outdoors with the *davul*. See L. Picken: *Folk Musical Instruments of Turkey* (London, 1975).

See also BĀLABĀN, (1) and DUDUK (i).

R. CONWAY MORRIS

Meydan sazı. Turkish long-necked lute. The *meydan sazı* ('public square *saz*') is the largest type of SAZ. It has four or more double courses of strings and is constructed and played like the BAĞLAMA.

Meyer, Conrad (*b* Marburg; *d* Philadelphia, 1881). American piano maker of German origin. He emigrated to Baltimore in 1819, subsequently working for the piano maker Joseph Hisky. In 1829 he settled in Philadelphia where he started his own firm, and in 1833 exhibited one piano with 'shifting or transposing action' and another with an iron frame at the Franklin Institute. He later claimed that this square was made in 1832 and was unique in the USA for its single cast-iron frame. He did not patent it, and was in fact preceded by ALPHEUS BABCOCK, who patented a similar frame in 1825. But Meyer was often credited with this clever design, which permitted greater string tension and consequently a more resonant tone. Spillane (1890) wrote that Meyer made excellent pianos and that on Meyer's death the firm passed to his sons. The firm continued into at least the 1890s.

BIBLIOGRAPHY

D. Spillane: *History of the American Pianoforte* (New York, 1890/*R*1969)

The Crosby Brown Collection of Musical Instruments of all Nations: Catalogue of Keyboard Instruments (New York, 1903)

MARGARET CRANMER

Mezzadri, Alessandro (*fl* Ferrara, *c*1690–1732). Italian violin maker. It has been said that he was a capable performer; a conflict between two careers would certainly explain his meagre output as a maker. There is little doubt that his best instruments have suffered from being relabelled with more famous names. His violins are essentially patterned after the Amati school but there appears to have been no obvious attempt at mere copying. While they tend to be small they invariably give the impression of being larger. The design of the soundholes usually derives from the Amati school, but those cut for his violas often lean towards Brescian models. The few surviving cut-down violas indicate, by the unusual length of their soundholes, that they originally must have measured close to 480 mm (or more) in body length. The quality of varnish can be exceptionally good and varies from a vivid orange-red to a golden brown.

BIBLIOGRAPHY

W. L. von Lütgendorff: *Die Geigen- und Lautenmacher vom Mittelalter bis zur Gegenwart* (Frankfurt am Main, 1904, rev. 6/1922/*R*1968)

JAAK LIIVOJA-LORIUS

Mezzo, mezza (It.: 'half', 'medium'). A word used in several different musical contexts, one of the commonest of which is the mezzo-soprano voice. In current Italian *mezza manica* means the half-position in string playing, *mezza cadenza* a half-cadence or half-close and *mezzotono* a semitone. In addition the following universally used technical meanings appear.

(1) *Mezza voce, mezzavoce* ('half-voice'). A direction in both vocal and instrumental music to produce a quiet, restrained tone, found as early as Tosi's *Opinioni* (1723, pp.20f), where it is recommended that ascending appoggiaturas, especially those involving chromatic intervals, be performed *mezza voce*. This very specific direction is most often found in operatic scores of the 19th century: in the second act of Verdi's *Otello*, for example, Iago's narration of Cassio's dream ('Era la notte, Cassio dormiva') is marked *mezza voce*; and the opening scene of *Simon Boccanegra* is marked 'tutta questa scena a mezzavoce'. It appears also in instrumental music, for example in the slow movements of Beethoven's opp.106, 109, 125 and 131; in very similar circumstances he also used *sotto voce* (*see* SOTTO). The French equivalent in the 18th century, *à demi* or *à demi voix*, also applied to both vocal and instrumental music. *Mezza voce* is entirely different from MESSA DI VOCE.

(2) *Mezzo-forte, mezzo-piano* (*mf, mp*). Dynamic indications implying moderation. Thus *mezzo-forte* is less loud than *forte*; and *mezzo-piano* is less soft, therefore louder, than *piano*. *See also* TEMPO AND EXPRESSION MARKS.

(3) *Mezzo-legato, mezzo-staccato* (and *legato-staccato*). Articulations normally designated by a slur with staccato dots beneath it; *see* ARTICULATION.

mf. *Mezzo-forte* (It.: 'moderately loud'); *see* MEZZO, MEZZA, (2).

Mfuhlulu ('ululation'). *See* TSHIHOHO.

Mfunga. Side-blown trumpet of the Nguli people of Zaïre. It is the smallest of the *funga* trumpets made from hollowed-out roots or branches (*LaurentyA*, 332).

Mgba. DRUM-CHIME of the Igbo people of Nigeria.

Mgung. Double clapperless bell of the Mbun people of Zaïre. *See* GONGA (i).

Mhiyém. Wooden cone flute, with one or two finger-holes, of the Shongo people of Zaïre (*LaurentyA*, 149).

Michaelis, Zanetto de. *See* ZANETTO DI MONTICHIARO.

Microchordon. A name used by COLLARD & COLLARD for a small upright piano.

