March 6, 1951 L. A. MEACHAM 2,544,466

ELECTRONIC MUSICAL ENTERTAINMENT DEVICE

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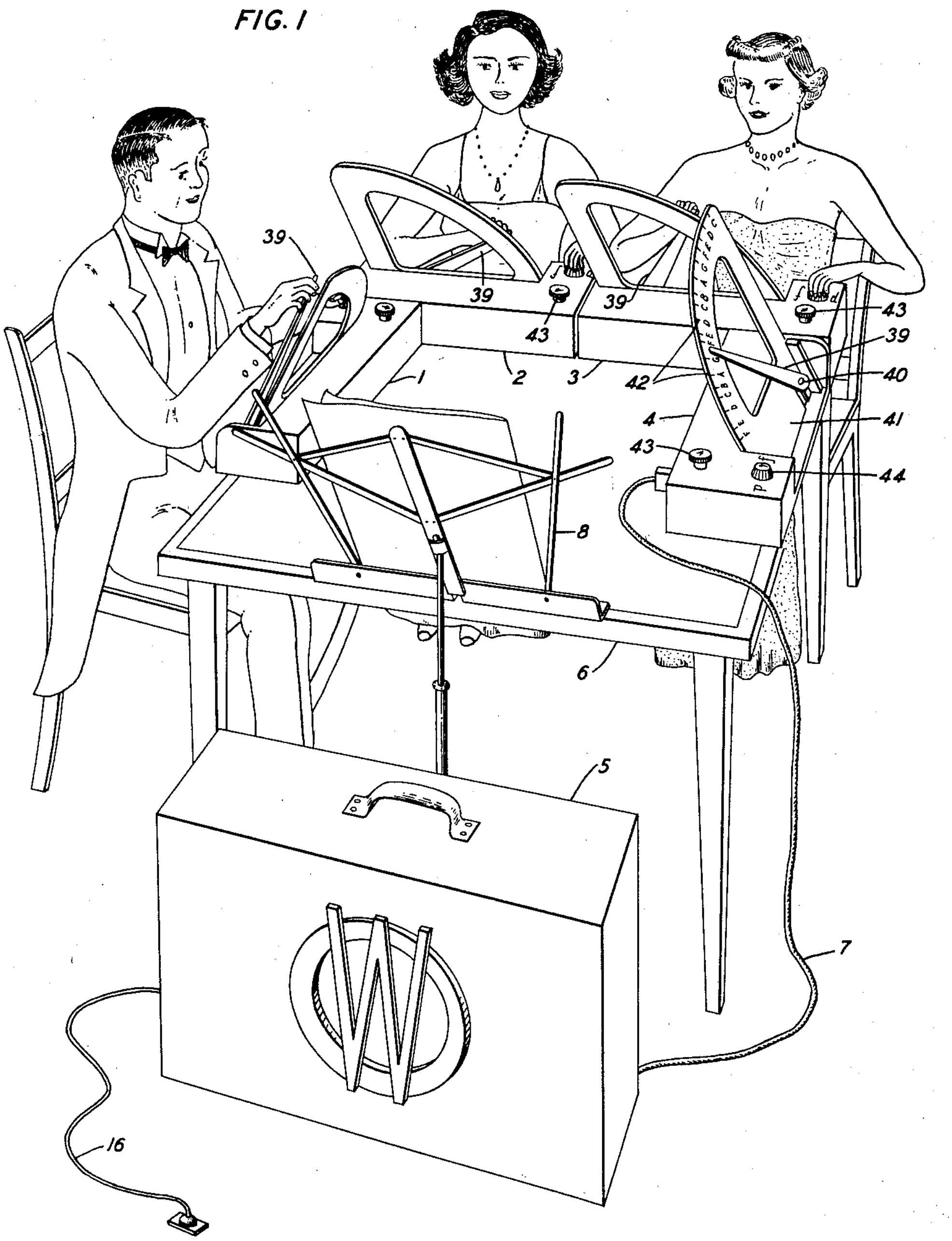
FIG. 1



