APPARATUS, INCLUDING ELECTRONIC EQUIPMENT FOR PROVIDING A TONAL STRUCTURE FOR THE METRONOMIC DIVISIONS OF MUSICAL TIME

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Filed: July 21, 1970

Appl. No.: 57,385

U.S. Cl. ...........................................84/484, 324/68
Int. Cl. ............................................G10b 15/00
Field of Search ..................................84/484; 58/130; 324/68, 69

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ABSTRACT

The repetition rates of audible sounds are correlated to the audio frequency values of tones. While the invention can be carried out by mechanical apparatus, the specific improvement disclosed utilizes electronic equipment for efficiency, effectiveness, accuracy and reliability. Electronic equipment produces auditable tones and audible sounds. Manually operated controls select a tone or a sound, select an octave range for the tone or the sound and control the duration and repetition rate of the tone or the sound. A electroacoustic transducer connected to the controls produces the selected tone or sound in the controlled octave range at the controlled duration and repetition rate to relate pitch tonally and numerically to the repetition rate of pulse beats.

10 Claims, 10 Drawing Figures

THE METROTON SCALE OF 12 TEMPO-TONES (INCLUDING ¼ TONES)
### The Metronome Scale of 12 Tempo-Tones (Including ¼ Tones)

<table>
<thead>
<tr>
<th>Tempo Tones</th>
<th>TEMPO</th>
<th>OUT TONES</th>
</tr>
</thead>
<tbody>
<tr>
<td>E + F + G + G# + A + A# + B + B# + C + C# + D + D#</td>
<td>I</td>
<td>40 42 43 44 45 46 48 50 51 52 54 56 58 60 63 64 66 68 69 72 74 76 78</td>
</tr>
<tr>
<td></td>
<td>II</td>
<td>80 84 86 88 90 92 96 100 102 104 108 112 114 116 120 126 128 132 136 140 144 148 152</td>
</tr>
<tr>
<td></td>
<td>III</td>
<td>160 162 164 166 168 170 172 176 180 184 192 200 204 208 216 224 228 232 240 252 256 264 272 276 280 288 296 304 312</td>
</tr>
</tbody>
</table>

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APPROATUS, INCLUDING ELECTRONIC EQUIPMENT FOR PROVIDING A TONAL STRUCTURE FOR THE METRONOMIC DIVISIONS OF MUSICAL TIME

BACKGROUND OF THE INVENTION

1. Field of The Invention

The present invention relates to a tonal structure for the metronomic divisions of musical time. More particularly, the invention relates to apparatus, hereinafter designated METRONOT, and in the specific embodiment described herein to electronic equipment for providing a tonal structure for the metronomic divisions of musical time.

2. Statement

We have discovered that the application of a single pitch with a definite tempo speed, creates a musical memory of tempo key or TEMPO-TONE. Herefore this understanding of a moving musical time motion has been relegated to numerical grasps of tempo understanding, or very broad semantic expressions of tempo.

The presence and practice of TEMPO-TONE is not only a disciplinary reference. Its basic purpose is to creatively form a deeper sense of approach to the meanings of a correct tempo. While a tempo physiscally forms the length of a phrase, it more directly is involved with the total rhythmic tone of the phrase.

3. Memory understanding of numerical tempo markings (80,120, etc.) without the musical sense of motion is meaningless. The numerical education of musical time is certainly considered as one of the weakest links in the study for a complete musicianship. The ignorance of the professional musician (soloist and instrumental) in the area of tempo knowledge, negatively leads to subtle block of internal confusions which permeates all the developments of musiciansian techniques. When a musicians' sense of tempo and its motion is damaged or cannot play freely within the infinites of music, then there can only be a retrogradation of understanding and ability.

The TEMPO-TONE of moving time in music, is the basic motivating force for all musical motion. This includes: rhythmic groups, accents, creation of pitch groups, melody, harmony, counterpoint orchestration and above all it controls and predicts the motional behavior of the fingers and the hand of the playing musician.

To reiterate, Tempo is an expression in music which achieves an aural form in a duration and span of time. Music and its meaning is in a consistent state of creative existence through the progressive motion of a musical time. Such progress is cultured and cultivated by the ratioed time speed of underlying pulsebeats nd is defined as tempo. Pulsebeats create tempo and its expression. By emitting a distinct series of audible and inaudible beats they formulate rhythmic patterns and within themselves contain a definitive character of rhythmic balances. The musical progress of the pulsebeats is created by the regular and irregular accents within the pulsebeats, while its rhythmic balances are derived from the qualitative shapes, weights and relative manners of musical motion. The pitch tonality of a series and group of pulse beats is defined as tempo tone. The vibrational structure of pitch is relative to the pulse beat structure of tempo and its tone. The tonality of a tempo is identified through an established tempo tone.

SUMMARY OF THE INVENTION

Our METRONOT system is one which measures and predicts the progress of a musical time period.

This system differs from the traditional metronome and its markings in direct vibrational structures of pitch and relating them both tonally and numerically, to the rate of beats per minute.

Apparatus according to the invention includes means for producing an audible sound system as a pulse beat, in combination with means for selectively varying the rate of the audible sound in direct relation with the audio frequency of a note or tone on the musical scale.

The principal object of the present invention is to provide a tonal structure for the metronomic divisions of musical time. The tonal structure of the present invention for the metronomic divisions of musical time may be provided by many means but for accuracy and versatility, electronic equipment is provided and function to provide the tonal structure with efficiency, effectiveness, accuracy and reliability. The electronic equipment of the present invention is of simple structure and is operated with facility and rapidity.

In accordance with the present invention, electronic equipment for providing a tonal structure for the metronomic divisions of musical time wherein pitch is related tonally and numerically to the repetition rate of pulse beats comprises a plurality of audio oscillators for producing audible tones. Each of the audio oscillators provides a plurality of tones in a corresponding octave range. A relaxation oscillator produces audible sounds. Control means connected to the audio oscillators and to the relaxation oscillator selects one of a tone and a sound for production, selects an octave range for the selected one of a tone and a sound and controls the duration and repetition rate of the selected one of the tone and the sound.

An electroacoustic transducer connected to the control means produces the selected one of the tone and the sound in the selected octave range at the controlled duration and repetition rate.

The control means comprises switching means. Manually controllable switch means in the switching means controls the connection of one of a selected one of the audio oscillators and the relaxation oscillator to the transducer. A manually controllable switch connected between each of the audio oscillators and the transducer connects one of the audio oscillators to the transducer. A manually controllable tuning is connected to each of the audio oscillators for tuning each of the audio oscillators to control the repetition rate thereof. A manually controllable decay network connected to the switching means controls the duration of the selected one of the tone and the sound.

