viz*. to C_{-2} , but G_{-1} being already near enough is indifferent and may remain, and D_{0} which has no gravity at all may go to the flat side C_{-2} or the sharp side E_{-2} indifferently. This being done we shall have C_{-2} E_{2} G_{-1} where the gravity as we have before observed is entirely at rest and consequently the ear perfectly satisfied.

The gravity of the modus durus of the quinta to *A* mollis, is determined in the same manner as that of <u>*G* dur to *C* dur</u> *viz* from its principal modus with those notes added there to, which it admits beside, either ascending or descending, which is in the following manner,

E	$F^{\#}$	$G^{\#}$	*A*	*B*	$C^{\#}$	$D^{\#}$	*e*	$D^{\natural}$	$C^{\natural}$	*B*	*A*	$G^{\#}$	$F^{\natural}$	*E*
-1	1	3	-2	0	2	4	-1	-3	-5	0	-2	3	-6	-1

Here no less than 10 degrees are admitted on account of the septima major $D^{\#}_{4}$ and the secunda diminuata $F^{\natural}_{-6}$, for these are at the distance of 10 degrees from each other as may be seen in the extended series of 30 degrees before given, or else may be taken from their indices. To find the gravity of any given interval we must substract the lesser index from the greater, therefore to find the gravity of $D^{\#}_{4}$ to $F^{\natural}_{6}$ we must take -6 from 4, which leaves us 10 degrees for the gravity of that interval.

The imperfection of this modus is accounted for from the same principles as that of G dur to C dur, for the tertia of its essential harmony E_{-1} $G^{\#}_{3}$ B_0 has 9

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degrees of sharpness and consequently a tendency to the flat side. And this must appear so much the more striking since it is referred to a flat chord as to its standard, for opposite of all kind are the easier distinguished the more they are opposite. Accordingly $G^{\#}_{3}$ tends to A_{-2} but E_{-1} having but one degree of flatness has no tendency and may remain, and B_0 as the punctum stans is entirely indifferent and may either proceed to C_{-5} or to A_{-2}. Which being done we have the essential chord of its principal modus A_{-2} C_{-5} E_{-1} where the ear rests satisfied in the manner above described, that is with a sensation of flatness, or eccentricity.

Chapt[r]-

Having thus fixed the gravity of every respective note of the modi, it will be easy from hence to explain the power of expression peculiar to each of them for this is nothing else than the gravity itself acting under different circumstances with every one of them. As no one note (octaves excepted) has the same gravity which another has, so no one can have the same power of expression with another. When we run over the keys of an organ or pass with our voices from one note to another, we may observe that in particular cases we are from some notes insensibly led to others. This is what we call a tendency in those notes from which we pass to those, to which we proceed.

But here we must carefully distinguish between arbitrary progressions and those to which we are naturally

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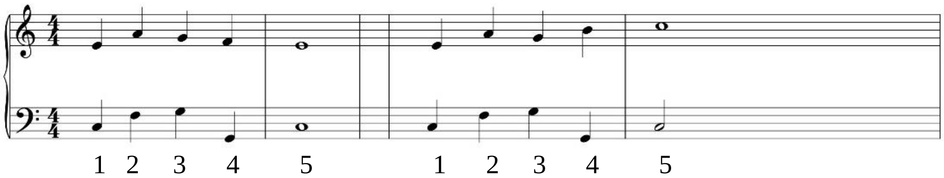
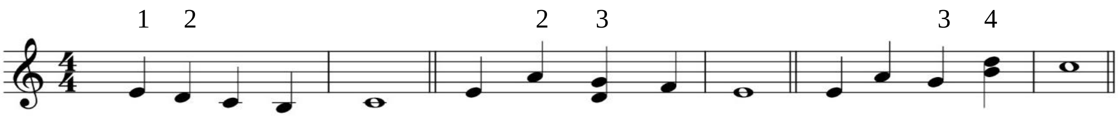
led by the tendency of the notes. An example or two will explain this sufficiently.