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ELECTRONIC MUSICAL ENTERTAINMENT DEVICE

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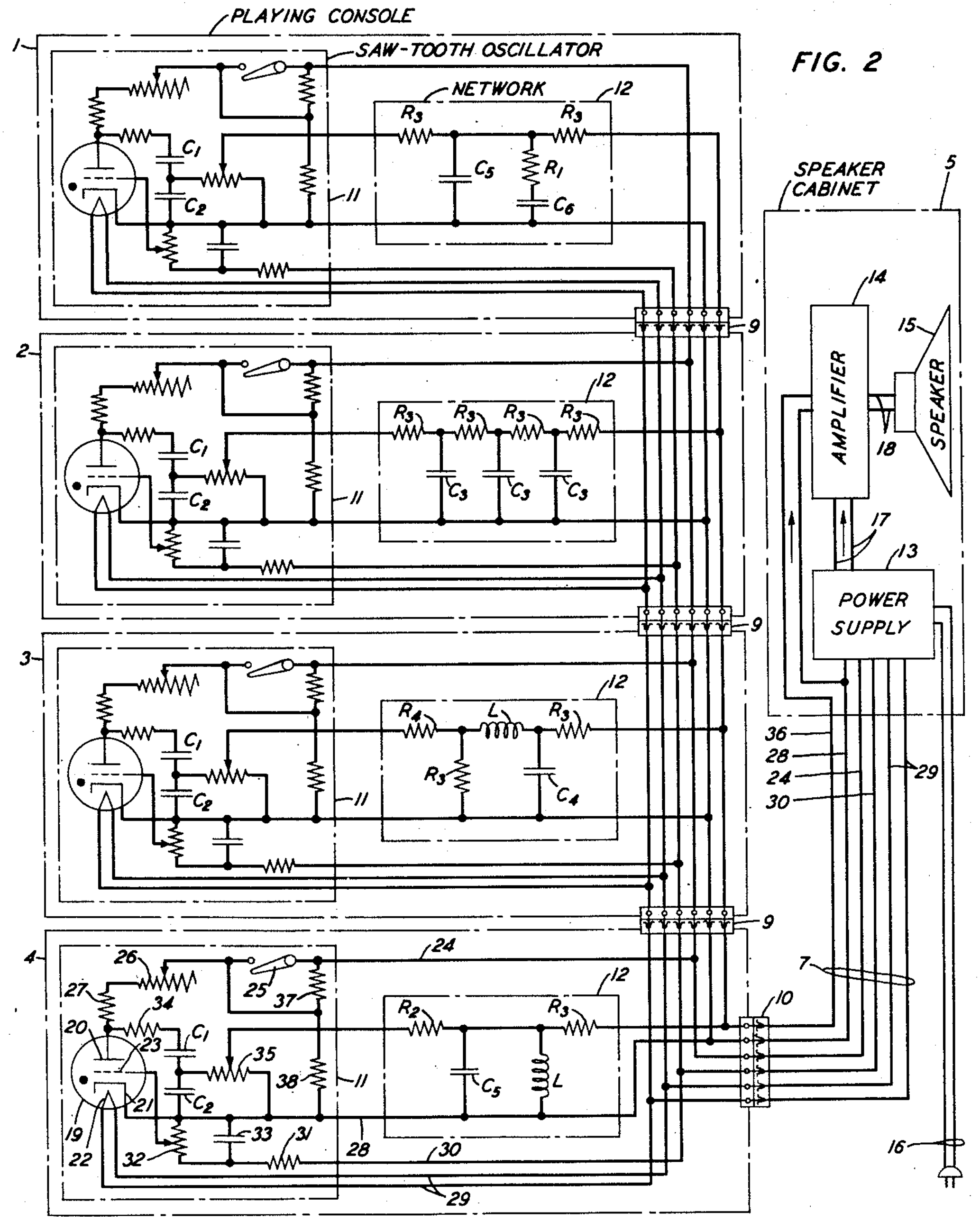

FIG. 2

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FIG. 3

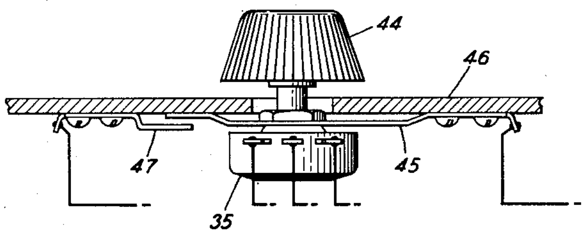
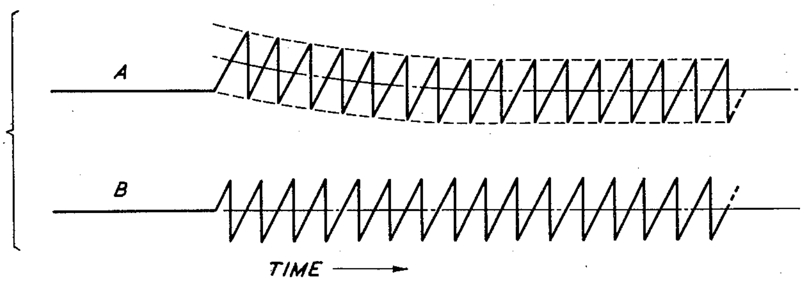