In accordance with the method of the present invention, a method of providing a tonal structure for metronomic divisions of musical time comprises relating pitch, both tonally and numerically, to the repetition rate of pulse beats. The method of the present invention also comprises producing the sound of a designated pitch and repeating the sound at the speed of a related repetition rate of pulse beats.

BRIEF DESCRIPTION OF THE DRAWINGS

In order that the present invention may be readily carried into effect, it will now be described with reference to the accompanying drawings, wherein:

FIG. 1 is a presentation of the Metronot scale of three tempo tone octaves;

FIG. 2 is a block diagram of an embodiment of the electronic equipment of the present invention for providing a tonal structure for the metronomic divisions of musical time;

FIG. 3 is a circuit diagram of an embodiment of circuitry which may be utilized as the electronic equipment of FIG. 1 and comprises FIGS. 3a, 3b, 3c, 3d, 3e and 3f; and

FIG. 4 is a perspective view of an embodiment of a cabinet for housing the electronic equipment of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The Metronot system of the present invention, which is constituted by the electronic equipment of the present invention, measures and predicts the progress of a musical time period and differs from the traditional metronome system by utilizing the vibrational structures of pitch and relating them, both tonally and numerically, to the rate of pulsebeats per minute. The Metronot system considers and adjudges twelve points and areas of pulsebeat area frequencies as being of definite and particular tones of tempo, as in the established 12-tone tempered scale in which vibrational points and areas are adjudged as being definite and particular pitches.
In the Metroton system of the present invention, each time speed is formulated from the pitch relationship within the 12-tone scale and is evaluated and considered to be a specific pitch/tone of tempo and is identified as a tempo tone.

The Metroton system includes a tempered 12-tempo tone scale of musical time, a tempo tone range of three octaves each comprising 12 tones, a series of quarter tones or partial series and group of tempi-overtones based on the harmonic structure of each tempo tone, and a related tempered rhythmic scale of eight tempo tones within a time range of four octaves. The 12-tempo tone scale and its three octaves utilize the pitch of C which is 512 vibrations per second, as the standard of pitch. In the lowest two audible octaves, C vibrates at the rate of 16 and 32 times per second. The tempered 12-tone scale, according to such standard, has the following vibrational relationship and structure in vibrations per second.

The foregoing vibrations per second are transformed into pulses/beats per second, so that 12 points within the progress of a minute are marked in a tempered relationship with each other and with the 12 tones of the scale. Thus, one vibration is one pulsebeat, 1 second is 1 minute, a pitch is a tempo tone and the pitch of G which is 48 vibrations per second is the tempo tone of G at 48 beats per minute, and so on.

FIG. 1 is a presentation of the Metroton scale of three-tempo octave tones. In FIG. 1, the graded Metroton tempo tone chart commences with the pitch of E which is 40 vibrations per second and thus 40 beats per minute, and then proceeds to the first octave of the second. The second and third octaves are double and triple the first. In FIG. 1, a + indicates a tempo quarter tone.

A single-tempo tone, although it retains its own tonal and rhythmic qualities, develops and creates a complete series of simultaneously sounding tempi-overtones which are considered to be the harmonic overtone series of each tempo tone. They are distinctly represented as specific rhythmic patterns of regular and irregular forms. This series of tempi within a tempo strikingly resembles the overtone partial structure of a single pitch. Although the partials of pitch are not always clearly audible, the inner tempo divisions or tempi-overtones are necessarily omnipresent and are audible at all times. The capacity for simultaneous interrelation of the tempi-overtones may well be compared to the horizontal and vertical naturalisms of melody and harmony. The true musical phenomenon of tempi-overtones is in its ability to extend a strong determining force, which creates the motional design and course of both melody and harmony, into and through the entire vibrational fields of pitch. Thus, the forward linear motions of music are created by the tempo tone and are rhythmically perpetuated by its own tempi-overtones.

The Metroton system of the present invention, which is based on the 12-tone scale of tempo tones and utilizes a relative series of quarter tones, functions as a musical instrument in the following manner. On each lettered and numerical tempo tone, the sound of the designated pitch repeats itself at the speed of the related number of pulse beats per minute. All the quarter tone tempo + marks of FIG. 1 do not indicate the sound of a pitch, which is indicated by a click. The tonal and rhythmic range is three octaves commencing with E in the bass clef, at 40 beats per minute, and extending to D above the treble clef, at 304 beats per minute. Any two tempo tones, regardless of octave positions, may sound simultaneously, with or without pitch. In the first octave, each tempo tone may play three or four beats and then remain silent for three or four beats such as, for example, ++++++ or +++++++. In the second octave, each tempo tone may play six or eight beats and then remain silent for six or eight beats such as, for example, ++++++++ or ++++++++ ++++++++ . This sound and silence pattern may continue indefinitely.

FIG. 2 is a block diagram of the Metroton system of the present invention. In FIG. 2, three separate and independent audio oscillators 11, 12 and 13 may be independently set to oscillate at three different audio frequency tones. A fourth oscillator 14, which preferably comprises a relaxation oscillator, produces spiked pulses at a repetition frequency lower than the frequencies of the oscillations produced by the audio oscillators 11, 12 and 13. The relaxation oscillator 14 produces the time intervals in which the tones produced by the audio oscillators 11, 12 and 13 appear.

The tempi-overtone series forms a rhythmic scale of tonal, as well as numerical identification. The study and understanding of this rhythmic scale assumes by its own nature, a tonal recognition and in consequence becomes a specified tonal practice of rhythmic division and of rhythmic patterns.

The tempo-overtone series encompasses, within each tempo tone a tonal rhythmic scale of eight (8) steps and seven (7) intervals.

