Dec. 21, 1937. A. H. MIDGLEY 2,103,169

APPARATUS FOR PRODUCING SOUNDS OF A MUSICAL CHARACTER

Filed Sept. 29, 1936 2 Sheets-Sheet 1

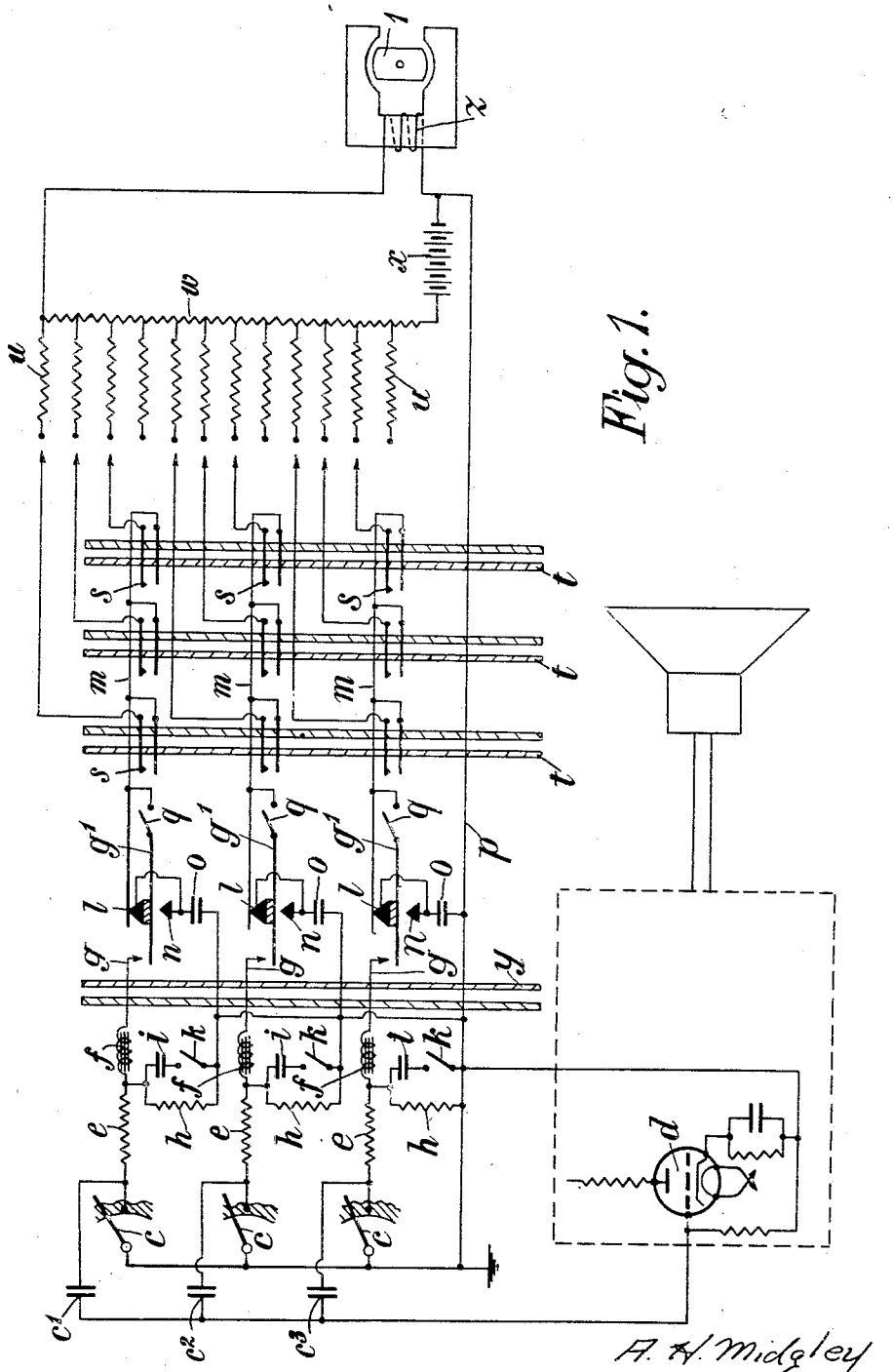


Fig. 1.