Microtonal instruments. Instruments adapted or specially constructed for performing music in microtonal tuning systems or to give accurate tuning in temperaments other than the 'standard' 12-note equal temperament. (There is considerable overlap between these two functions in some microtonal instruments.) This article deals only with Western instruments; instruments constructed in other parts of the world for the performance of music in systems of intonation other than 12-note equal temperament are dealt with under their own headings.

Three main periods can be distinguished in the development of Western microtonal instruments: the work of theorists in the 16th and 17th centuries, acoustic research in the second half of the 19th century, and the explorations of composers, performers and researchers throughout the 20th century. Until the end of the 19th century there was little interest in microtonal compo-

ic guitar (?1829; for illustration *see* JUST INTONATION, fig.5), the 31-note 'githarfa' (Ger. 'Guitharfe') built by the Hungarian physicist József Petzval in Vienna in 1862, and a quarter-tone trumpet (1893, now in the Odessa Conservatory). In 1864 a piano tuned in just intonation was built for the Russian Prince Odoevsky.

3. 1900–30. Around 1890 Carl Andreas Eitz extended his experiments to quarter-tones; similar interests were soon pursued by others, especially in Germany, and inaugurated a new phase in microtonal music. This was characterized by the appearance not only of a considerable number of compositions in various tuning systems, but also of a great variety of specially constructed instruments.

Much of the quarter-tone music written in this period involves retuning or different fingering of existing instruments. The earliest composition to use quarter-tones appears to have been Halévy's *Prométhée enchaîné* (1849), in the string parts; in 1898 the British composer John Foulds wrote a string quartet (now lost) that used quarter-tones, and from 1905 he included microtones for bowed strings in other works. The first important quarter-tone composition, and perhaps the first fully microtonal work, was Charles Ives's *Chorale* for strings; this was variously dated 1903–14 and 1913–14 by the composer, and was probably based on experiments carried out with two pianos tuned a quarter-tone apart around 1900–01. The *Chorale* is also lost, but it was arranged for two pianos by Ives as the last of his *Three Quarter-Tone Pieces for Two Pianos* (1923–4), from which Alan Stout has reconstructed the original.

Other quarter-tone practitioners before 1930 included Julián Carrillo, who evolved the theory of 'the 13th sound' (*el sonido trece*) in 1895, but wrote no microtonal music until 1922; Arthur Lourié, who between 1908 and around 1913 wrote a number of works, including a string quartet (1910); several Soviet composers in the mid-1920s, including Georgy Rimsky-Korsakov, who founded the Petrograd society for quarter-tone music (1923) and directed its ensemble (1925–32), and who wrote parts in his works for quarter-tone harmonium and Emiriton, Arseny Avraamov (who also devised an $\frac{1}{8}$-tone 'universal tonal system'), Nikolay Malakhovsky and Aleksandr Kenel'; and a number of musicians who developed or commissioned special instruments (see below). During this period quarter-tones were also briefly exploited in single works by Vittorio Gnecchi, Ernest Bloch and Alban Berg.

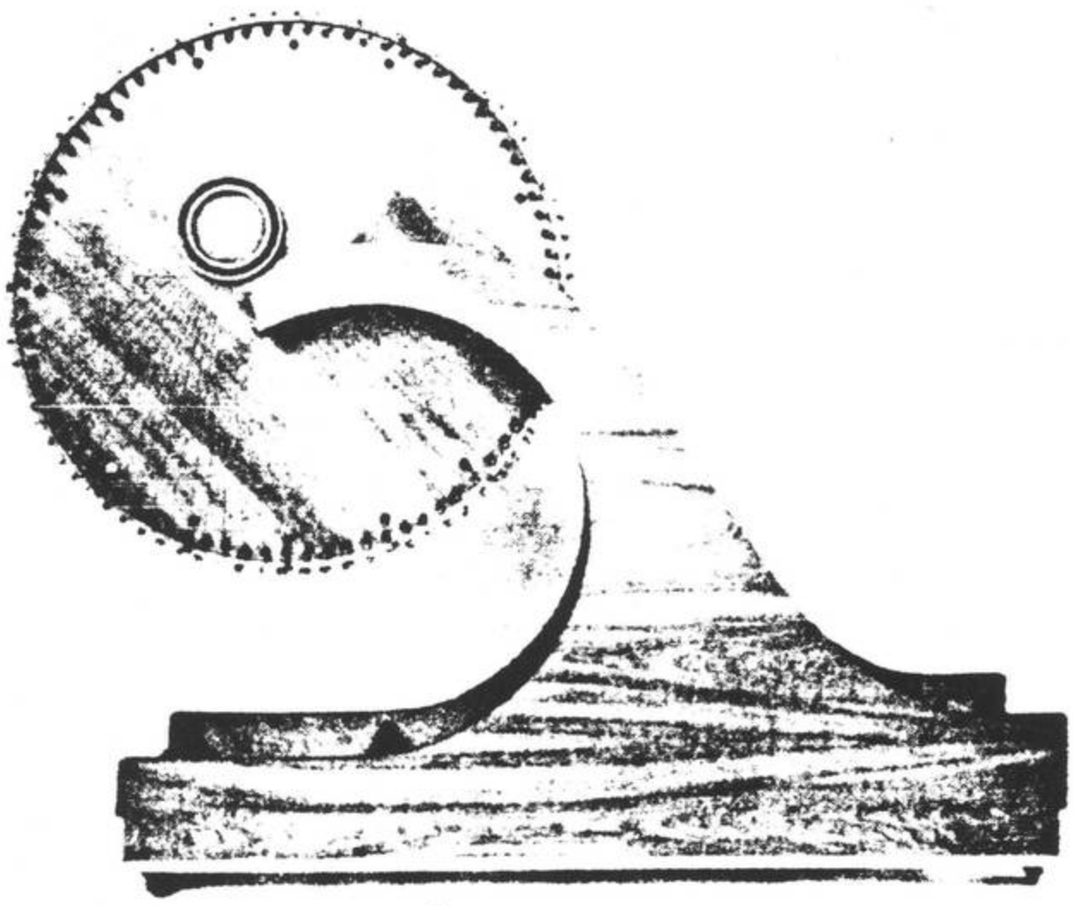
Before the 1890s only a few quarter-tone instruments were constructed; they included one built around 1850 by Alexandre-Joseph Vincent and Bottée de Toulmon, who were inspired by the Greek modes, and a set of tuned glasses and an instrument with about 24 strings made around 1885 by George Ives (the composer's father). From 1890 a considerable number of quarter-tone pianos and harmoniums were built (see Table 2), as well as a few in other tunings. Some of these instruments have two manuals tuned a quarter-tone apart; others have three manuals, the third duplicating the first to allow alternative fingerings (the length of the keys diminishes on each manual, so that on the one furthest from the player the white keys are the same size as the black ones). Those instruments with a single manual, including the harmoniums by Max F. Meyer and von Moellendorf, have unconventional keyboard lay-outs (*see also* KEYBOARD, §3).