<table>
<thead>
<tr>
<th>The eight steps and</th>
<th>The seven overtone intervals</th>
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</thead>
<tbody>
<tr>
<td>1. E-40</td>
<td>1. Octave</td>
</tr>
<tr>
<td>2. E-90</td>
<td>2. Fifth, perfect</td>
</tr>
<tr>
<td>3. B-120</td>
<td>3. Fourth, perfect</td>
</tr>
<tr>
<td>4. E-160</td>
<td>4. Third (major-minor)</td>
</tr>
<tr>
<td>5. G-200</td>
<td>5. Third (major-minor)</td>
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<tr>
<td>7. C#-280</td>
<td>7. Third (major-minor)</td>
</tr>
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<td>8. E-220</td>
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THE METRONOT TEMPO-OVERTONE SERIES:

<table>
<thead>
<tr>
<th>d</th>
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<th>6</th>
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<tr>
<td>E</td>
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<td>E160</td>
<td>G200</td>
<td>E240</td>
<td>C5-290</td>
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<tr>
<td>F</td>
<td>F43</td>
<td>F86</td>
<td>C125</td>
<td>C165</td>
<td>G215</td>
<td>A256</td>
<td>D295</td>
<td>F295</td>
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<tr>
<td>G</td>
<td>G36</td>
<td>G79</td>
<td>D128</td>
<td>D172</td>
<td>G222</td>
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<td>E056</td>
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<td>E044</td>
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<tr>
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<td>D342</td>
<td>F342</td>
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</table>

Note: The values in the table represent the pitch and tempo intervals of the Metroton system.
A variable impedance network 15 has an output connected to the input of the audio oscillator 11 via a lead 16, an output connected to the input of the audio oscillator 12 via a lead 17, an output connected to the input of the audio oscillator 13 via a lead 18 and an output connected to the input of the relaxation oscillator 14 via a lead 19. The variable impedance network 15 is manually set to determine the frequencies of the four oscillators 11, 12, 13 and 14. The relaxation oscillator 14 produces clicking sounds, when desired, instead of tones. The output of the audio oscillator 11 is connected to an input of a switching circuit 21 via a lead 22. The output of the audio oscillator 12 is connected to an input of the switching circuit 21 via a lead 23. The output of the audio oscillator 13 is connected to an input of the switching circuit 21 via a lead 24.

A variable decay network 25 has an input connected to the output of the relaxation oscillator 14 via a lead 26. The variable decay network 25 functions to determine the duration of the tones produced by the relaxation oscillator 14. The output of the variable decay network 25 is connected to the input of an inverter 27 via a lead 28. The inverter 27 functions as a buffer stage. The output of the inverter 27 is connected to the input of a cyclic counter 29 via a lead 31. The cyclic counter 29 determines the number of each of the tones to be skipped. When the tone is skipped, it does not sound and thus cannot be heard. The cyclic counter 29 may, if desired, energize a sequence of lamps (not shown in the FIGS.) through the switching circuit 21 in order to provide a visual presentation of the basic unit of time, although the predetermined tones may be skipped.

The switching circuit 21 transfers the tones produced by the audio oscillators 11, 12 and 13 to an amplifier 32 via a switch circuit output lead 33 under the control of the cyclic counter 29. The outputs of the cyclic counter 29 are connected to inputs of the switching circuit 21 via leads 34, 35 and 36. The amplifier 32 functions to amplify either the clicking sounds, produced by the relaxation oscillator 14 and supplied from an output of said relaxation oscillator to an input of the switching circuit 21 via a lead 37, or the tones produced by the audio oscillators 11, 12 and 13. The amplified tones of clicks are supplied by the amplifier 32 to the input of a speaker 38 via a lead 39. The speaker 38 transforms the tones or clicks into audible sound. The variable decay network 25 is also connected to the switching circuit 21 via a lead 40.

FIG. 3 is a composite block diagram indicating the relation of FIGS. 3a, 3b, 3c, 3d, 3e and 3f which comprise the circuit diagram of the Metronom system of the present invention. The audio oscillators 11, 12 and 13 may comprise any suitable audio oscillators such as, for example, a Colpitts oscillator or phase-shifting oscillator. A suitable audio oscillator is that shown in FIG. 3a as the oscillator 11. A relaxation oscillator is known as such, and is shown in FIG. 3b as the oscillator 14. The audio oscillator 11 is shown in FIG. 3b as comprising a unijunction transistor 41 of known type. At the beginning of a cycle, the voltage of the emitter 42 of the unijunction transistor 41 is zero, because the voltage of a capacitor 43 connected to such emitter cannot vary rapidly. The emitter junction is reverse-biased and no current flows through the unijunction transistor 41.

As the voltage of the capacitor 42 of the oscillator 11 increases, current flows through a resistor 44. The resistor 44 is a variable resistor having a slide connection or tap 45 connected to the emitter 42 of the unijunction transistor 41. When the voltage of the capacitor 43 reaches a predetermined value, the emitter junction of the unijunction transistor 41 becomes forward biased and current flows through it. A current flow through the emitter junction of the transistor 41 reduces the internal resistance of said transistor and the voltage drop across it. Subsequently, the capacitor 43 is discharged and the cycle is repeated, producing a sawtooth oscillation, the frequency of which depends upon the capacitance of the capacitor 43 and the total resistance of the variable resistor 44. Another variable resistor 46 is connected in series with the variable resistor 44 to a base of the unijunction transistor 41.

A variable resistor 47 of rotary type is connected via its slide connection or switch arm 48 to the emitter of the unijunction transistor 41 via a lead 49 and to the variable resistor 44 via a lead 51. The switch arm 48 of the variable resistor 47 is rotated under the control of a wafer switch 51 which is mechanically coupled to said switch arm 48 via a linkage 52. The frequency of the tones produced by the audio oscillator 11 is determined by the setting of the switch arm 48 of the variable resistor 47 under the control of the wafer switch 51 (not shown in FIG. 3a).

The oscillator 11 produces tones at frequencies in the higher octave. It is a relatively inexpensive circuit, because it comprises a single transistor and utilizes variable resistors as the tuning elements. Although the output tone of the audio oscillator 11 is a sawtooth rather than sinusoidal wave, as desired, this does not adversely affect the operation of the system, since in the higher frequency range the resultant sound is not objectionable to the human ear.

The audio oscillator 13 is shown in FIG. 3a as comprising a simple circuit, also, and produces a tone which is closer to a sinusoidal wave than is the tone produced by the audio oscillator 11. The audio oscillator 13 is, in fact, a relaxation oscillator. At the lower frequencies in which the tones of the audio oscillator 13 are produced, the human ear is more discerning between different wave shapes than at the higher frequencies. It is therefore important that the audio oscillator 13 produce a more closely sinusoidal output wave than the oscillator 11, since said oscillator 13 produces tones in the lower octave.