A. H. Midgley
INVENTOR

By: Glascock Downing & Seebold
Attys.

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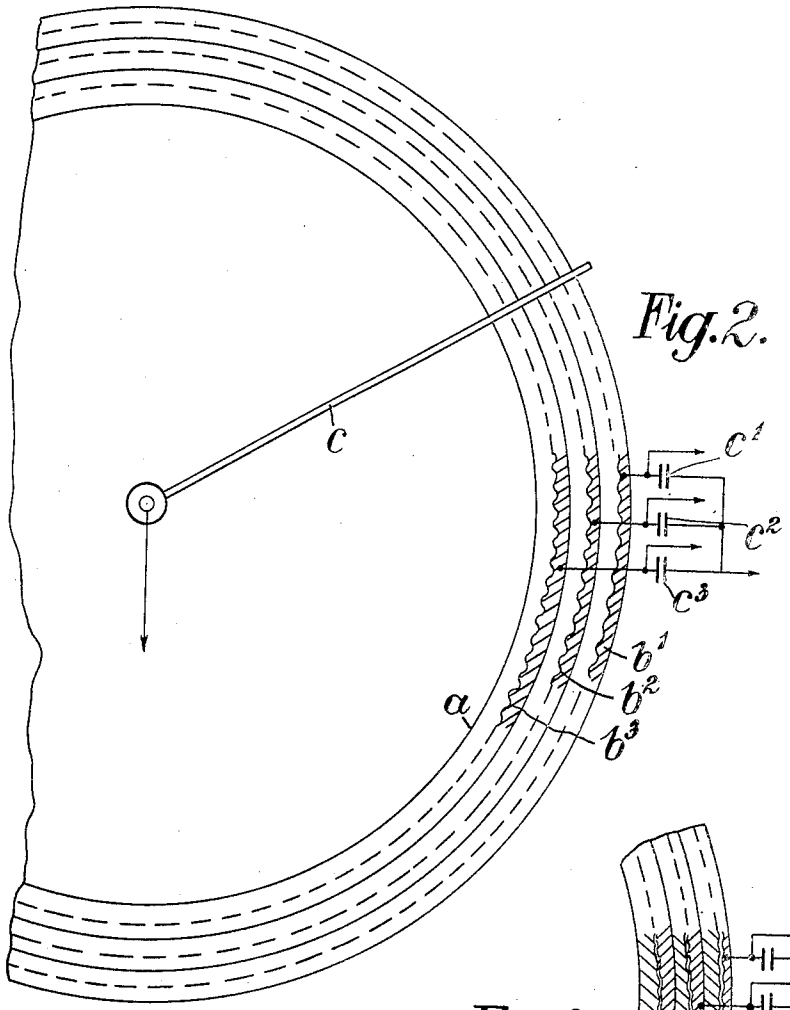


Fig. 2.

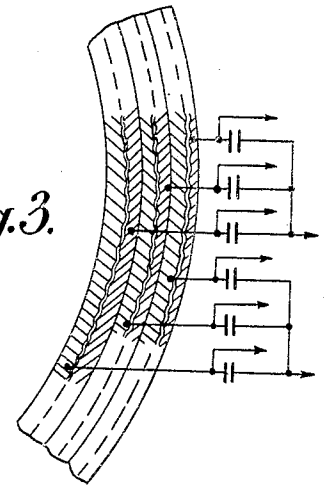


Fig. 3.

A. H. Midgley
INVENTOR

By: Glascock Downing & Seebold
Attys.

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UNITED STATES PATENT OFFICE

2,103,169

APPARATUS FOR PRODUCING SOUNDS OF A MUSICAL CHARACTER

Albert Henry Midgley, Wembley, England

Application September 29, 1936, Serial No. 103,218
In Great Britain February 6, 1935

6 Claims. (Cl. 84—1)

This invention relates to sound producing apparatus and has for its object to devise improved apparatus of simple construction whereby electrical vibrations of any desired controlled frequency and wave form may be produced and converted into sound waves, the invention being particularly designed to produce by all-electric means any musical notes or combinations of same such as might be produced by an ordinary organ, orchestra or the like.