FIG. 4



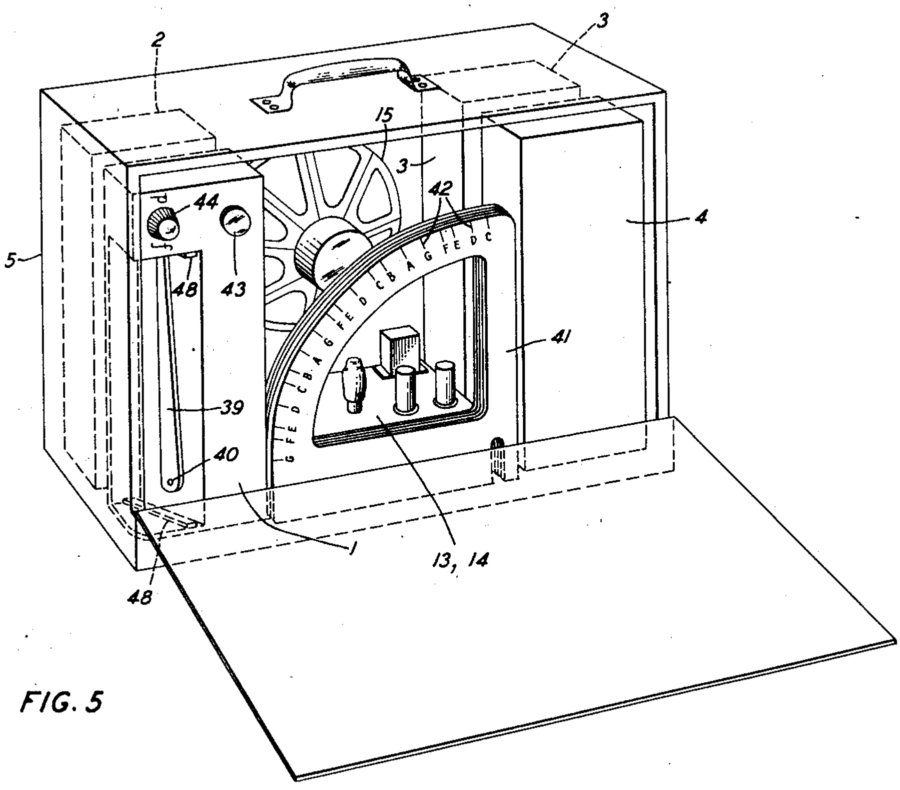


FIG. 5

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2,544,466

ELECTRONIC MUSICAL ENTERTAINMENT DEVICE

Larned A. Meacham, New Providence, N. J.

Application April 27, 1950, Serial No. 158,546

9 Claims. (Cl. 84—1.17)

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This invention relates to electronic musical entertainment devices, and more particularly to such a device that is intended to be of low cost and to afford participative recreation to amateur and family groups.

The primary object of the invention is to facilitate the production of harmonic or polytonic music, the component voices thereof being conveniently and independently controllable in pitch over wide ranges, and also in continuity and volume, by separate performers who need have little or no experience with the manipulation of conventional musical instruments.

A second object is to employ a minimum amount of apparatus, the electrical components of which are simple and conventional, hence tending to be both inexpensive and readily available.

A third object is to achieve convenient portability of the entertainment device.

Known electronic musical instruments, exclusive of conventional acoustical musical instruments to which mechanico-electrical reproducing devices have been applied, such as the so-called "electric guitar," fall into two principal categories. In the first category, electrical vibrations or waves are produced by a single electrical source, and the pitch and amplitude thereof are controllable by the operator, as for example by varying the capacitance of a tuning condenser, for pitch, and the value of an attenuating resistance, for amplitude or volume. Such instruments are characteristically monotonic; that is to say, they can play only one tone at a time. In some cases within this category the pitch or frequency is continuously variable over the entire range of the instrument, for example as disclosed in Patent 1,791,374, granted February 3, 1931, to H. C. R. Pechadre. In other cases, only particular discrete frequencies are provided (commonly separated by musical intervals of a semitone), the corresponding discrete values of the frequency-determining element being selected by operation of electrical contacts or keys. An example of such cases is afforded by Patent 2,233,-258, granted February 25, 1941, to L. Hammond.

In the second category, electrical vibrations of substantially constant pitch are generated by independent or semi-independent sources, these sources or combinations thereof being selected by contacts or keys for transmission to a loud speaker or other electro-acoustical transducer. In some cases the harmonic content of the electrical vibrations, and therefore the tone quality, may be controlled by electrical "stops." Such instruments are characteristically polytonic. However,

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since the discrete pitches of the several sources are substantially constant, in contrast to being under sensitive control of the performer, they are at best tuned in accord with the even-tempered scale. Hence, as is common knowledge, such instruments lack the harmonic purity which characterizes music produced by ensemble groups such as a string quartet or a vocal quartet which do not have this limitation. Furthermore, being essentially keyboard instruments, they are not capable of many of the details of expression and nuance that contribute to the distinctive interest and beauty of ensemble music. In addition they require long practice and the development of considerable manual dexterity before even a moderate degree of musical satisfaction is afforded to either the player or to listeners.

The present invention avoids these restrictions, and combines the advantages of the instruments of both of the foregoing categories. In addition, it affords to the operators thereof the same satisfaction or thrill of teamwork as that which is known to be one of the principal sources of enjoyment among chamber music players and members of choral ensembles.