The audio oscillator 13 is shown in FIG. 3a as comprising a transistor 53 having an emitter 54, a collector 55 and a base 56. The frequency of the oscillation produced by the oscillator 13 determined by the inductance of the primary winding 57 of the transformer 58. The primary winding 57 of the transformer 58 is connected to the emitter 54 of the transistor 53. The frequency of the tone produced by the oscillator 13 is also determined by the capacitance selected by the switch arm 59 of a variable capacitor 61. The variable capacitor 61 is connected across the primary winding 57 of the transformer 58 via the switch arm 59 and a lead 62 and via a lead 63. The secondary winding 64 of the transformer 58 functions as a tickler winding and provides positive feedback to the low impedance primary winding 57. If the primary and secondary windings 57 and 64 are suitably phased, the current induced in the primary winding reinforces the oscillations produced by the oscillator 13.

At the beginning of the cycle, the base 56 of the transistor 53 is short-circuited to the emitter 54 through the primary winding 57 of the transformer 58. The collector current is very small, but increases rapidly. The current flowing through the secondary winding 64 of the transformer 58 induces a voltage in the primary winding 57 thereof. The voltage induced in the primary winding 57 of the transformer 58 produces a forward bias in the emitter-base circuit of the transistor 53, thereby causing the collector current to increase. Electromagnetic induction via the transformer 58 causes the collector current to increase further until said transformer saturates. When the transformer 58 saturates, the induction commences to decrease and the collector current stops increasing. When the magnetic flux in the core of the transformer 58 is constant, the induced emitter-base current begins to decrease and the collector current decreases. The collector current decreases and then begins to increase, thereby commencing a new cycle. A suitable DC power supply 65 provides operating power for the oscillator 13 as well as each of the oscillators 11 and 12. Although the power supply 65 itself is not shown in FIG. 3, its connections to the oscillators are shown.
The audio oscillator 12 produces tones in the middle octave and may comprise the same circuit as the oscillator 11 or the same circuit as the oscillator 13. The circuits of the oscillators 11 and 13, shown in FIG. 3a, are illustrative of suitable circuits which may be utilized as such oscillators and said oscillators are not restricted to such circuits. Any suitable audio oscillator circuit may be utilized as the oscillator 11, the oscillator 12 or the oscillator 13.

The switch arm 59 of the variable capacitor 61 is rotated under the control of a waf er switch S3 which is mechanically coupled to said switch arm via a linkage 66. The frequency of the tones produced by the audio oscillator 13 is determined by the setting of the switch arm 59 of the variable capacitor 61 under the control of the wafer switch S3 (not shown in FIG. 3a). A variable resistor 67 of rotary type or a variable capacitor 67 of rotary type has a switch arm 68 and is connected via said switch arm and a lead 69 and via a lead 71 to the oscillator circuit 12. The switch arm 68 of the variable resistor or variable capacitor 67 is rotated under the control of a wafer switch S2 which is mechanically coupled to said switch arm via a linkage 72. The frequency of the tones produced by the audio oscillator 12 is determined by the setting of the switch arm 68 of the variable resistor or capacitor 67 under the control of the wafer switch S2.

The relaxation oscillator 14 produces spiked pulses. The spike pulses produced by the relaxation oscillator 14 produce a clicking sound, when desired. The variable decay network 25 determines the duration of the tones produced by the oscillators 11, 12 and 13 under the control of the spiked pulses produced by the relaxation oscillator 14. The relaxation oscillator shown in FIG. 3b comprises a transistor 73 having an emitter 74, a collector 75 and a base 76. The transistor 73 overcomes the inherent resistance losses of the circuit in order to sustain oscillations. At the beginning of a cycle, the transistor 73 starts drawing current from the DC power supply 65 because its base 76 is forward-biased by resistors 77 and 78 and a variable resistor 79 (FIG. 3a). The variable resistor 79 is of a rotary type and has a switch arm 81. The variable resistor 79 (FIG. 3a) is connected via the switch arm 81, a lead 82, a multiposition switch S4 and a lead 83 to a common point in the connection between the resistors 77 and 78 and via leads 84 and 85 (FIG. 3b) to the base 76 of the transistor 73. The switch arm 81 of the variable resistor 79 is rotated under the control of the waf er switch S1 (FIG. 3a) which is mechanically coupled to said switch arm via a linkage 86. When current flows through a transformer 87 (FIG. 3b), a current is induced in the primary winding 88 of said transformer. A capacitor 89, which is connected to the primary winding 88 of the transformer 87 is charged by the induced current. The capacitor 89 then discharges through the resistors 77, 78 and 79 until the base 76 of the transistor 73 becomes forward-biased again and a new cycle begins. A second transformer 91 has a primary winding 92 connected in parallel with the primary winding 88 of the transformer 87 and functions as a voltage amplifier and as an impedance matching stage for the following inverter 27.

The three wafer switches S1, S2 and S3 are ganged switches which jointly control the corresponding switch arms 48 and 81 of the variable resistor 47 of the audio oscillator 11 and the variable resistor 79 of the relaxation oscillator 14, respectively, the corresponding switch arms 68 and 93 of the variable resistor 67 of the audio oscillator 12 and a variable resistor 94 of the relaxation oscillator 14, respectively, and the corresponding switch arms 95 and 96 of the variable capacitor 61 of the audio oscillator 13 and a variable resistor 96 of the relaxation oscillator 14. The variable resistors 79, 94 and 96 are the same as each other. The switch arm 93 of the variable resistor 94 is rotated under the control of the wafer switch S2 which is mechanically coupled to said switch arm via a linkage 97. The multiposition switch S4 has a switch arm 99 which selectively connects the common point in the connection between the resistors 77 and 78 to the switch arm 81, the switch arm 93 or the switch arm 95, via a lead 101 or a lead 102, respectively. The base 76 of the transistor 73 (FIG. 3b) is connected in common to the variable resistors 79, 94 and 96 (FIG. 3a) via the lead 85, the lead 84, a lead 103 and a lead 104, respectively. In order to adjust the resistance value of the variable resistors 79, 94 or 96 respectively, the wafer switch S1, S2 or S3, respectively coupled thereto, is rotated. Variation of the variable resistor 79, 94 or 96 varies the frequency of the relaxation oscillator 14 when such variable resistor is connected to said oscillator via the switch S4 and each of said variable resistors serves as the tuning element or its corresponding audio oscillator 11, 12 and 13, respectively. Thus, the setting of a wafer switch S1, S2 or S3 selects one of the audio oscillators 11, 12 and 13 to determine the frequency of the tempo tone output of the Metronot and determines the frequency of the relaxation oscillator 14, and the setting of the multiposition switch S4 selects the octave.