TABLE 2

Instrument	*Date*	*Inventor, builder*
'achromatisches Klavier' (2 manuals)	1892	G. A. Behrens-Senegalden (Berlin)
harmonium (1 manual)	1902	Max F. Meyer (USA)
harmonium	*c*1906	Josef Anton Gruss (Franzensbad, Bohemia, now Františkovy Lázně)
harmonium (2 manuals)	1911	Jörg Mager (Aschaffenburg), built by Steinmeyer
piano (unfinished)	*c*1913–14	Arthur Lourié (St Petersburg), built by Maison Diederichs
'bichromatisches Harmonium' (1 manual)	1915	Willi von Moellendorf (Berlin), built by Otto Pappe
'enharmonium'	1921	Silvestro Baglioni (Rome)
piano (unfinished) (2 manuals)	1922	Ivan Vïshnegradsky (Paris), built by Pleyel
piano (2 manuals)	1924	Moritz Stoehr (New York)
piano (3 manuals)	1924	Alois Hába (Berlin), Ivan Vïshnegradsky (Prague), built by Grotrian-Steinweg
piano (2 manuals)	1924	Alois Hába (Prague), built by Förster
piano (3 manuals)	1925	Alois Hába (Prague), built by Förster
piano (3 manuals)	1928	Ivan Vïshnegradsky (Paris), built by Förster
piano (2 manuals)	1928	Hans Barth (New York), built by George L. Weitz of Baldwin
2 pianinos	1931	Alois Hába, built by Förster
harmonium (3 manuals)	1931	Alois Hába (Prague), built by Förster

Harmoniums using other microtonal tunings were also constructed at about this time. Ferruccio Busoni, inspired in 1907 by reports of the second model of Thaddeus Cahill's TELHARMONIUM (which had 36 notes to the octave in just intonation), experimented in New York (probably in 1910 or 1911) with a rebuilt three-manual harmonium tuned in $\frac{1}{3}$-tones; a two-manual $\frac{1}{6}$-tone instrument constructed for him by J. & P. Schiedmayer was completed only in 1925, several months after his death. In Cambridge Wilfrid Perrett built a harmonium in just intonation with 19 notes to the octave (*c*1925) which he called the 'olympion'. An electric harmonium designed by Lev Termen around 1926 (but not completed) was tunable in subdivisions of up to $\frac{1}{100}$-tones. Alois Hába commissioned a $\frac{1}{6}$-tone harmonium from August Förster in 1927. In 1932 Shōhei Tanaka, working in Tokyo, produced an instrument with 21 keys per octave (assignable to 46 notes) in just intonation. Around the same time the Polytone, a 60-key, 53-note harmonium with a special keyboard, consisting of ten differently coloured rows of keys, was constructed for the composer Arthur Fickénsher at the University of Virginia. From the early 1930s several 43-note harmoniums were constructed by Harry Partch under the names Ptolemy and CHROMELODEON.