Here the progressions in the treble, from 1 to 2, 2 to 3, and 3 to 4 are arbitrary but those from 4 to 5 are not. We call them arbitrary because they may be changed any how with equal satisfaction to the ear, as is evident from these examples,



where they are all changed notwithstanding the same harmony remains as before. But since we cannot interrupt the progressions from 4 to 5 without committing a sort of violence to nature, we must allow them to have a particular tendency which the others have not. (Note -We would by no means confine a composer always to proceed without interruption from *f* to *e* or *b* to *c*, whenever the harmony above given might occur. On the contrary we know very well that upon many occasions it may answer his purpose better to proceed otherwise, as thus

where *b* is not followed by *c*, but this is comprehended under resolution or motion by supposition as the reader will find both chapt[r]- where the note to [End of Text]

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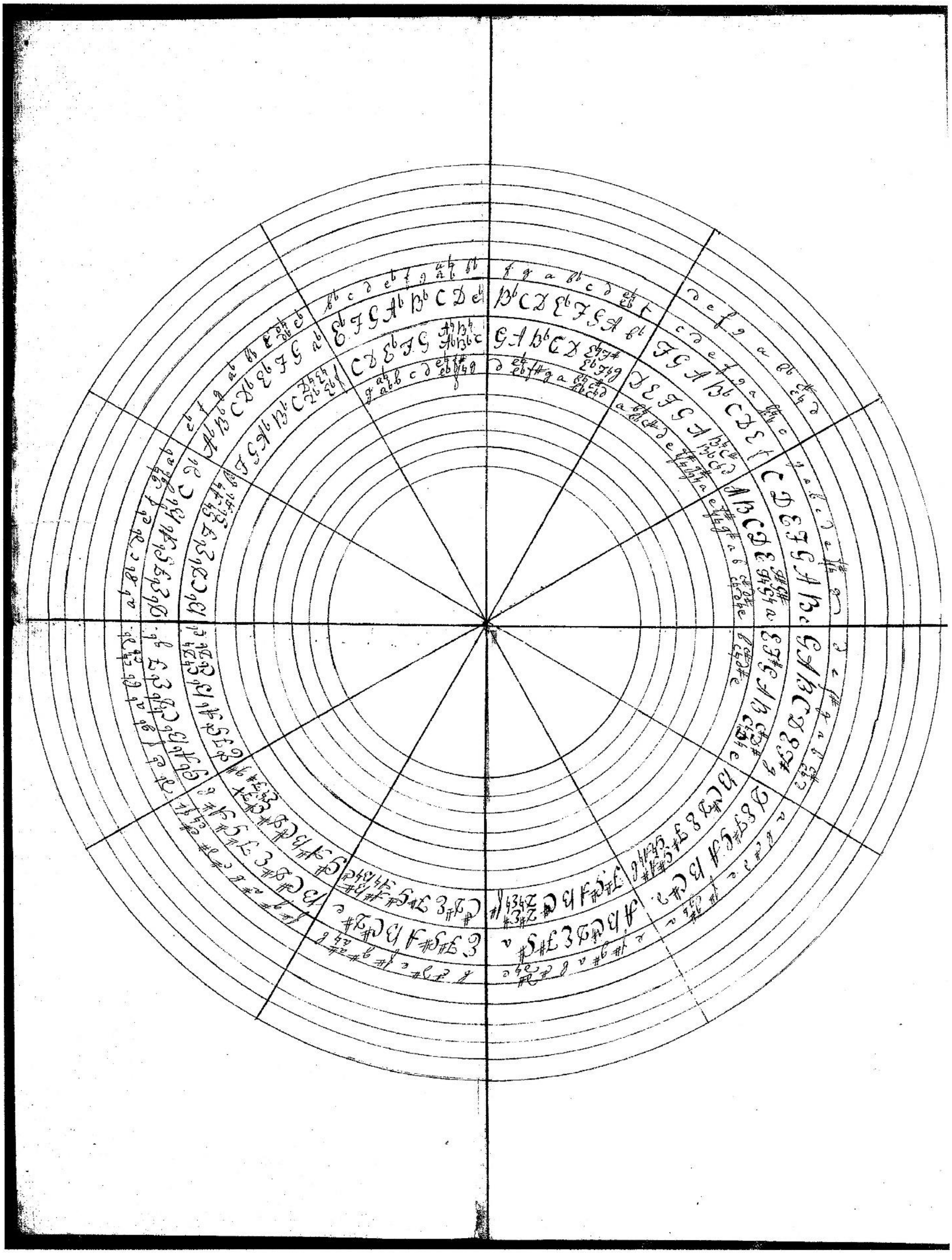