The pulses produced by the relaxation oscillator 14 are supplied to the variable decay network 25 (FIG. 3b) via the secondary winding 105 of the transformer 91 of said relaxation oscillator and a lead 106. A diode 107 permits current to flow in the forward direction, so that the voltage across a capacitor 108 increases rapidly when the relaxation oscillator 14 supplies a pulse to the variable decay network 25. The increase of the voltage across the capacitor 108 is retarded to a predetermined extent by a resistor 109 connected in series with the diode 107. The voltage across the capacitor 108 appears across an output voltage divider 110 connected across said capacitor. Although the current may flow freely in the forward direction and charges the capacitor 108, the charge of said capacitor remains, and said capacitor may discharge only through a variable resistor 111 connected across the diode 107 when there is no pulse supplied by the relaxation oscillator 14. The greater the resistance value of the variable resistor 111, the longer the decay time of the pulses supplied by the relaxation oscillator 14.

The output signal of the variable decay network 25 is supplied to the input of the inverter 27. The output signal of the variable decay network 25 is provided at the voltage divider 110 thereof and is supplied via a lead 112 to the base 113 of a transistor 114 of the inverter 27. The transistor 114 has an emitter 115 and a collector 116, as well as the base 113, and is connected in grounded collector configuration, to prevent loading of the output of the variable decay network 25 by the relatively low impedance of a second transistor 117. The grounded collector connection is characterized by a high input impedance and a low-output impedance. The second transistor 117 has an emitter 118, a collector 119 and a base 121.

A signal from the emitter 115 of the first transistor 114 is supplied to a differentiating network comprising a capacitor 122 and a resistor 123. The resistor 123 and the capacitor 122 are connected in series in the emitter-collector path of the first transistor 114, with said resistor being connected in series with a diode 124 in the emitter-base path of the second transistor 117. The signal provided by the differentiating network 122, 123 comprises two spikes per pulse, one positive and one negative. The diode 124 functions to cut out the positive spike and permits only the negative spike to reach the second transistor 117. The second transistor 117 then inverts and amplifies the negative spike. The transistors 114 and 117 are biased via the DC power supply 65 and resistors 125, 126 and 127.

The output signal of the inverter 27 is supplied to the input of the cyclic counter 29 (FIG. 3c) via a lead 128 and a coupling capacitor 129. The capacitor 129 is connected to the base 131 of a trigger transistor 132 of the cyclic counter 29. The trigger transistor 132 has an emitter 133 and a collector 134, as well as the base 131. A capacitor 135 connected to the DC power supply 65 via a resistor 136 and a lead 137 functions to reset the counter 29 upon the switching ON of the.
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Metroton. The trigger transistor 132 is normally in its conductive condition and is switched to its nonconductive condition by the trigger transistor 132 is in its nonconductive condition, its collector voltage increases.

The counter 29 comprises a plurality of counter stages 138A, 138B, 138C (FIG. 3c), 138D, 138E, 138F, 138G, 138H (FIG. 3d) 138I, 138J, 138K and 138L (FIG. 3e). If the first counter stage 138A is ON, transistors 139 and 141 there are conductive and present a very low impedance in a voltage divider which includes the resistor 136 and resistors 142, 143 and 144. The resistor 142 is connected in series with the resistor 136 between the collector 145 of the transistor 139 and the lead 137. The resistor 143 is connected in series with a diode 146 between the emitter 147 of the transistor 139 and a lead 148 connected to the collector 134 of the trigger transistor 132. The resistor 144 is connected between the collector 149 of the transistor 141 and a lead 151 to the DC power supply 65, said resistor being connected to said collector via a lead 152.

The collector voltage of the transistor 141 is high when the transistors 139 and 141 are in their conductive condition. When a pulse is supplied to them, the transistors 139 and 141 are switched to their nonconductive condition. When the transistor 139 is switched off, its internal resistance becomes very high, so that its emitter voltage decreases and applies a negative pulse via a coupling capacitor 153 to the emitter of the transistor of the second counter stage 138B which corresponds to the transistor 139; the counter stages 138A to 138L comprising the same circuitry.

The process is repeated through any number of successive counter stages A multiwafer switch S5 (FIGS. 3c, 3d and 3e) comprises a plurality of switch arms 154A, 154B, 154C, 154D, 154E, 154F, 154G and 154H mechanically coupled to each other via a linkage 155 and jointly rotatable. Each of the counter stages 138A to 138L is connected to the DC power supply 65 via the lead 151 connected between a common point in the connection between the base of the transistor 139 and the collector 149 of the transistor 141 and the resistor 144. The switch arm 154A of the multiwafer switch S5 is connected to the switching circuit 21 via a lead 156 and a plurality of the switch points of the wafer with which said switch arm cooperates are connected to the DC power supply 65 via a lead 157 and the resistor 144.

The switch arm 154F of the multiwafer switch S5 is connected to a common point between the diode and resistor of the counter stage 138B corresponding to the diode 146 and resistor 143 of the counter stage 138A via a lead 158 and a plurality of switch points of the wafer with which said switch arm cooperates are connected to the emitter of the transistor of the third counter stage 138C corresponding to the transistor 139 of the counter stage 138A via a lead 159 and a coupling capacitor corresponding to the coupling capacitor 153 of the second counter stage 138B. The switch arms 154C to 154G (FIG. 3d) and the switch points of their corresponding wafers are connected similarly to the switch arm 154B and the switch points of its corresponding wafer. The switch arm 154H of the multiwafer switch S5 is connected to a common point between the diode and resistor of the counter stage 138H corresponding to the diode 146 and resistor 143 of the counter stage 138A via a lead 158.