Microtonal instruments other than keyboards from the first half of the 20th century include the quarter-tone clarinet (*c*1906) of Richard H. Stein; Luigi Russolo's INTONARUMORI (1913–), in all of which divisions of at least $\frac{1}{4}$-tone were possible; a string instrument (1920) that combined features of the violin and balalaika, devised by Mikhail Matyushin (who had published a quarter-tone violin tutor in 1912); Carrillo's $\frac{1}{8}$-tone *octavina* (which resembled a bass guitar), the $\frac{1}{16}$-tone *arpa citera* or 'harmony harp' (*c*1922), 14 other instruments in the



2. Chrysalis (1976) by Cris Forster

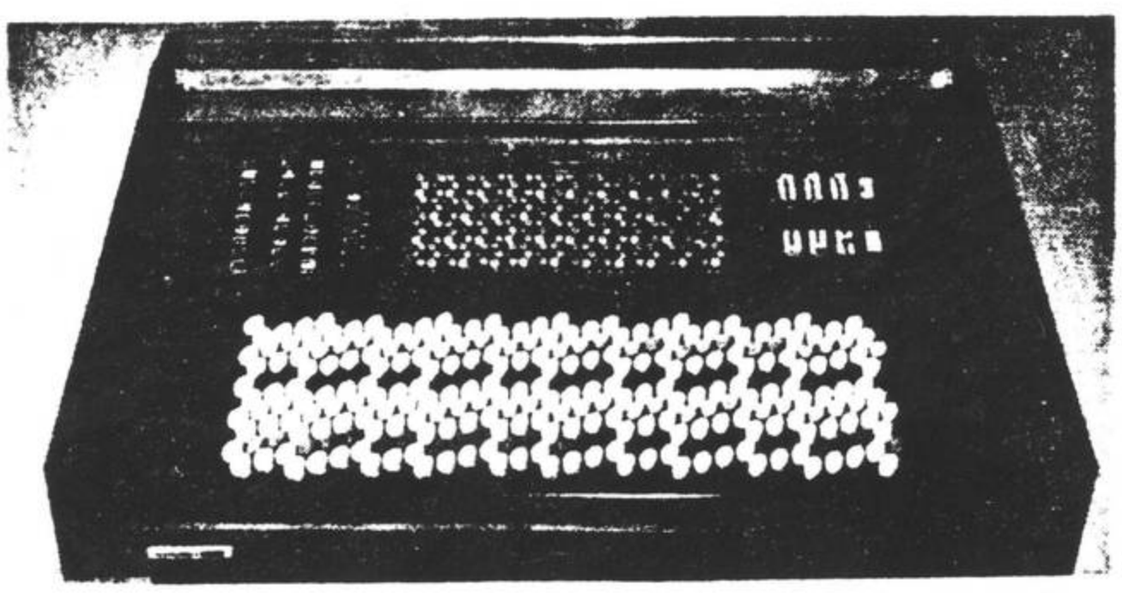
a disc mounted vertically on a stand with 82 strings on each face, which radiate out from an off-centre circular bridge. The composer DAVID COPE has constructed several percussion instruments tuned to 33-note just intonation. Other inventions to come out of California include Tillman H. Schafer's Undevigintivox, a 19-note metallophone (early 1960s), and a more recent 53-note metallophone built for L. E. Hanson. Schafer (now based in Boston), Warren F. Kimball and others have refretted guitars. Kimball and Skip La Plante in New York have built microtonal 'harmonic canons' inspired by Partch.

In California there has also been some use of microtones in jazz. In the mid-1960s the Hindustani Jazz Sextet explored both microtones and complex time signatures (from 5/4 to 33/16). The Sextet included two musicians who went on to form their own bands in the late 1960s: the trumpeter Don Ellis, who commissioned from Frank Holton & Co. quarter-tone trumpets with a fourth valve for the whole of his trumpet section; and the percussionist Emil Richards, whose Microtonal Blues Band consisted of several electroacoustic instruments and a wide range of percussion from many cultures, tuned microtonally to give, for instance, 22, 24, 31, 33 and 43 subdivisions of the octave.

(ii) Electronic instruments. Since World War II electronics have been widely applied to microtonal keyboard instruments, and electronic instruments have been used to perform microtonal music. In the late 1940s Percy Grainger, searching for means of producing 'gliding tones', managed to simulate them by using $\frac{1}{6}$- and $\frac{1}{8}$-tone tunings respectively in the first two models of the CROSS-GRAINGER FREE MUSIC MACHINE. Between 1950 and 1957 Evgeny Murzin developed the ANS, a photoelectric composition machine tuned to 72 equal octave divisions. In the mid-1960s Robert A. Moog constructed three microtonal electronic keyboard instruments: one with 43 notes to the octave over a range of four octaves; one with 31 notes to the octave and a total of 479 keys for a range of seven octaves; and one with 137 keys. At about the same time a microtonal version of the ONDIOLINE was produced for the composer Jean-Etienne Marie by Georges Jenny; this could be tuned in a variety of systems (e.g. divisions of the tone into between three and seven). On the basis of principles proposed by Alain Daniélou, Stephan Kudelski designed a 53-note unequally tempered keyboard instrument in the early 1960s in collaboration with the harpsichord builders Wayland Dobson and Jean Eicher; this was followed in the late 1970s by the S52, built by Claude Cellier and André Kudelski and tuned to 52 notes per octave, with a touch-sensitive keyboard the compass of which can be transposed within a total range of eight octaves. The 31-note Arcifoon was manufactured in Holland from 1971 (see §(iv) below). In the early 1970s George Secor developed the SCALATRON (fig.3), in which each note is independently tunable; Kenneth Macfadyen's 'detunable organ' (1968–9, constructed by A. E. Davies & Son) is similarly conceived, though its tuning (including meantone) can be reset instantly while that of the Scalatron must be fixed one note at a time. An electronic organ constructed by Ivor Darreg in 1962 retunes itself automatically to any of several different systems. The *ekmelische Orgel* of Franz Richter Herf (1973–4), built with the assistance of Rolf Maedel, has three 84-note manuals tuned to 72 divisions of the octave.