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About the treatise

Basic remarks

Here are some remarks concerning the treatise. Some of them are obvious but we quote them for clarity.

- The text contains some pagination errors, so we have included the author’s numbers along with the 'real' page numbers.
- Due to variations in the density of the text, some pages are creased and ink in the original is badly smudged, some words or passages are illegible (see figure 5), which we have indicated in the text. In particular the contrast of page 20 is very weak and very difficult to read (we can suppose the text was in the sunlight for a long time).
- The binding frequently obscures text in the guttering.
- William Herschel is a German born musician, so the English text contains vocabulary and grammatical errors. In order to respect the musical content, we have not corrected the text, except for clarity, when mistakes are obvious.
- This is an 18th century English text; so the 'old' English words, letters (*f* for *s*) and terms are corrected.
- *Modus durus* and *modus mollis* are the major and minor modes.
- The treatise is not finished, or the pages have been lost. However one can see the reproduction of the last page which shows a "rose window" containing the 12 tones as a memorandum to help for harmonic transposition.
- The treatise contains a long discussion (about 10 pages) concerning the use of the common signs *#*, *b*, ♮ and × (the latter corresponding to *##*). The aim is to write music not overcharged with such signs, with developments about the cancellation (or not) in one bar or more of such signs.
- The notion of *punctum stans* is derived from the astronomical influences of Herschel, It is known to define the static Ptolemaic universe, or the five Lagrange points in the solar system, where no interaction occur (the ideal place for long term observing of satellites).

Comments on the treatise

The aim of these comments is not to present a critical analysis of the treatise, but to allow the reader to develop his own view of the musical ideas and acoustic theories developed by William Herschel in the light of what was known or admitted in the second half of the 18th century, and the numerous harmonic problems.

The treatise essentially tries to solve many acoustic questions as it was written at the same time by authors and musicians such as Jean-Philippe Rameau (1683-1764), *Traité de l'Harmonie* (1722), which initiated a revolution in music theory. Rameau posited the discovery of the *fundamental law* or what he referred to as the *fundamental basis* of all western music. Influenced by new Cartesian modes of thought and analysis, Rameau incorporated mathematics, commentary, analysis and a didacticism that was specifically intended to illuminate, scientifically, the structure and principles of music. With careful deductive reasoning, he attempted to derive universal harmonic principles from natural causes. Previous treatises on harmony (e.g. *Harmonie Universelle* by Marin Mersenne published in 1636-1637) had been purely practical; Rameau embraced the new philosophical rationalism quickly rising to prominence in France as the "Isaac Newton of Music".

Another essay in music at the same period was written by Jean-Jacques Rousseau (1712-1778): *Projets concernant de Nouveaux Signes pour la Musique* published in 1742. Rousseau developed his own system of musical notation which was numbered and compatible with typography. He presented the invention to the *Academie des Sciences*, which politely rejected it, while praising his innovation and creativity. However, with compositions later written, Rousseau got a position at the *Encyclopédie* of Denis Diderot (1713-1784) and Jean le Rond D'Alembert (1717-1783) where he wrote the *Lettre sur la Musique Française* and several articles about music.