The emitter 115 of the transistor 114 of the inverter 27 is connected to a switch point of the wafer cooperating with the switch arm 154A via a lead 161 (FIGS. 3b and 3c). Although the number of switch points connected to the resistor 144 of the first counter stage 138A is a maximum, the number of switch points connected to each succeeding counter stage gradually decreases to a minimum of switch points connected to the counter stage 138H. The emitter 139 of the first counter stage 138A is connected via a coupling capacitor 162, a lead 163 and a coupling capacitor of the counter stage 138F (FIG. 3e) corresponding to the coupling capacitor 162 of the first counter stage 138A to the emitter of the transistor of said counter stage 138I corresponding to the transistor 139 of the counter stage 138A. The number 1 switch point of the second wafer (FIG. 3c) is connected to the common lead 163 via a lead 164. The number 2 switch point of the third wafer (FIG. 3d) is connected to the common lead 163 via a lead 165. The number 3 switch point of the fourth wafer (FIG. 3d) is connected to the common lead 163 via a lead 166. The number 4 switch point of the fifth wafer (FIG. 3d) is connected to the common lead 163 via a lead 167. The number 5 switch point of the sixth wafer (FIG. 3d) is connected to the common lead 163 via a lead 168. The number 6 switch point of the seventh wafer (FIG. 3e) is connected to the common lead 163 via a lead 169. The number 7 switch point of the eighth wafer (FIG. 3e) is connected to the common lead 163 via a lead 171. The multiwafer switch S5 determines after how many stages the output negative pulse of a particular counter stage will be supplied to the first counter stage 138A as an input pulse. The first sequence of the eight counter stages 138A to 138H is for the higher octave. The second sequence of two counter stages 138I and 138J is for the middle octave. The third sequence of two counter stages 138K and 138L is for the lower octave.

A two-wafer switch S6 (FIG. 3e) comprises a pair of switch arms 172A and 172B mechanically coupled to each other via a linkage 173 and jointly rotatable. The switch arm 172A of the two-wafer switch S6 is connected to the switching circuit 21 via a lead 174. The zero switch point of the first wafer of the two-wafer switch S6 is connected to the DC power supply resistor of the counter stage 138I via a lead 175 and to the zero switch point of the second wafer via a lead 176. The number 1 switch point of the first wafer is connected to the DC power supply resistor of the counter stage 138I via a lead 177. The zero switch point of the second wafer is connected to the number 7 switch point of the eighth wafer of the multiwafer switch S5 via a lead 178. The number 1 switch point of the second wafer is connected to a common point in the connection between the counter stage 138I and the counter stage 138J via lead 179. The number 2 switch point of the second wafer is connected to a common point of the diode and resistor of the counter stage 138J corresponding to the diode 146 and the resistor 143 of the counter stage 138A via a lead 181. The switch arm 172B of the two-wafer switch S6 is connected to the capacitor of the counter stage 138K corresponding to the capacitor 153 of the counter stage 138B via a lead 182.

The two-wafer switch S6 determines after how many counter stages of the second sequence of stages 138I and 138J, an input pulse is supplied to the third sequence of stages 138K and 138L. A wafer switch S7 comprises a switch arm 183 which is rotatable. The switch arm 183 of the wafer switch S7 is connected to the switching circuit 21 via a lead 184. The zero switch point of the wafer of the wafer switch S7 is connected to the zero point of the first wafer of the two-wafer switch S6 and via the lead 175 via the lead 176. The number 1 switch point of the wafer of the wafer switch S7 is connected to the DC power supply resistor of the counter stage 138K via lead 185. The number 2 switch point of the wafer of the wafer switch S7 is connected to the DC power supply resistor of the counter stage 138L via a lead 186. The wafer switch S7 determines after how many counter stages of the third sequence of stages 138K and 138L, an output pulse is provided.

If desired, a lamp may be connected in series with the DC power supply resistor of each counter stage 138A to 138L, corresponding to the resistor 144. With the exception of counter stage 138A, between the corresponding counter stage and the resistor. The lamps may then serve as visual indication of the operation of the counter stages and the corresponding wafer switches.

The positive voltages and positive pulses provided by the variable decay network 25 are supplied to the switching circuit 21 FIG. 3f) via a lead 187. The lead 187 is connected to a diode 188 of a first AND-gate 189 and the lead 156 from the switch arm 154A of the multiwafer switch S5 of the counter 29 is connected to a second diode 191 of the first AND-gate
189. The lead 187 is connected to the diode 188 via a lead 192, to a diode 193 of a second AND-gate 194 via a lead 195 and to a diode 196 of a third AND-gate 197 via lead 198. The lead 174 from the switch arm 172A is connected to a second diode 199 of the second AND-gate 194. The lead 184 from the switch arm 183 is connected to a second diode 201 of the third AND-gate 197.

The first AND-gate 189 is connected in the input of a first Schmitt trigger circuit 202 comprising a pair of transistors 203 and 204. The second AND-gate 194 is connected in the input of a second Schmitt trigger circuit 205 comprising a pair of transistors 206 and 207. The third AND-gate 197 is connected in the input of a third Schmitt trigger circuit 208 comprising a pair of transistors 209 and 211. Each of the transistors 203, 204, 206, 207, 209 and 211 has an emitter, a collector and a base. The base of the first transistor 203, 206, and 209 of each Schmitt trigger is connected to the collector of the second transistor 204, 207, and 211 thereof and the base of the second transistor is connected to the base of said first transistor. The emitter of the first transistor is connected to the collector of the second transistor via a resistor 212, 213, and 214 in each of the first, second and third Schmitt triggers, respectively. The emitter of the second transistor is connected to the collector of the first transistor via a resistor 215, 216 and 217 in each of the first, second and third Schmitt triggers, respectively.

Each AND-gate is connected to the collector of the first transistor and to the base of the second transistor of each of the first, second and third Schmitt trigger circuits, respectively, via a resistor 218, 219 and 221.

The output of each Schmitt trigger circuit is provided at the resistor 212, 213 and 214, respectively. Thus, the positive pulses from the variable decay network 25 and the voltage from the wafer switch S6 are supplied to the high octave first AND-gate 189. When said pulses and said voltage are both positive, the first AND-gate 189 is switched to its conductive condition and supplies a triggering signal to the corresponding Schmitt trigger circuit 202. As long as the sawtooth pulse from the variable decay network 25 has a magnitude above a predetermined threshold level and a positive voltage signal is supplied from the first sequence of counter stages 138A to 138B of the counter 29, the second transistor 204 is in its conductive condition so that its impedance is decreased. Since the transistor 204 is connected in series with the energizing winding of a first relay 222 via a lead 223, the decrease in impedance of said transistor permits the energization of said relay.

When the relay 222 is energized, its armature 222A is attracted and is moved into electrical contact with a contact 224. When the armature 222A contacts the contact 224, the output of the first audio oscillator 11 is connected via a lead 225, said armature and a lead 226 to the amplifier 32.

The sawtooth pulses from the variable decay network 25 and the voltage from the wafer switch S6 are supplied to the middle octave second AND-gate 194. When said pulses and said voltages are both positive, the second AND-gate 194 is switched to its conductive condition and supplies a triggering signal to the corresponding Schmitt trigger circuit 205. As long as the sawtooth pulse from the variable decay network 25 has a magnitude above a determined threshold level and a positive voltage signal is supplied from the second sequence of counter stages 138L and 138J of the counter 29, the second transistor 207 is in its conductive condition so that its impedance is decreased. Since the transistor 207 is connected in series with the energizing winding of a second relay 227 via a lead 228, the decrease in impedance of said transistor permits the energization of said relay.