Some synthesizer keyboards, which can be adjusted not only in range but also in compass, have been used to create any number of equal divisions of the octave. The American composer Easley Blackwood has used Moog and Polyfusion synthesizers and the Scalatron in this way, and John Eaton has performed on the SYNKET in a number of his microtonal compositions; La Monte Young has used a Moog synthesizer and Terry Riley a Yamaha electronic organ to play music in just intonation. The digital EGG synthesizer adds a manual with three rows of keys tuned in $\frac{1}{4}$-tones (197 keys in all) to an 85-note standard equal-tempered manual. In the early 1950s composers working in the electronic music studio at the Nordwestdeutscher Rundfunk in Cologne used various equal subdivisions of the octave or larger intervals in order to avoid 12-note equal temperament: in Stockhausen's *Studie II* (1954) 28 semitones ($2\frac{1}{4}$ octaves) are divided into 25 equal intervals so that there are no octave relationships, and *Gesang der Jünglinge* (1955–6) uses up to 60 divisions of the octave with vocal material and 42 with electronic sounds.

(iii) American gamelan. In Europe several groups of musicians (often including composers) have been formed, for example in Amsterdam, Basle and London, to perform on genuine Javanese or Balinese gamelans. As well as similar groups, there are in the USA around 25 specially constructed Western gamelans. Many of these were inspired by the gamelan Si Darius (named after the composer Milhaud, who taught at Mills College between 1940 and 1971), which was built in the early 1970s by

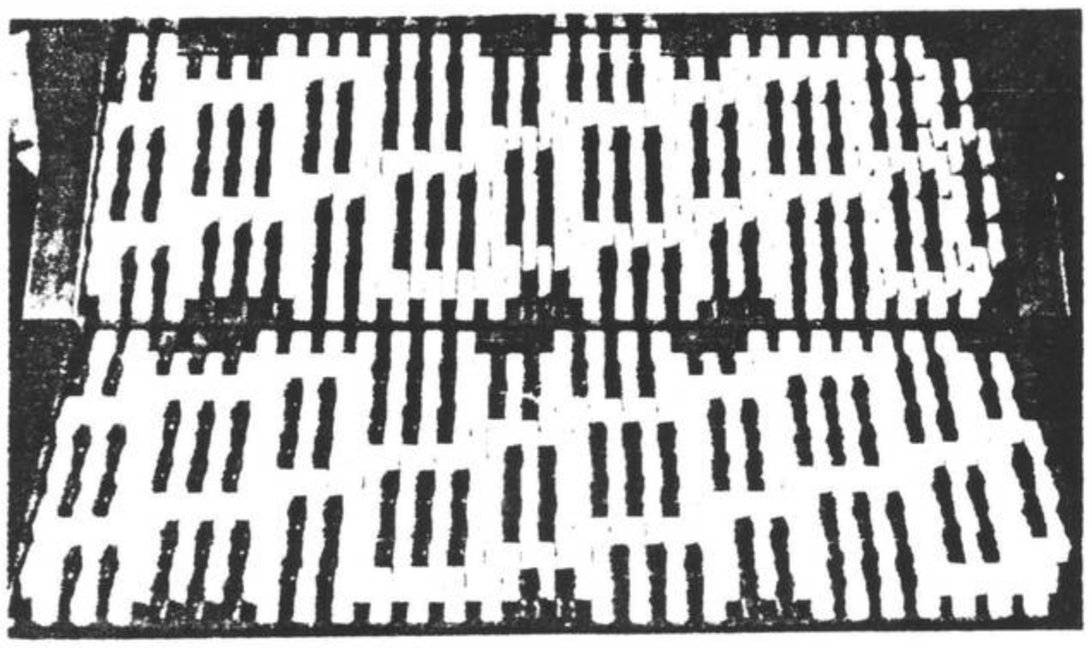


3. Second version of the Motorola Scalatron (1979–81), an electronic microtonal keyboard instrument; the 294 colour-coded keys give up to 56 individually tunable notes to the octave and the instrument has a memory that can store up to 17 tuning systems

Harrison and Colvig and for which Harrison has composed several works; this and most of those built on the West Coast are tuned in just intonation. More recently, Harrison and Colvig have produced the gamelan Si Betty (named after a local patroness, Betty Freeman). Three others are well known. Gamelan Son of Lion was constructed in New Jersey in 1974 by the composer and ethnomusicologist Barbara Benary, using designs by Dennis Murphy derived from traditional Javanese instruments; it consists of 21 iron metallophones with tin-can resonators and gongs made from hubcaps and oil drums. Benary, Philip Corner and Daniel Goode are among the composers who have written for and perform in the ensemble, which also plays central Javanese court music. In 1975, David Doty's Other Music gamelan, tuned to 14 unequal divisions of the octave, was built in San Francisco. In Berkeley, California, the composer Daniel Schmidt constructed the similar Western Gamelan in 1976 with Paul Dresher, using aluminium metallophones (some with tin-can resonators). More recently Schmidt has added new timbres, from tuned rod resonators for example; he is also the composer of much of the ensemble's repertory.