With special regard to the second object of the invention, recited hereinbefore, the present invention avoids the use of a multiplicity of contacts, frequency sources, or other components, such as are generally required for keyboard instruments in either the aforesaid monotonic or polytonic categories. It avoids the need for specially designed or unconventional variable tuning elements. Furthermore, it affords means which so facilitate accurate ensemble playing by its several operators as to make feasible the combination of their respective electrical tones or voices for transmission through a common set, as contrasted with individual sets, of amplifying and reproducing apparatus; therefore it minimizes the necessary amount of such apparatus.

The nature of the invention will be more fully understood from the following detailed description and by reference to the accompanying drawings, of which:

Fig. 1 is a pictorial representation of an embodiment of the invention, suitable for simultaneous use by four players, the device being shown assembled upon a table such as a card table in readiness for playing, and three of the four players being shown in typical playing positions;

Fig. 2 is a schematic circuit diagram portraying the electrical apparatus and connections of the device shown in Fig. 1;

Fig. 3 is a sectional view of a portion of the device of Fig. 1, showing a feature of the invention;

Fig. 4 is a waveform diagram illustrating a feature of the invention; and

Fig. 5 shows the entertainment device of Fig. 1 with its major components reassembled for storage or transportation.

Referring now particularly to Fig. 1, there is shown an entertainment device comprising four playing consoles **1**, **2**, **3**, and **4** and a speaker cabinet **5**. The playing consoles are supported by a card table **6** and are so disposed thereon as to form three sides of a rectangle. Pairs of playing consoles adjacent to one another are connected solidly together mechanically and electrically, as by means of conventional multi-contact connectors (plugs and sockets), and the entire assembly is connected electrically to the speaker cabinet by a flexible multiconductor cable **7**. The four players, only three being shown, are seated around three sides of the table facing their respective consoles. The fourth side of the table is preferably turned toward any audience that may be present, and may be faced by a music rack **8** if desired. The speaker cabinet **5** may be placed in any convenient location near enough to the table to allow its sound output to be clearly heard by the performers.

In the schematic diagram, Fig. 2, it is shown that the connections between the consoles **1**, **2**, **3** and **4** are provided by means of three six-contact connectors **9**, and that the connection between this assembly and the speaker cabinet **5** is by means of another similar connector **10** and the six-conductor cable **7**. Each console contains a source of electrical vibrations rich in harmonics, represented in this embodiment by a saw-tooth oscillator **11**, with means for control of this source by the operator, and a waveform-shaping network **12**. The speaker cabinet **5** contains a power supply **13**, an amplifier **14**, and a speaker **15**. The power supply is connected to a primary source of power through the cable **16** and to the amplifier **14** by the conductors **17**. The amplifier output is connected to the speaker by the conductors **18**.

All of the consoles are alike except with regard to the values of certain circuit parameters and the details of the waveform-shaping networks; therefore they may be described, for convenience, with reference to a particular one of them. Console **4** will be used, it being portrayed more clearly than the others in Fig. 1.

Referring again to Fig. 2, the sawtooth oscillator **11** is basically of a conventional type, commonly used to generate sweep potentials in cathode-ray oscilloscopes and for other similar applications. It employs a gas-filled discharge tube **19** having an anode **20**, a cathode **21** heated by a filamentary heater **22**, and a control electrode **23**. A positive supply potential of approximately 150 volts, preferably regulated in any well-known manner so as to have no fluctuations greater than plus or minus 0.2 percent, is impressed by the power supply **13** upon the conductor **24**, and is thereby conveyed through the switch **25** (when the latter is closed), a variable resistor **26** (1,000,000 ohms maximum or total value), and a fixed resistor **27** (10,000 ohms) to the anode **20** of the tube **19**. The opposite side of this 150-volt supply, referred to herein as "ground," is connected through conductor **28** to the cathode **21**. Heater power is supplied through conductors **29** to the filamentary heater

22. A bias potential of 60 volts, negative in polarity with respect to ground and preferably regulated to the same accuracy as the 150-volt supply, is connected through conductor **30**, resistor **31** (150,000 ohms), and a potentiometer **32** (35,000 ohms) to ground, and the movable contact of this potentiometer is connected to the control electrode **23**. A by-pass condenser **33** (0.1 microfarad) is connected in parallel with potentiometer **32**. Two condensers C2 and C1 having different values in the respective consoles (tabulated hereinafter), and a current-limiting resistor **34** (300 ohms), are all connected in series, in the order given, from ground to the anode **20**. A potentiometer **35** (200,000 ohms total) is connected from the common terminal of condensers C1 and C2 to ground, and the movable contact of this potentiometer is connected to one of the two input terminals of the network **12**, the other input terminal being grounded. The two output terminals of the network **12** are connected by conductors **36** and **28** to the input of amplifier **14**. A voltage divider comprising the resistors **37** and **38** in series (1,300,000 ohms and 510,000 ohms, respectively) is connected between conductor **24** and ground, and the junction of the two resistors is connected to the common terminal of the variable resistor **26** and the switch **25**.