When the relay 227 is energized, its armature 227A is attracted and is moved into electrical contact with a contact 229. When the armature 227A contacts the contact 229, the output of the second audio oscillator 12 is connected via a lead 231, said armature and a lead 232 to the amplifier 32.

The sawtooth pulses from the variable decay network 25 and the voltage from the wafer switch S7 are supplied to the low octave third AND-gate 197. When said pulses and said voltage are both positive, the third AND-gate 197 is switched to its conductive condition and supplies a triggering signal to the corresponding Schmitt trigger circuit 208. As long as the sawtooth pulse from the variable decay network 25 has a magnitude above a determined threshold level and a positive voltage signal is supplied from the third sequence of counter stages 138K and 138I of the counter 29, the second transistor 211 is in its conductive condition so that its impedance is decreased. Since the transistor 211 is connected in series with the energizing winding of a third relay 233 via a lead 234, the decrease in impedance of said transistor permits the energization of said relay.

When the relay 233 is energized, its armature 233A is attracted and is moved into electrical contact with a contact 235. When the armature 233A contacts the contact 235, the output of the third audio oscillator 13 is connected via a lead 236, said armature and a lead 237 to the amplifier 32.

The output tones produced by the audio oscillators 11, 12 and 13 are supplied to the amplifier 32 via coupling resistors 238, 239, and 241, respectively, and via a two-position switch S8. The two-position switch S8 comprises a switch arm 242, a switch contact 243 connected to each of the coupling resistors 238, 239 and 241, and a switch contact 244 connected to the secondary winding 245 of the transformer 87 of the relaxation oscillator 14 via a lead 246 and a coupling resistor 247. The switch S8 thus connects either the audio oscillators to the amplifier, in which case tones are produced by the speaker 38, or the relaxation oscillator to said amplifier, in which case clicks are produced by said speaker.

The switch arm 242 of the switch S8 is connected via a lead 248 to a potentiometer 249 of the amplifier 32. The potentiometer 249 is connected either in series with the coupling resistors 238, 239 and 241 or in series with the coupling resistor 247 by the switch arm 242. The potentiometer 249 functions to adjust the volume of the sound produced by the speaker 38. The amplifier 32 may comprise any suitable amplifier such as, for example, a transistor 251 connected in grounded emitter circuit and biased by resistors 252, 253 and 254. A capacitor 255 is connected across an emitter resistor 256 and functions as a bypass capacitor. A coupling capacitor 257 couples the potentiometer 249 to the base of the transistor 251 and a coupling capacitor 258 couples the collector of said transistor to the sound coil 259 of the speaker 38 via a lead 261. Although the transistor 251 functions as an inverter, the human ear cannot distinguish the phase difference of the audio signal.

FIG. 4 is a cabinet for housing the Metrotom system electronic equipment of the present invention. In FIG. 4, each of the wafer switches S1, S2 and S3 (FIG. 3) is rotated by a corresponding knob K1, K2 or K3. The operator thus selects the desired tone and the corresponding tempo tone in the higher, middle and lower octaves by manual rotation of the knobs K1, K2 and K3 of the wafer switches S1, S2 and S3. Each of the knobs K1, K2 and K3 may be rotated to any of 12 distinct positions to simultaneously set the tones and the tempo tones. The position of each knob K1, K2 and K3 is indicated by a corresponding dial DJ, D2 and D3.

The position of each knob K1, K2 and K3 determines a tone, whereas the corresponding tempo tone of a selected knob controls the basic duty cycle of the Metrotom system to function as the basic clock thereof. The switch S4 (FIG. 3c) is rotated by a knob K4. The operator selects the octave which is to provide the basic clock by manual rotation of the Knob K4. The switch S8 (FIG. 3f) selects either tones or clicks. If the switch S8 is set for"clicks," the speaker 38 produces only clicks. The repetition rate of the clicks produced by the speaker 38 is determined by the setting of the switch S4. If the switch S8 is set for "tones," the speaker 38 (FIG. 3f) produces tones of one, two or three octaves, dependent upon the settings of the other knobs.
Each of the multiwafer, two-wafer and wafer switches S5 (FIGS. 3c, 3d and 3e), S6, and S7 (FIG. 3e) is rotated by a corresponding knob K5, K6 and K7, respectively. A circular number scale is positioned on the cabinet around each of the knobs K5, K6 and K7. The numbers around each of the knobs K5, K6 and K7 indicate how many times the tones set by the knobs K1, K2 and K3 are skipped. The numbers around the number scale around the knob K5 indicates that no skipping tempo tone is sounded. Thus, for example, if the knob K5 is set at the number 7 on the number scale, there are seven skip or silent periods and one sound period, so that the tone indicated by the dial D1, D2 or D3 sounds once every eight intervals or duty cycles of the basic tempo tone.

The numbers of the number scales of the knobs K6 and K7 indicate the number of times that the tones set by the knobs K2 and K3, respectively, are skipped. The repetition rate of the tone is not referenced to the basic tempo tone, but to the repetition rate of the tone in the next higher octave, which next higher octave is selected by the knobs K2 and K3. The sign of each number scale indicates absolute silence of the tone in the particular octave.

Each of the dials D1, D2 and D3 indicates, by means of circular number scales positioned on the cabinet under them and diametrically opposed notches formed in their edges and a window formed through each, the tone and tempo tone such as, for example, E, F, F#, and so on, the number of cycles per second of the selected tone and the number of cycles per minute of the selected tempo tone, which is the same number, and the musical symbol of the selected tone. The tone and tempo tone are thus indicated by the notches N1, N2 and N3, the number of cycles per second of the tone and cycles per minute of the tempo tone are indicated by the notches N4, N5 and N6, and the musical symbol of the tone is indicated by the windows W1, W2 and W3. A pointer or arrow design may be utilized on each knob to indicate the corresponding notches and windows, if desired. The musical pentagram may be suitably indicated.

A switch S9 is rotated by a knob K9 which is mechanically coupled to and moves the variable resistor 111 of the variable decay network 25 (FIG. 3b) to select the duration of the tone. A switch S10 is rotated by a knob K10 which is mechanically coupled to and moves the variable resistor 249 of the amplifier 32 (FIG. 3f) to control the volume of the sound produced by the speaker 38 (FIG. 3f). A switch S11 is manually operated by the operator to turn the Metroton system on and off.