The present invention consists in apparatus for producing musical sounds comprising a member containing a series of concentric rings of sine wave or undulating formation adapted to generate electrostatically fundamental frequencies of the musical scale progressing geometrically, and means for varying the amplitude of and combining certain frequencies in order to produce notes of the musical scale of varying tone and pitch.

Further, from a single member I can obtain two series of musical notes of the musical scale which may be played from two separate manuals.

I may employ a plurality of members fixed to the same shaft or geared to one another to produce the harmonics of the fundamental tones produced by one of said members.

The invention consists in apparatus for producing sounds of a musical character by the relative movement of an arm or other electrode or electrodes in close proximity to elements of sine wave or undulating formation (a difference of static potential being maintained between the said parts) in order to produce electrostatically electrical vibrations or an undulating potential which is converted into sound waves by means of a thermionic amplifier and loud speaker or other sound reproducing apparatus, arranging the elements of undulating formation to be carried by a common member and in such a way that frequencies progressing geometrically can be obtained therefrom, and providing means for varying the amplitude of and/or combining certain frequencies in order to produce notes of the musical scale of varying tone and pitch.

Further features of the invention will be apparent from the description given hereafter.

In the accompanying drawings:—

Figure 1 is a diagram of one convenient arrangement according to the invention.

Figure 2 is a view on a larger scale of a part of the apparatus, and

Figure 3 shows a modification of detail.

In carrying my invention into effect in one convenient manner as, for example, in its application to apparatus for producing organ music, I provide a circular disc a of insulating material to the face of which is fixed a number of concentric rings of conducting material, the inner surface of each ring being of sine wave formation.

There is one ring provided for each semi-tone of the musical scale and the total number of rings will be dependent on the number of octaves of the musical scale which it is desired to produce. Only three such rings b' b^2 b^3 are shown in Figure 2. The numbers of undulations of successive rings progress geometrically approximately in the ratio of

$$1 \text{ to } 12\sqrt{2}$$

which is the interval of a semi-tone. That is to say the number of sine wave formations on the surface of ring b^2 are

$$\sqrt[12]{2}$$

times the number of undulations of ring b^1. In a like manner the number of undulations carried by ring b^3 are

$$\sqrt[12]{2}$$

times the number on the surface of ring b^2.

A thin radial arm c or arms of conducting material is adapted to rotate about the axis of the rings and in close proximity to the surface of all the rings.

Each ring is connected to one plate of a small condenser c' c^2 c^3 of about .01 to .1 microfarad and the opposite plates of the condensers are all connected to the grid of the first valve d of a suitable amplifier. Each ring is also connected through a resistance e of about 5 to 10 megohms and a choke coil f to a key switch g (the choke coil being used to silence the key switch contact), and between the junction of each resistance and choke coil and the earth or negative return lead there is arranged a further resistance h of about ½ megohm, in parallel with a condenser i controlled by a switch k.

The key switches g are adapted to be moved downward by means of the relay rod y and thus complete respectively circuits from the choke coils f to the poles g^1. The movement of the relay rod y may be effected in any manner that is well known to the art such as providing a mechanical connection from the keyboard of the organ to the relay rod y. Other well known remote control means may be provided to actuate the rods such as electromagnetic means associated with the rod y which may be manually controlled from the keyboard of the organ.

The poles g^1 of each key switch carries an insulated contact l, (i. e., insulated from the pole g^1)

which is moved downwardly when the pole g engages the end of the pole g^1. In other words the pole g^1 may be assumed to pivot and cause the respective contacts l to move away from the several bus bars m and thus break the separate connections between the contacts l and the bus bar m. The downward movement of the relay rod y also causes the under side of the poles g^1 to respectively engage the contacts n.

The contacts n are each permanently connected to the contacts l and respectively to one side of condensers o so that circuits are respectively established thereto from the bus m when the key switch is open. The opposite side of the condensers o are each connected to the return lead p and earth.

For the purpose of providing connections from the poles g to the bus bars m when the key switches are closed, as above described, a switch q is provided for each key switch appropriately connected to the respective bus bars m.

A number of stop switches s is associated with each bus bar so that when a stop is operated contact is made with the bus bar, the stop switches also being operated from the stop keys by similar relay rods t. Each of these stop switches can be connected to any one of a number of bus bars fed at predetermined voltages through resistances u connected to points on a potentiometer w supplied with current from a battery x, the resistances being of such a value that when two or more stops are operated the sections of the potentiometer in use are not short circuited.