(iv) Other developments. Microtonal keyboards have preoccupied inventors rather less in the period since World War II. The 31-NOTE ORGAN of Adriaan Fokker (1950) and its later electronic version the Arcifoon (1971) have a 31-note, equally divided octave, based on Christiaan Huygens's theories; they have a keyboard like that introduced by Bosanquet (see Table 1) with keys in three colours – blue, black and white. A number of composers, including Hába and Vishnegradsky, have written works for the 31-note organ. In Oslo the composer Eivind Groven built a non-tempered 36-note harmonium (1936), a small pipe organ (1954) and a 43-note electronic organ (1965), all in just intonation; around 1970 a similar complete pipe organ was constructed for him by Walcker. All four instruments use conventional keyboards with assignment facilities. In the 1940s A. R. McClure advocated tuning pianos and organs in mean-tone tuning, and an 'extended meantone organ' with 19 pipes to the octave was built to his specification in 1950; several mean-tone organs have recently been installed in the USA. Arnold Dreyblatt's portable pipe organ in just intonation dates from around 1980.

A series of *pianos metamorfoseadores* (microtonal upright pianos with conventional keyboards), each in a different tuning from $\frac{1}{3}$- to $\frac{1}{16}$-tones, was planned by Carrillo in 1927; a $\frac{1}{3}$-tone grand was built in 1947 and the uprights (by the Carl Sauter Pianofortefabrik in Spaichingen, Baden-Württemberg) in 1957–8. The range of these pianos becomes smaller as the number of subdivisions of the octave is increased, so that the $\frac{1}{16}$-tone instrument has a compass of a single octave, in the middle range, with 97 keys. Many of Carrillo's instruments are to be housed in the Carrillo Museum in Mexico City. Since the 1930s Augusto Novaro, a former pupil of Carrillo's, has built a number of Novares – pianos that sound less percussive than normal and are tuned in such divisions of the octave as 14, 15, 19, 22, 31 and 53; he has also constructed asymmetrical microtonal bowed and plucked string instruments.



4. The manuals of Fokker's 31-note pipe organ, 1945–50 (Teyler Museum, Haarlem); each manual has 143 black, white and blue keys, giving a 31-note octave tuned in equally tempered $\frac{1}{4}$-tones

Activities in building microtonal instruments without keyboards have been largely concentrated in California; elsewhere developments have been sporadic. Since 1977 Dean Drummond in New York has built a family of Zoomoozophones – aluminium tube metallophones in 31-note just intonation. In Toronto the composer Gayle Young produced Columbine in 1977–8, a 61-note steel tube metallophone covering nearly three octaves in a 23-note unequal temperament based on frequency ratios; she followed it in 1980 with Amaranth, a koto-like instrument with 24 strings and movable bridges, which is tuned in various systems and can be plucked, struck and bowed. Another recent instrument is the Si-Xen, constructed for Xenakis's *Pléïades* (1976), written for Les Percussions de Strasbourg; this is a set of six 19-note metallophones, each of which has different pitches in an unequal scale of 21 notes to the octave, consisting of alternate $\frac{1}{4}$- and $\frac{1}{3}$-tones. John Grayson in Vancouver has employed non-equal tunings in some of his instruments, such as the Pyrex Marimba (1967) which has 24 notes in a compass of about one and a half octaves. Since Carrillo's death in 1965 the *arpa citera* has been redesigned in Cuernavaca by Oscar Vargas Leal and the composer David Espejo Avilés; several large *arpas armónicas* with 400 notes to the octave have been built, as well as smaller models, including a three-octave version with 100 notes in equal temperament played by Pepe Aton Estevane since the late 1970s. Péter Eötvös has performed on a '55-chord', a specially built Hungarian *citera* tuned in intervals based on the golden section, which results in a logarithmic scale lacking any integral frequency ratios or interval steps of identical size.

Many of the new acoustic and electronic instruments produced by musicians and sound sculptors use non-tempered tunings that are microtonal but do not adhere to any specific system. Examples include some of the work of Mario Bertoncini and the Sonambient series of Harry Bertoia, which produce constellations of microtonal intervals. Microtonal systems are equally feasible with the techniques of DRAWN SOUND, as in the work of Arseny Avraamov.