The operation of the saw-tooth oscillator will now be described, even though it is basically conventional, to provide background for what is to follow. The gas-filled tube **19** can conduct current across its anode-cathode gap only when the gas within it is ionized, and ionization is initiated by raising the anode-cathode potential above a critical "breakdown" value, which is determined by the value of the bias potential applied to the control electrode **23**. In the oscillator the breakdown potential is normally set at about 80 volts by adjustment of the potentiometer **32**. When the switch **25** is open, a potential of approximately 40 volts is applied to the moving contact of the variable resistor **26** from the voltage divider **37**, **38**, and as a result condenser C1 is charged to the same potential. This voltage is also present across the anode-cathode gap, there being no ionization of the tube because the critical potential is not exceeded. When the switch **25** is closed, however, current flows through resistors **26**, **27** and **34** and charges the condensers C1 and C2 so that the anode-cathode potential rises exponentially, tending to approach a value of 150 volts as an asymptote. This rise continues until the critical voltage is reached, whereupon the tube becomes strongly conducting and condensers C1 and C2 are very rapidly discharged. The resistor **34** prevents damage to the tube by limiting the discharge to a tolerable value. Upon completion of the discharge, the anode current diminishes to so small a value that ionization is no longer sustained, and the tube once more becomes non-conducting. When this has occurred, the current flowing from the 150-volt source through resistors **26** and **27** is no longer passed through the anode-cathode path to ground, but instead flows through resistor **34** and charges the condensers. As before, this continues until breakdown is reached, and thus the cycle of operation is repeated. The voltage across the condensers, and particularly that across condenser C2, is accordingly of the well-known saw-tooth waveform. This voltage is applied across the potentiometer **35**, and from thence an adjustable fraction of the wave is applied to the network 12 through which a modified waveform is transmitted to the amplifier 14. Generation of the saw-tooth wave continues until the switch 25 is opened, whereupon the wave is immediately interrupted, and soon thereafter condenser C2 is completely discharged by conduction through potentiometer 35, while condenser C1 is restored to its original potential of 40 volts by conduction from the voltage divider 37, 38.

As an alternative to the particular oscillator circuit arrangement shown in Fig. 2, the connections to the anode 20 and those to the cathode 21 may be interchanged, the polarity of the 150 volt supply being simultaneously reversed, this supply, now negative in potential, being connected to resistor 31 in place of the 60-volt negative supply, and the value of resistor 31 being reduced sufficiently to allow the potential of the control electrode 23 to be adjusted to approximately 80 volts, negative with respect to ground. The description of operation given in the preceding paragraph applies equally well to this alternative arrangement and to the circuit as shown in Fig. 2.

The period of each cycle of the saw-tooth wave, and hence the frequency of the wave, is determined by the rate of rise of the potential across the two condensers, and the range of potential through which it rises before breakdown occurs. The rate of rise is inversely proportional to the product RC, where R is the overall charging resistance comprising resistances 26, 27, and 34, in series, and C is the effective capacitance of C1 and C2, also in series. Thus variation of resistor 26 can be used to change the frequency, as can also the choice of the effective capacitance C. As noted earlier the critical breakdown potential depends upon the setting of potentiometer 32. All three of these frequency-determining means are utilized, as will be shown.

Referring now to both Fig. 1 and Fig. 2, the variable resistor 26, actuated by a movable "playing arm" 39, is used by the performer as the principal pitch control. The playing arm, carried on a rotatable shaft 40 which also carries the moving contact of the variable resistor 26, is arranged to be turned through an angular range of about 75 degrees, and the corresponding variation of the charging resistance R is such that the pitch changes through a range of approximately two and one-half octaves, or about six to one in frequency. This range is at least as great as that of the human voice. By choice of different values for the condensers C1 and C2 in the respective consoles, the frequency or pitch range may be located differently on the spectrum for each console. Accordingly, console 1 may be made to cover the range of a bass voice; console 2 that of a contralto; console 3, soprano; and console 4, tenor. The ranges may alternatively be chosen to correspond to the four voices of a male quartet, or to the parts of some other musical group. A typical set of capacitance values and corresponding pitch and frequency ranges is tabulated below. Standard musical notation is used; capacitance is given in microfarads, and frequency in cycles per second.

Voice	Pitch Range	C1	C2	Frequency Range
Soprano	f to c‴	0.025	0.25	175 to 1,050
Contralto	c to g″	0.035	0.35	130 to 780
Tenor	F to c″	0.05	0.5	87.5 to 525
Bass	C to g′	0.07	0.7	65 to 390

It should be pointed out that the purpose of using two condensers C1 and C2 in series instead of a single condenser is to provide a point of lower impedance for connection to the potentiometer 35, and thus to secure a better impedance relationship between source and load. This allows more signal power to be transmitted to the network 12, and also prevents variations in the setting of potentiometer 35 from having any appreciable effect upon the oscillator frequency or waveform.