It is essential to be familiar with the basis of musical theory when examining Herschel's text. One of the most relevant treatises on music is the famous *Science & Music* published in 1937 by Sir James Jeans; it is considered to be the best exposition on the subject. Note that, like William Herschel, Sir James Hopwood Jeans (11 September 1877 – 16 September 1946) was a physicist, astronomer and mathematician. Jeans was elected Fellow of Trinity College in October 1901 and taught at Cambridge, but went to Princeton University in 1904 as a professor of applied mathematics. He returned to Cambridge in 1910. He made important contributions in many areas of physics, including quantum theory, the theory of radiation and stellar evolution; he is also a founder of British cosmology. Note that Jeans second wife was the Austrian organist and harpsichordist Suzanne Hock (better known as Susi Jeans), who recorded for the first time organ pieces of Herschel. The following lines summarize the basic of music's theory.

Since time immemorial, the "official" scale has remained that of Pythagoras, the principle of which is based on the successive multiplication and division of the fundamental by the 3/2 ratio. Sequences of fifths are thus stacked in a series where C_1 corresponds to 1, rising towards the upper:

C_1	G_1	D_2	A_2	E_3	B_3	$F^{\#}_4$	$C^{\#}_5$	$G^{\#}_5$	$D^{\#}_6$	$A^{\#}_6$	$E^{\#}_7$	$B^{\#}_7$
1	3/2	$(3/2)^2$	$(3/2)^3$	$(3/2)^4$	$(3/2)^5$	$(3/2)^6$	$(3/2)^7$	$(3/2)^8$	$(3/2)^9$	$(3/2)^{10}$	$(3/2)^{11}$	$(3/2)^{12}$

or descending lower (the division by 3/2 corresponding to a multiplication by 2/3):

C	F	B_b	E_b	A_b	D_b	G_b	C_b	F_{bb}	B_{bb}	E_{bb}	A_{bb}	D_{bb}
1	2/3	$(2/3)^2$	$(2/3)^3$	$(2/3)^4$	$(2/3)^5$	$(2/3)^6$	$(2/3)^7$	$(2/3)^8$	$(2/3)^9$	$(2/3)^{10}$	$(2/3)^{11}$	$(2/3)^{12}$

Knowing that a note doubles its frequency in the upper octave, we must therefore have $B^{\#}_7 = C_8$, or $2^7 = 128$. However, we see that we now have $B^{\#}_7 = (3/2)^{12}$ or 129.7463. This difference of 1.7463 is the Pythagorean comma, the value of which is a function of the units chosen. The term “savart” is commonly used to express the intervals between two sounds; an octave has 300 savarts, so there are 25 savarts in a semitone (the twelfth). In this scale, the Pythagorean comma corresponds to 5.885 savarts. The disadvantage of this scale lies in the tuning of an instrument with extended tones such as the organ, the harpsichord or the piano: after 7 octaves adjusted according to this principle, C7 would have a tonality increased by more than 40 savarts, i.e. almost D7. For this reason, the Pythagorean scale is not used in tuning musical instruments, especially when they are played together.

Zarlin's scale (also attributed to Aristoxenes which often appears in Herschel treatise) is based on dividing a string into 2, 3, 4 etc. equal parts. The sounds obtained, relative to the same octave, give all the notes of the scale. If we take for example C_1 as the fundamental reference corresponding to the integer 1, we have the upper octave C_2 for the integer 2. We define in this way a sequence of sounds:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
C_1	C_2	G_2	C_3	E_3	G_3	B^b_3	C_4	D_4	E_4	$F^{\#}_4$	G_4	$G^{\#}_4$	B^b_4	B_4

The thing is now to calculate the ratio of each note from a fixed fundamental which here is C. The C-D interval corresponds to harmonics 8-9 and is noted 9/8; the interval C-E is written 5/4, C-F 4/3 (this is a fourth equal to G-C), and so on.