The negative pole of the battery and potentiometer is connected to the return lead p and earth, while the rotating radial arm or arms is or are also connected to the return lead and earth and to the earth or cathode side of the amplifier d.

The arrangement is such that the rings can be charged from the potentiometers to any desired potential and on rotation of the arm or arms in close proximity to the rings, electrical vibrations or an undulating potential will be electrostatically induced in each ring that is charged, and such undulating potential will pass through the condensers connected between the rings and the amplifier, and will be amplified and converted into sound waves by the loud speaker.

By combining various rings charged to a predetermined potential many qualities of sound can be obtained and any desired number of harmonics may be combined with each fundamental note.

For the purpose of describing the operation of the apparatus it will be assumed that each note is to contain the fundamental and two harmonic tones. Thus, for example, when the middle C on the manual is depressed this operates a rod y which closes the key switches g of the rings giving the frequencies for the middle C^1 (fundamental tone) C^2 (2nd partial), and G^2 (3rd partial).

When a stop is drawn this operates a stop rod t which closes the associated stop switches s with the bus bars and the voltage of each ring is thus selected so that the desired tone is obtained.

If the switches q connecting the bus bars and the key switches are all closed, when a manual key is depressed the sound will continue so long as the key is kept depressed as in an organ. If in addition the switches k controlling the condensers in parallel with the ½ megohm resistances h are all closed, when the manual key is released the sound will continue and gradually diminish in volume due to the charge in the condenser gradually leaking away through the ½ megohm resistance h. This produces a reverberation or sustaining effect, the length of time of which is governed by the values of the condenser i and resistance h.

If however the switches k controlling these condensers and the switches q connecting the bus bars m and key switches g are all open and a manual key is depressed, then a percussion effect such as a piano or bell will be produced, as the key switches g of the note (fundamental and harmonics) first disconnect the bus bars m from the condensers o and then connect the condensers, which are already charged, to the rings.

The duration of the note will depend on the values of the capacity of the condensers and of the leak resistances.

If it is desired to employ two separate manuals operating two amplifiers and loud speakers, then instead of forming undulations on the inner edge of each ring, the undulations are cut in the centre of the ring as shown in Figure 3 thus dividing it and forming two rings, one with undulations on its inner edge and the other with undulations on its outer edge, and in this way the disc contains two complete sets of rings, each set being connected to a separate amplifier and loud speaker as previously explained.

If it is desired to use pure harmonic tones for the harmonics then these can be obtained by either mounting on the same shaft or gearing thereto further discs of similar construction to the first disc.

Supposing, for example, that it is required to produce tones of 6 harmonics.

From the first disc would be obtained the fundamental, second and fourth partials. Each ring in the second disc would have three times the number of undulations of the corresponding ring of the first disc and from this second disc would be obtained the third and sixth partials. Each ring in the third disc would have five times the number of undulations of the corresponding ring in the first disc, and from this third disc would be obtained the fifth partial. The rings would be all connected to either one or two manuals and amplifiers as previously explained.

Instead of driving the discs all at one speed they may be geared together at different speeds, and the number of undulations per ring on each disc would require to be modified according to the gear ratio in order to give the correct frequencies.

The control of the volume of sound given by the apparatus can be governed either by the usual volume control on the amplifier connected to a suitable operating pedal, or by varying the voltage of the supply to the potentiometers.

Tremolo effects can be obtained by passing the supply current to the potentiometer through a winding z on the yoke of a U-shaped electromagnet and rotating between the poles of same a straight bar armature l so that the magnetic flux passing through the electromagnet will be interrupted at a given speed causing a slight undulation of the voltage of the supply to the potentiometer and thereby the charge on the rings.

Where more than one rotating arm is used it is essential that the distance apart of the arms for each ring or pair of rings is an exact multiple of the wave length of the undulations in that particular ring or pair of rings, and

all the arms are then connected together. Moreover, since these rotating arms are all connected to earth they can be in the form of thin metal vanes of the radial width of a ring fixed to a metal disc which will also act as an electrostatic shield over the charged rings.