The playing arm 39 is operated by the right hand of the player in relation to a sloping "scale quadrant" 41 which carries musical scale designations 42 around the curved portion of its periphery. These designations are intended to be used only as a rough guide, but they are found to be of value even to an experienced player in making rapid changes over large musical intervals, and they tend to be indispensable to a beginner. For accuracy of intonation and true blending of the four voices of the instrument, each player must relay upon his own "ear" and judgment. Experience in playing this instrument has shown that although steady tones, without "vibrato," are desirable in some kinds of music, a much more generally useful "live" effect can be obtained by wobbling the playing arm smoothly back and forth through a small angular range above and below the position of true intonation. This corresponds to the vibrator used in playing a violin or trombone, or occurring naturally in the human singing voice. The players have generally agreed that a vibrato of small extent (less than half a semi-tone peak to peak) and at a rate of about four or five cycles per second is desirable. This motion gives an interesting appearance to the group of players, and has led to use of the term "Wobble Organ" for the entertainment device. Incidentally, it will be noted that the letters W and O are superimposed as a monogram over the loud speaker opening in the cabinet 5, the W also forming a guard to protect the speaker diaphragm.

To allow a player's hand to produce the aforesaid vibrato with a comfortable wrist motion, the notes should be spread well apart on the pitch scale 42. A uniform spacing of about one inch per whole tone is found to be satisfactory. To secure this relationship, it is essential that the pitch vary linearly with the angle of the playing arm, so that equal musical intervals anywhere in the range correspond to equal increments of angle. This condition is achieved with considerable accuracy by using for the variable resistor 26 a commercially available device known as the Type J one-megohm logarithmic potentiometer, manufactured by the Allen-Bradley Company of Milwaukee, Wisconsin. When this device is connected as described earlier, in series with fixed resistances having a combined value of 10,300 ohms, it is found that the shaft angle varies accurately as the logarithm of the overall charging resistance R, over at least the portion of the resistance range between 75,000 and 450,000 ohms. On account of the fact that the musical pitch is proportional to the logarithm of the frequency, and that the frequency is inversely proportional to the resistance value R, the arrangement described affords the desired linear relationship between angular position and pitch. For the particular elements and resistance values given, the variation is at a rate of about five degrees per whole tone, or thirty degrees per octave. Since the playing arm swings over a range of 75 degrees, the corresponding pitch range is two and one-half octaves as noted earlier. The playing arm 39 is set on the potentiometer shaft at such an angle that the minimum and maximum values actually used correspond approximately with the limits of the resistance range referred to above. In order that the end of the playing arm shall move about an inch per whole tone its length is made approximately twelve inches.

One other pitch control, a tuning adjustment to compensate for temperature variations, aging and the like, is required as in almost any other musical instrument. A tuning knob 43, connected to the shaft of potentiometer 32, is provided for this purpose, allowing each voice to be tuned to a standard of pitch such as a tuning fork or the "a" of a piano while the playing arm is held at the corresponding pitch indication on the scale quadrant.

As indicated earlier in connection with switch 25, the operation of the tone source is not continuous; it can be started and stopped at will by the corresponding performer. The oscillator is normally idle. Oscillation is started by a slight downward pressure of the player's left hand on a "dynamics knob" 44 located at the left front of the console. This pressure closes a contact which in Fig. 2 is represented by the switch 25. Thus the player may use a "portamento" between notes, leaving the tone on, or play in a "detaché" or "stacatto" manner, momentarily interrupting the tone, as desired.

The amplitude of the wave delivered by the individual console is also under control of the dynamics knob 44, for it is arranged to be turned as well as pressed by the player's left hand, and is coupled to the moving contact of potentiometer 35. Its rotation may be calibrated in musical symbols of intensity, such as "*pp—p—mp—mf—f—ff*," or this can be left to the inclination of the player, with "*p*" and "*f*" noted as rough guides near the ends of the range, as shown in Fig. 1. The simple mechanism of the dynamics control is illustrated in Fig. 3. The knob 44 is carried by the shaft of the potentiometer 35, and the latter is mounted upon a flat cantilever spring 45 having its fixed end attached to the under side of the console top 46. Downward pressure on the knob causes spring 45 to deflect, making contact with a rigid member 47, also attached to the console top 46.

It was pointed out in the description of the oscillator that each time the switch 25 was opened the potentials across condensers C1 and C2 were restored to normal values of 40 volts and zero, respectively. If the voltage dividing resistances 37 and 38 were not provided, the opening of switch 25 would leave the potential across C1 at an indefinite value which would depend upon the particular instant at which the opening occurred. For example, the voltage might be left at its minimum value if the interruption occurred immediately after completion of a suddent discharge. In this case the initial rise of the anode potential upon reclosure of the switch 25 would be through substantially the entire range from near zero to the breakdown potential, a range corresponding to the peak to peak amplitude of the saw-tooth wave. Concurrently, the voltage across C2 would rise a proportionate amount, starting from zero potential, as shown in line A of Fig. 4. During succeeding cycles of the saw-tooth observed across C2 the envelope thereof would gradually change so that the wave became symmetrically disposed with respect to the line of zero potential, in accordance with well established principles of transient behavior, there being no means of sustaining a "direct-current component" of the wave. Such a starting transient is found to give an objectionable "thump" at the beginning of a note, particularly if the amplitude is great enough to cause the initial excessive voltage rise to overload the amplifier 14. Provision for restoring the potential on C1, during quiescence, to a value of 40 volts, which is approximately equal to the average value of the same potential during oscillation, avoids this objectionable effect, for it causes the wave observed across C2 to be symmetrically disposed above and below the zero line from the very beginning, as illustrated in line B of Fig. 4. The "thump" referred to is thereby substantially eliminated.