The result gives the following values:

C-D	C-E	C-F	C-G	C-A	C-B	C-C
2nd	3rd	4th	5th	6th	7th	8th
9/8	5/4	4/3	3/2	5/3	15/8	2

This table makes it possible to calculate all the ratios of two consecutive sounds, C-D, D-E, E-F etc., by calculating the ratio of each note to its fundamental. Thus, D-E is the ratio of 5/4 to 9/8, or 10/9. We thus obtain three families of intervals:
- the major tone equal to 9/8, i.e.: C-D, F-G, A-B
- the minor tone equal to 10/9, i.e: D-E, G-A.
- the major semitone equal to 16/15, i.e.: E-F and B-C.

The interval between a major tone and a minor tone is the ratio of 9/8 to 10/9, or 81/80: this quantity is called Zarlin's comma. The structure of such a scale breaks down as follows: the sequence (9/8, 10/9, 16/15) to go from C to F, (9/8) from F to G and (10/9, 9/8, 16/15) to go from G to C, that is to say two tetrachords separated by a major tone. This scale can be altered by the introduction of flats whose value is equal to a minor semitone, i.e. the ratio of a minor tone (10/9) divided by a major semitone (16/15) which gives the value 25/24.

The difficulties of the Zarlin range are manifold; in particular, transposition to another key is impossible there because of the inequality of the successive intervals. It is impossible to obtain a scale formed of two tetrachords inserting a major tone, without readjusting the tuning of the instrument. While this handicap is easily remedied on a continuously tuned instrument (like the violin) with a slight slide of the finger, any such transposed scale will sound out of tune on an organ.

In the absence of being able to compensate for the sounds of the pipes by any artificial means, Werckmeister’s idea consisted in "reducing" certain deviations (therefore symmetrically "increasing" others). To do this, he distributed the Pythagorean comma over 4 fifths (C–G, G–D, D–A and B–G^b). Called "Werckmeister III" (Andreas Werckmeister, 1645-1706), this temperament is the one most used to tune old organs or copies of old ones.

All these questions are clearly expressed in William Herschel treatise with different solutions, or approaches to solve them. In particular, it is obvious that Herschel was mainly concerned to fix the tuning of his different organs, especially at the *Octagon Chapel* in Bath. This is probably why the treatise largely follows the Zarlin range, trying to find tricks in order to upgrade the possibilities of transcription without the difficulties presented above. The compositions of William Herschel for solo instruments, orchestra and voices have no more than 3 sharps or 3 flats which simplifies all these problems, and it is certain that the quality of his music is at the same high level as his qualities as an astronomer.

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Dominique Proust has both a scientific and a musical background and is a research scientist at the CNRS and an astrophysicist at the Paris Observatory. After his Doctorate, his works were directed towards observational cosmology and entails his use of the largest telescopes throughout the world. He has published many scientific works in several journals of astronomy and written text books for the university and for popular astronomy. He received the CNRS Medal of Honour in 2015.

Dominique Proust is organist at Notre Dame de l'Assomption at Meudon (Paris) and has studied the organ with Pierre Moreau and Jacques Marichal, both organists of Notre Dame de Paris, and with Daniel Roth, organist of St Sulpice in Paris. He has given concerts in Europe, Canada, Australia, Brazil, Peru and Chile as well as on Radio France and at international festivals. He has made world premier recordings of the organ works of William Herschel (1738-1822) and of Pierre Moreau (1907-1991) which were both received with international critical acclaim.

Gus Orchard was born in London 139 years after the Great Comet C/1811 F1. Despite this coincidence, he studied to become a chartered accountant as well as pursuing musical activities, principally playing the organ and singing. In 1975, he moved to Paris for his work and, soon after arriving there, met Dominique and Brigitte Proust in the choir at Notre Dame. A great friendship developed and Anglo-French relations have improved considerably as a result. His work as an accountant and then finance director of a number of companies caused him to move back to England where he lives with his wife Lucy in the county of Worcestershire.

In his retirement, he is formalising his organ studies and, having obtained his diploma as an Associate of the Royal College of Organists in 2019, is supposedly studying for his Fellowship. In the meantime, Dominique keeps him interested in astronomy by sending him texts to translate from French into English and this is undoubtedly a novel but effective method of learning something different.