Most contemporary composers and performers prefer to use conventional instruments that are retuned or specially fingered. Ben Johnston's Sonata (1963) requires a piano tuned in a just system in which only seven pairs of keys, mostly several octaves apart, give octave relationships. Just intonation is also used in La Monte Young's *Well-Tuned Piano* (1964), which has been revived effectively since 1974 with a Bösendorfer piano. Serge Cordier has specialized in tuning pianos to equal temperament with justly tuned 5ths. Bjørn Fongaard has written several works since the mid-1960s involving quarter-tone guitars, and the guitarist John Schneider

performs in mean-tone, just and Pythagorean tunings. Since the 1950s Maurice Ohana has used zithers tuned in $\frac{1}{4}$- and $\frac{1}{3}$-tones in several works. Henri Pousseur adopted a 19-note tuning in his solo cello piece *Racine 19* (1975), and quarter-tones have been used, primarily but not exclusively with bowed string instruments, in works by Boulez, Ligeti, Penderecki and Xenakis, and younger composers such as Alain Bancquart. Jean-Etienne Marie has composed for some of Carrillo's instruments (several of which are in his possession), for the microtonal Ondioline and for synthesizers such as an Oberheim. Pavel Blatný wrote a study for quarter-tone trumpet and jazz orchestra in 1964. Microtonal inflections and beats are featured in works by Giacinto Scelsi and Phill Niblock.

In New York a variety of conventional instruments have been played microtonally, especially in the series of concerts given since 1981 under the title American Festival of Microtonal Music; these are organized by a leading participant, the bassoonist Johnny Reinhard. Refretted guitars and the Scalatron have also appeared in these concerts. Tui St George Tucker has specialized in quarter-tones since the 1950s, especially in her compositions for members of the recorder family. A number of microtonal ensembles have been active in the USA, including the Interval Players, The NewBand, Sonora and John Catler's 31-note rock group, J. C. and the Microtones.

BIBLIOGRAPHY

N. Vicentino: *L'antica musica ridotta alla moderna prattica* (Rome, 1555/*R*1959, 2/1557)

G. Zarlino: *Le istitutioni harmoniche* (Venice, 1558/*R*1965, rev. 3/1573/*R*1966)

N. Vicentino: *Descrizione dell'arciorgano* (Venice, 1561); Eng. trans. in Kaufmann, *JMT*, v (1961), 32

F. de Salinas: *De musica libri septem* (Salamanca, 1577)

M. Mersenne: *Harmonie universelle* (Paris, 1636-7/*R*1963), iii; Eng. trans. (1957)

C. Huygens: *Novus cyclus harmonicus*, 1661; in *Opera varia* (Leiden, 1724), 747; ed. in *Oeuvres complètes*, xx (The Hague, 1940)

H. W. Poole: 'An Essay on Perfect Intonation in the Organ', *American Journal of Sciences and the Arts*, 2nd ser., ix (1850), 68, 199

H. L. F. von Helmholtz: 'Über musikalische Temperatur', *Naturhistorische-Medizinischer Verein Heidelberg* (23 Nov 1860); rev. in *Die Lehre von den Tonempfindungen als physiologische Grundlage für die Theorie der Musik* (Brunswick, 1863, 5/1896), 501, 664, 669; Eng. trans. by A. J. Ellis as *On the Sensations of Tone as a Physiological Basis for the Theory of Music* (London, rev. 2/1885/*R*1954), 310, 422, 429, 466

T. P. Thompson: *On the Principles and Practice of Just Intonation* (London, 9/1866)

H. W. Poole: 'On Perfect Harmony in Music', *American Journal of Science and the Arts*, 2nd ser., xliv (1867), 1

A. J. Ellis: 'On the Temperament of Instruments with Fixed Tones', *Proceedings of the Royal Society*, xiii (1874), 404

R. H. M. Bosanquet: *An Elementary Treatise on Musical Instruments and Temperament* (London, 1876)

G. Engel: *Das mathematische Harmonium: ein Hilfsmittel zur Veranschaulichung der reinen Tonverhältnisse* (Berlin, 1881)

C. Brown: *Music in Common Things* (London, 1885)

S. Tanaka: 'Studien im Gebiete der reinen Stimmung', *VMw*, vi (1890), 1–90

C. A. Eitz: *Das mathematisch-reine Tonsystem* (Leipzig, 1891)

G. A. Behrens-Senegalden: *Die Vierteltöne in der Musik* (Berlin, 1892)

F. Busoni: *Entwurf einer neuen Ästhetik der Tonkunst* (Trieste, 1907, 2/1910/*R*1954); Eng. trans. as *Sketch of a New Esthetic of Music* (New York, 1911/*R*1962)

J. Mager: *Vierteltonmusik* (Aschaffenburg, 1915)

W. von Moellendorf: *Musik mit Vierteltönen* (Leipzig, 1917)

A. Avraamov: 'Jenseits von Temperierung und Tonalität', *Melos*, i (1920), no.6, p.131; no.7, p.160; no.8, p.184

F. Busoni: 'Dritteltonmusik', *Melos*, iii (1922), 198

R. H. Stein: 'Vierteltonmusik', *Die Musik*, xv (1922–3), 510

J. Mager: *Eine neue Epoche der Musik durch Radio* (Berlin, 1924)

E. H. Pierce: 'A Colossal Experiment in "Just Intonation"', *MQ*, x (1924), 326

S. Baglioni: *Udito e voce: elementi fisiologici della parola e della musica* (Rome, 1925)

C. Ives: 'Some "Quarter-tone" Impressions', *Franco-American Music Society Bulletin*, xxv/3 (1925); repr. in *Essays Before a Sonata and Other Writings*, ed. H. Boatwright (New York, 2/1962), 105