The four networks 12 are given different characteristics in order to produce distinctive tone qualities for each voice of the instrument. This is important from two standpoints. First, it affords interesting and pleasing variety in tone color, and second, it allows each player to distinguish clearly his own contribution to the ensemble of sound coming from a common speaker. The latter consideration is particularly important, for it is found that without these tonal differences some other means of making the voices more clearly distinguishable to the players is needed, such as the provision of separate amplifiers and speakers to secure spacial or directional discrimination.

The networks function by suppressing particular ranges of frequency more than others in the complex harmonic structures of their respective saw-tooth waves. They may have any of a wide variety of well-known configurations. If desired, simple switching arrangements may be employed to make several different networks, and thus different tone qualities, available to each performer for the sake of variety and contrast. Alternatively the networks may be mounted on or within the consoles as "plug-in" units, using conventional three-terminal or four-terminal sockets, the tone qualities being selected accordingly.

A tabulation is given below of the component parts of the particular networks shown in Fig. 2, the values being expressed in ohms, microfarads, and henries.

Element	Value
R1	5,100
R2	10,000
R3	24,000
R4	51,000
C3	0.002
C4	0.003
C5	0.05
C6	0.25
L	0.45

These networks have comparable amounts of attenuation over significant portions of the audio band, and therefore the voices are in reasonably good balance for like settings of the several amplitude-controlling potentiometers 35. Furthermore, they all have relatively high series resistances R3 in their output paths, with the result that they can all be connected to the common pair of conductors 36 and 28 terminated by the input of the amplifier 14, without appreciable mutual interference.

For convenience in transportation of this instrument, and its storage when not in use, the speaker cabinet is arranged to contain the four consoles as shown in Fig. 5. The rear of this cabinet is preferably hinged for ready access. Space is provided for two consoles on either side of the amplifier and speaker, which are mounted centrally for mechanical balance. The scale quadrants **41**, normally held in place on the consoles by guides **48**, are removed before storage, and may then be stacked in the center rear of the speaker cabinet, as also shown in Fig. 5.

I claim:

1. An electronic musical instrument comprising a plurality of self-oscillating electronic sources of electric waves, rotary manual means for independent frequency variation of each of said sources over a continuous range of at least one octave, means for independent amplitude variation of each of said sources, means for independent interruption of each of said sources, means for combining the electric waves of said sources, and an electromechanical transducer for converting the sum of said waves into sound, whereby a plurality of players, respectively controlling said sources, may produce polyphonic music.

2. A plurality of consoles adapted to be located in mutual contiguity and electrically interconnected, each of said consoles containing a source of electrical oscillations of a waveform which is rich in harmonics of a fundamental frequency, a network coupled to said source for determining the fundamental frequency of oscillation of said source, said network comprising at least one variable frequency-determining impedance element, rotary mechanical means for varying said element, said element having a preassigned non-linear characteristic relating its magnitude to the angular displacement of said mechanical means such that the logarithm of the fundamental oscillation frequency of said source is substantially proportional to said angular displacement, said network also comprising at least one other variable frequency-determining impedance element for use in tuning said source to a reference pitch while said means is held at a reference position, an electromechanical transducer fed by all of said sources for converting the wave energy of each of said sources into sound, and each of said consoles further containing a wave-shaping network electrically interposed between said oscillation source and said transducer, said networks serving to individually control the qualities of the tones generated by the individual oscillation sources.

3. In an electronic musical instrument, a plurality of electrical wave generators adapted to be independently controlled by separate players, and a common electromechanical transducer actuated by all of said generators for converting the wave energy of said generators into sound, each of said generators comprising a source of electrical oscillations of a waveform which is rich in harmonics of a fundamental frequency, a network coupled to said source for determining the fundamental frequency of oscillation of said source, said network comprising a variable frequency-determining impedance element, a rotary shaft for varying said element, said element having a preassigned non-linear characteristic relating its magnitude to the angular displacement of said mechanical means such that the logarithm of the fundamental oscillation frequency of said source is substantially proportional to said angular displacement, said network also comprising a second variable frequency-determining impedance element for use in tuning said source to a reference pitch while said shaft is held at a reference position, means including a potential source and a push switch for energizing said oscillation source, means including a third variable impedance element for varying the output amplitude of said source, said amplitude-varying means being mounted on said switch for movement therewith, a rotary knob for controlling said amplitude-varying means by rotation thereof and for actuating said switch by depression thereof, said knob being located conveniently to one hand of one of said separate players, and a control arm, fixed to said rotary shaft for rotating it, and located conveniently to the other hand of said player.