Instead of rings fixed to a disc I may use rings fixed to a cylinder in which case the circumference of the rings would be of undulating formation.

I do not wish to limit the invention to the particular method described of charging the rings or the construction of the rings as this method and also the method of operation and combination of the tones may be modified or altered without departing from the invention. Moreover, the values herein given are by way of example only, and may be modified as may be necessary to meet any practical requirements.

I do not claim herein per se any of the features in apparatus for producing musical sounds which are claimed in the British application No. 14308 of 1936.

Having now described my invention, what I claim as new and desire to secure by Letters Patent is:—

1. Apparatus for producing musical sounds comprising, a secondary element consisting of concentric rings of undulating formation, one of said rings having a given number of undulations, a second ring having a number of undulations differing in number from said given ring and each successive ring having a number of undulations differing from its preceding ring, said rings being sufficient in number to cover the entire musical scale, a primary element movably mounted adjacent said secondary element, means for impressing a potential across said primary element and any ring of said secondary element, means for causing relative movement between said primary element and said secondary element at one speed,—whereby undulating potentials of different frequencies are generated in said secondary element, and means associated with said secondary element responsive to the undulating potentials electrostatically induced therein for producing musical notes of the entire musical scale corresponding to the combined frequencies generated in said secondary element.

2. Apparatus for producing musical sounds comprising, a plurality of concentric rings, one group of said rings having undulations along the inner surface thereof, the other group of rings having undulating formations along the outer surfaces said rings being arranged in a coaxial relation with the undulations adjacent each other, a primary element mounted adjacent said rings, means for selectively electrically charging said rings, means for imparting relative movement between said rings and said primary element whereby a plurality of undulating potentials are electrostatically generated in said rings and means associated with each group of rings responsive to the undulating potentials induced in each for producing two series of musical notes corresponding to frequencies generated in each group of rings.

3. Apparatus for producing musical sounds comprising, a secondary element consisting of coaxial rings of undulating formation, one ring of said group having a given number of undulations and each succeeding ring having $\sqrt[12]{2}$ times the number of undulations of its preceding ring, said rings being sufficient in number to provide each semi-tone of at least a portion of the musical scale, a primary element movably mounted adjacent said secondary elements, means for impressing a potential across said primary element and any of said secondary elements, means for moving said primary element with respect to said secondary element whereby undulating potentials of different frequencies are generated in said secondary element, and means associated with said secondary element responsive to the undulating potentials electrostatically induced therein for producing musical notes corresponding to the combined frequencies generated in said secondary element.

4. Apparatus for producing musical sounds comprising, a single secondary element consisting of concentric rings of undulating formation, one of said rings having a given number of undulations, a second ring having a number of undulations differing in number from said given ring and each successive ring having a number of undulations differing from its preceding ring, said rings being mounted on a single disc and of such a number as to cover the entire musical scale, a primary element movably mounted adjacent said secondary element, means for impressing a potential across said primary element and any ring of said secondary element, means for causing relative movement between said primary element and said secondary element at a given speed, whereby undulating potentials of different frequencies are generated in said secondary element, and means associated with said secondary element responsive to the undulating potentials electrostatically induced therein for producing musical notes corresponding to the combined frequencies generated in said secondary element.

5. In apparatus for producing musical sounds, a secondary element consisting in a plurality of discs, each disc carrying a number of rings of undulating formation, one of said rings having a given number of undulations, a second ring having a number of undulations differing in number from said first mentioned ring and each ring of said secondary having a number of undulations differing from each other ring in accordance with the frequency ratio of the interval of a semi-tone, a primary element consisting of an electrode mounted adjacent each of said discs, means for causing relative movement at one speed between said primary element and said secondary element whereby all of said electrodes move relative to said discs at the same speed.

6. In apparatus for producing musical sounds, a secondary element consisting of a plurality of discs, each disc carrying a number of rings of undulating formation, said rings being sufficient in number to cover the entire musical scale, one of said rings having a given number of undulations and each succeeding ring having $\sqrt[12]{2}$ times the number of undulations of the preceding rings, a primary element consisting of electrodes, one of said electrodes being movably mounted adjacent each of said discs on a common shaft and means for rotating said shaft whereby all of said electrodes move at one speed with respect to said discs.

ALBERT HENRY MIDGLEY.