G. M. Rimsky-Korsakov: 'Obosnovaniye chetvyortitonovoy muzïkal'noy sistemï' [The basis of the musical quarter-tone system], *De musica*, i (Leningrad, 1925)

L. Kallenbach-Greller: 'Die historischen Grundlagen der Vierteltöne', *AMw*, viii (1926), 473

W. Perrett: *Some Questions of Musical Theory* (Cambridge, 1926)

G. Overmyer: 'Quarter-Tones -- and Less', *American Mercury*, xii (1927), 207

G. Rimsky-Korsakov: 'Theorie und Praxis der Reintonsysteme', *Melos*, vii (1928), 15

M. F. Meyer: *The Musician's Arithmetic*, University of Missouri Studies, iv/1 (Columbia, 1929)

J. Yasser: *A Theory of Evolving Tonality* (New York, 1932)

J. Foulds: *Music Today: its Heritage from the Past, and Legacy to the Future* (London, 1934), 59

W. Dupont: *Geschichte der musikalischen Temperatur* (Kassel, 1935)

A. Fickénsher: 'The "Polytone" and the Potentialities of a Purer Intonation', *MQ*, xxvii (1941), 356

E. W. Tipple and R. M. Frye: *A Graphic Introduction to the Harmon* (Boston, 1942)

J. Carrillo: *'Sonido 13': fundamento científico e histórico* (Mexico City, 1948); Eng. trans. in *Soundings*, no. 5 (1973), 64

E. Groven: *Temperering og renstemning* (Oslo, 1948; Eng. trans., 1970)

A. D. Fokker: *Just Intonation and the Combination of Harmonic Diatonic Melodic Groups* (The Hague, 1949), 195–319

H. Partch: *Genesis of a Music* (Madison, Wisc., 1949, rev. 2/1974), 361–457

J. M. Barbour: *Tuning and Temperament: a Historical Survey* (East Lansing, Mich., 1951/*R*1972)

A. R. McClure: 'An Extended Meantone Organ', *The Organ*, xxx (1950–51), 139

H. W. Kaufmann: 'Vicentino's Arciorgano: an Annotated Translation', *JMT*, v (1961), 32

J. Mandelbaum: *Multiple Division of the Octave and the Tonal Resources of the 19-Tone Temperament* (diss., Indiana U., 1961)

Ll. S. Lloyd and H. Boyle: *Intervals, Scales and Temperament* (London, 1963/*R*1978)

A. D. Fokker: *Neue Musik mit 31 Tönen* (Düsseldorf, 1966; Eng. trans. 1975)

H. W. Kaufmann: *The Life and Works of Nicola Vicentino*, MSD, xi (1966), 163

L. Gerdine, P. Yates, B. Johnston, L. A. Hiller, J. Mandelbaum and C. Gamer: 'Microtonal Music in America', *Proceedings of the American Society of University Composers*, ii (1967), 77 [forum]

E. Groven: *Renstemningsautomaten* (Oslo, 1968)

K. A. Macfadyen and D. Greer: 'A Detunable Organ', *MT*, cx (1969), 612

A. Hába: *Mein Weg zur Viertel- und Sechsteltonmusik* (Düsseldorf, 1971)

W. Colvig: 'A Western Gamelan', *Sound Sculpture: A Collection of Essays by Artists*, ed. J. Grayson (Vancouver, 1975), 162

D. Ellis: *Quartertones: a Text with Musical Examples, Exercises and Etudes* (Plainview, NY, 1975)

F. R. Herf: *Die ekmelische Orgel: eine elektronische Feinstufenorgel mit 72 Tonstufen in der Oktave* (Salzburg, 1975)

S. Schneider: *Mikrotöne in der Musik des 20. Jahrhunderts* (Bad Godesberg, 1975)

J.-E. Marie: *L'homme musical* (Paris, 1976), 25–94

Interval – Exploring the Sonic Spectrum (1978–)

K. Terry: 'La Monte Young: Avant-Garde Visionary Composer and Pianist', *Contemporary Keyboard*, vi/8 (1980), 12

E. Blackwood: 'Discovering the Microtonal Resources of the Synthesizer', *Keyboard*, viii/5 (1982), 26

'Microtonal Music', *Ear Magazine East*, vii/5 (1982–3) [special issue]

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Micundo. Plural of MUCUNDO, drum of Angola.

Micupela. Plural of MUCUPELA, drum of Angola.

Midgley–Walker organ. An ELECTRONIC ORGAN developed from the mid-1920s by A. H. Midgley and completed with A. M. Midgley in 1937; a few instruments were made by the organ builders J. W. Walker & Sons