4. An electronic musical instrument as defined in claim 1, wherein each source is a controllable source of electric relaxation oscillations which comprises a gas discharge device having an anode and a cathode, a capacitor connected from said anode to said cathode, a load impedance element connected in parallel with a portion of said capacitor, a source of a first potential in excess of the firing potential of said device, a path including a variable frequency-control resistor and a normally open series switch interconnecting said anode and the source of said first potential, by way of which said capacitor is charged upon closure of said switch, said switch having a first terminal connected to said source and a second terminal connected to said variable resistor, a source of a second potential of the order of magnitude of the average potential of the said anode, the average being taken with respect to time throughout a complete cycle of the oscillation of said relaxation oscillator, and a second path coupling the second named terminal of said switch to said second named source.

5. An electronic musical instrument as defined in claim 1, wherein each source is a relaxation oscillator comprising a gas discharge device having an anode and a cathode, a capacitor connected from said anode to said cathode, a load impedance element connected in parallel with at least a portion of said capacitor, a source of a first potential in excess of the firing potential of said device, a series path including a resistor, a normally open switch, the said capacitor, and the source of said first potential, by way of which said capacitor is charged upon closure of said switch, said switch having a first terminal connected to said source and a second terminal connected to said resistor, a source of a second potential of the order of magnitude of the average instantaneous potential to which the capacitor is charged, the average being taken with respect to time throughout a whole number of cycles of the oscillation of said relaxation oscillator, and a second path coupling the second named terminal of said switch to said second named source, by way of which the voltage across said capacitor is restored to equality with said second potential upon opening of said switch.

6. In an electronic musical instrument, a plurality of independently controllable relaxation oscillators, each of which comprises a gas discharge device having an anode and a cathode, a capacitor connected from said anode to said cathode, a load element connected in parallel with a portion of said capacitor, a source of a first potential in excess of the firing potential of said device, a path including a variable frequency-control resistor and a normally open series switch interconnecting said anode and the source of said first potential, by way of which said capacitor is charged upon closure of said switch, said switch

having a first terminal connected to said source and a second terminal connected to said variable resistor, a source of a second potential of the order of magnitude of the average potential of the said anode, the average being taken with respect to time throughout a complete cycle of the oscillation of said relaxation oscillator, a second path coupling the second named terminal of said switch to said second named source, and a common electromechanical transducer for reproducing the oscillations of all of said relaxation oscillators as sound.

7. An electronic musical instrument as defined in claim 1, wherein each source is a relaxation oscillator comprising a condenser having two terminals, means for alternately charging and discharging the said condenser to produce a periodic saw-tooth wave of potential difference between the said two terminals, a source of power for said relaxation oscillator, a series switch connected between said source and said oscillator for determining the state of oscillation or non-oscillation of the said relaxation oscillator, and means for establishing a steady potential across the said condenser while the said switch is open which is substantially equal to the average instantaneous potential existing across the said condenser while the said switch is closed, the said average being taken with respect to time throughout a whole number of cycles of the said saw-tooth wave.

8. In an electronic musical instrument, a plurality of independently controllable sources of electric oscillations, an electromechanical sound reproducing device connected to all of said sources and supplied with the oscillations thereof, tuning means in circuit with each of said sources, a switch and a volume control device in circuit with each of said sources, said switch comprising an elastic conductive member and being open in the rest position of said member and being closable by the application of a light pressure to said member, said volume control device being mechanically mounted on, supported by and movable with said elastic member, said control device having a rotatable control element, and a knob fixed to said rotatable element, whereby a separate player, controlling any one of said sources of electric oscillations may conveniently alter the volume of the corresponding component of sound delivered by said reproducing device in a continuous manner by rotation of said knob and in a discontinuous manner by depression of said knob.

9. An electronic musical instrument as defined in claim 1, wherein each source is a controllable relaxation oscillator comprising a gas discharge device having an anode and a cathode, a capacitor connected from said anode to said cathode, a source of a first potential in excess of the firing potential of said device, a series path including a resistor, a normally open switch, the said capacitor and the source of said first potential, by way of which said capacitor is charged upon closure of said switch, said switch having a first terminal connected to said source and a second terminal connected to said resistor, a source of a second potential of the order of magnitude of the average instantaneous potential to which the capacitor is charged, the average being taken with respect to time throughout a complete cycle of the oscillation of said relaxation oscillator, a second path coupling the second named terminal of said switch to said second named source, said switch comprising an elastic conductive member and being open in the rest position of said elastic member and being closable by the application of a light pressure to said member, a volume control device electrically in circuit with said relaxation oscillator and mechanically mounted on, supported by and movable with said elastic member, said device having a rotatable control member, and a knob fixed to said rotatable control member, whereby a player may conveniently alter the amplitude of the output of said relaxation oscillator in a continuous manner by rotation of said knob and in a discontinuous manner by depression of said knob.

LARNED A. MEACHAM.

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The following references are of record in the file of this patent:

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