The cabinet may comprise any suitable material such as, for example, steel or nickel steel or other suitable metal of suitable thickness. The various knobs and dials may comprise any suitable material such as, for example, plastic material such as Bakelite or Lucite. The dials are preferably Lucite or Plexiglas and may have an opaque backing on them except for their windows W1, W2 and W3 and for their notches N1, N2, N3, N4, N5 and N6, where the are kept translucent.

If desired, a plurality of lamps of suitable or desired size, color, position and arrangement may be utilized on the front panel or other surface of the cabinet to indicate the higher, middle or lower octave selected. The various tempo tones are provided at the 36 different frequencies or repetition rates at which the Metroton system of the present invention operates. The tempo tones are adjusted to have frequencies lower than the tones, E, F, F#, G, G#, A, A#, B, C, C#, D and D# by a fixed ratio such as, for example, 60:1. When the ratio of 60:1 is utilized, the frequency of each tone in cycles per second is the same as the frequency of the corresponding tempo tone in cycles per minute.

Quarter tone intervals may be provided by the Metroton system of the present invention at 72 independent settings of tempo quarter tones. If, for example, the basic tempo tone in the higher octave is to be B at 240 cycles 1 per minute (FIG. 1), which corresponds to a tone of B of 240 cycles per second and is to sound at every fourth basic tempo tone, if the tone of B of the middle octave is to sound every other time that the B 240 cycle tone sounds (FIG. 1) and furthermore, is the tone E of the lower octave is to be 40 cycles per second and is to sound every third time that the tempo tone B at 120 cycles sounds, the Metroton system is operated as follows.

1. The switch S4 is manually set via its knob K4 to a position in which its dial D1 notch N1 indicates B and its notch N4 indicates 240.
2. The switch S1 is manually set via its knob K1 to a position in which its dial D2 notch N2 indicates B and its notch N5 indicates 120.
3. The switch S2 is manually set via its knob K2 to a position in which its dial D3 notch N3 indicates E and its notch N6 indicates 60.
4. The switch S3 is manually set via its knob K3 to a position in which its dial D3 notch N3 indicates E and its notch N6 indicates 60.
5. The multiwafer switch S5 is manually set via its knob K5 to the number position 3.
6. The two-wafer switch S6 is manually set via its knob K6 to the number position 1.
7. The switch S7 is manually set via its knob K7 to the number position 2.
8. The switch S8 is manually set to "tones."
9. The switch S11 is manually set to ON.
10. The switch S10 is manually rotated via its knob K10 to adjust the volume to the desired level.
11. The switch S9 is manually set via its knob K9 to the desired duration of the tone.

The results of such manual operation are that a tone B at 240 cycles per second sounds every second, a tone B at 120 cycles per second sounds every 2 seconds, and a tone E at 40 cycles per second sounds every 6 seconds. The Metroton scale of FIG. 1 is preferably affixed to the top of the cabinet of FIG. 4 so that it is in sight of the operator.

While the invention has been described by means of specific examples and in a specific embodiment, I do not wish to be limited thereto, for obvious modifications will occur to those skilled in the art without departing from the spirit and scope of the invention.

What is claimed is:

1. Apparatus for relating tone to the repetition rate of metronomic sound, said apparatus comprising sound-producing means for producing metronomic audible sound; control means connected to said sound-producing means for selecting repetition rate of said sound; means for producing an audio tone, and means operatively connected to said control means and said audio tone-producing means for simultaneously adjusting said repetition rate and the frequency of said audio tone whereby there is a one-to-one correspondence between said repetition rate and the frequency of said audio tone, and said audio frequency is adjustable by said adjusting means to increase only with increases in said repetition rate and to decrease only with decreases in said repetition rate.
2. Electronic equipment for providing a tonal structure for the metronomic divisions of musical time wherein pitch is related tonally and numerically to the repetition rate of pulse beats, said electronic equipment comprising tone-producing means for producing audible tones; sound-producing means for producing audible sounds; control means connected to said tone-producing means and to said sound-producing means for selecting one of a tone and a sound for production, for selecting an octave range for the selected one of a tone and a sound and for controlling the duration and repetition rate of
the selected one of a tone and a sound; and production means connected to said control means for producing the selected one of the tone and the sound in the selected octave range at the controlled duration and repetition rate.

3. Electronic equipment as claimed in claim 2, wherein said tone-producing means comprises a plurality of audio oscillators each providing a plurality of tones in a corresponding one of said octave ranges.

4. Electronic equipment as claimed in claim 3, wherein said sound-producing means comprises relaxation oscillator means and wherein said control means comprises switching means, manually controllable switch means in said switching means for controlling the connection of one of a selected one of said audio oscillators and said relaxation oscillator means to said production means, manually controllable switch means connected between each of said audio oscillators and said production means for connecting one of said audio oscillators to said production means, manually controllable tuning means connected to each of said audio oscillators for tuning each of said audio oscillators to control the repetition rate thereof and manually controllable decay means connected to said switching means for controlling the duration of the selected one of the tone and the sound.

5. Electronic equipment as claimed in claim 2, wherein said production means comprises an electroacoustic transducer.

6. Electronic equipment as claimed in claim 2, wherein said sound-producing means comprises relaxation oscillator means.

7. Electronic equipment as claimed in claim 6, wherein said production means comprises an electroacoustic transducer.

8. Apparatus for providing tonal structure for the metronomic divisions of musical time, comprising means for producing repetitively occurring pulses of audible tones, and means for simultaneously adjusting the frequency of said tones and the repetition rate of said pulses, whereby the frequency of said audible tones has a 1:1 correspondence with the repetition rate of said audible tones, and the frequency of said tones is varied by said adjusting means only in the same sense as said repetition rate.

9. An apparatus for providing tonal structure for the metronomic divisions of musical time, said apparatus comprising means for producing audio frequency tones, control means connected to said tone producing means for periodically sounding said tones, said control means comprising means for selectively controlling the repetition rate of said sounded tones, and means for simultaneously adjusting the frequency of said tones and said repetition rate whereby each said repetition rate corresponds only to a single separate audio tone and said repetition rate and frequency of said tone are varied by said adjusting means only in the same sense.

10. The apparatus of claim 9 wherein said control means further comprises switch means connected to inhibit the sounding of said audio frequency tones while permitting the sounding of beats at said repetition rate.

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