March 4, 1930. R. ZOUCKERMANN 1,749,685

PROCESS FOR THE GENERATION AND SYNTHESIS OF SOUNDS

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Fig. 2.

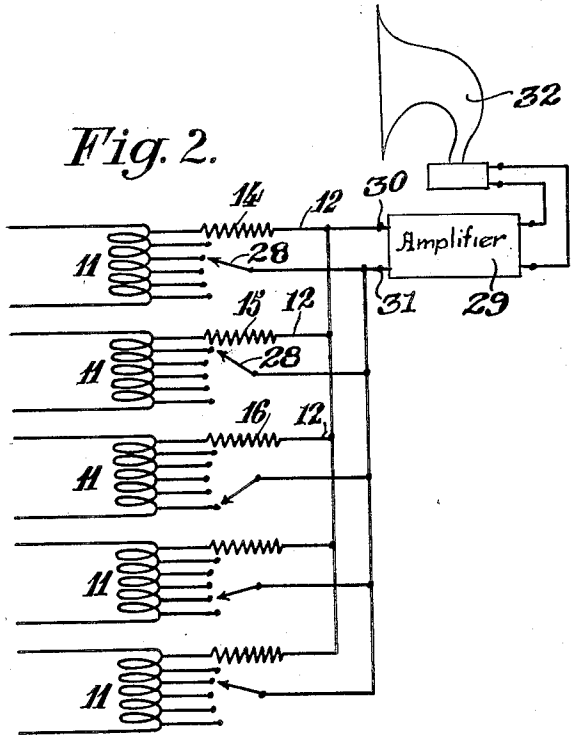
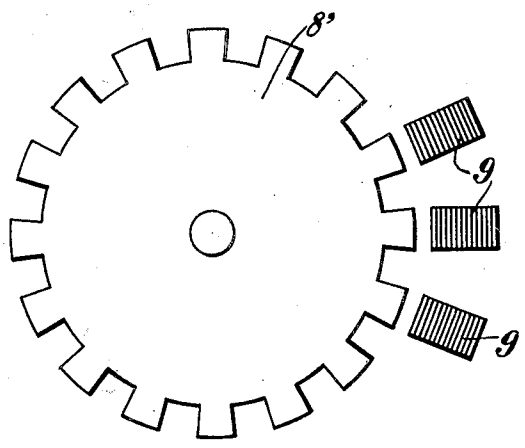


Fig. 1.



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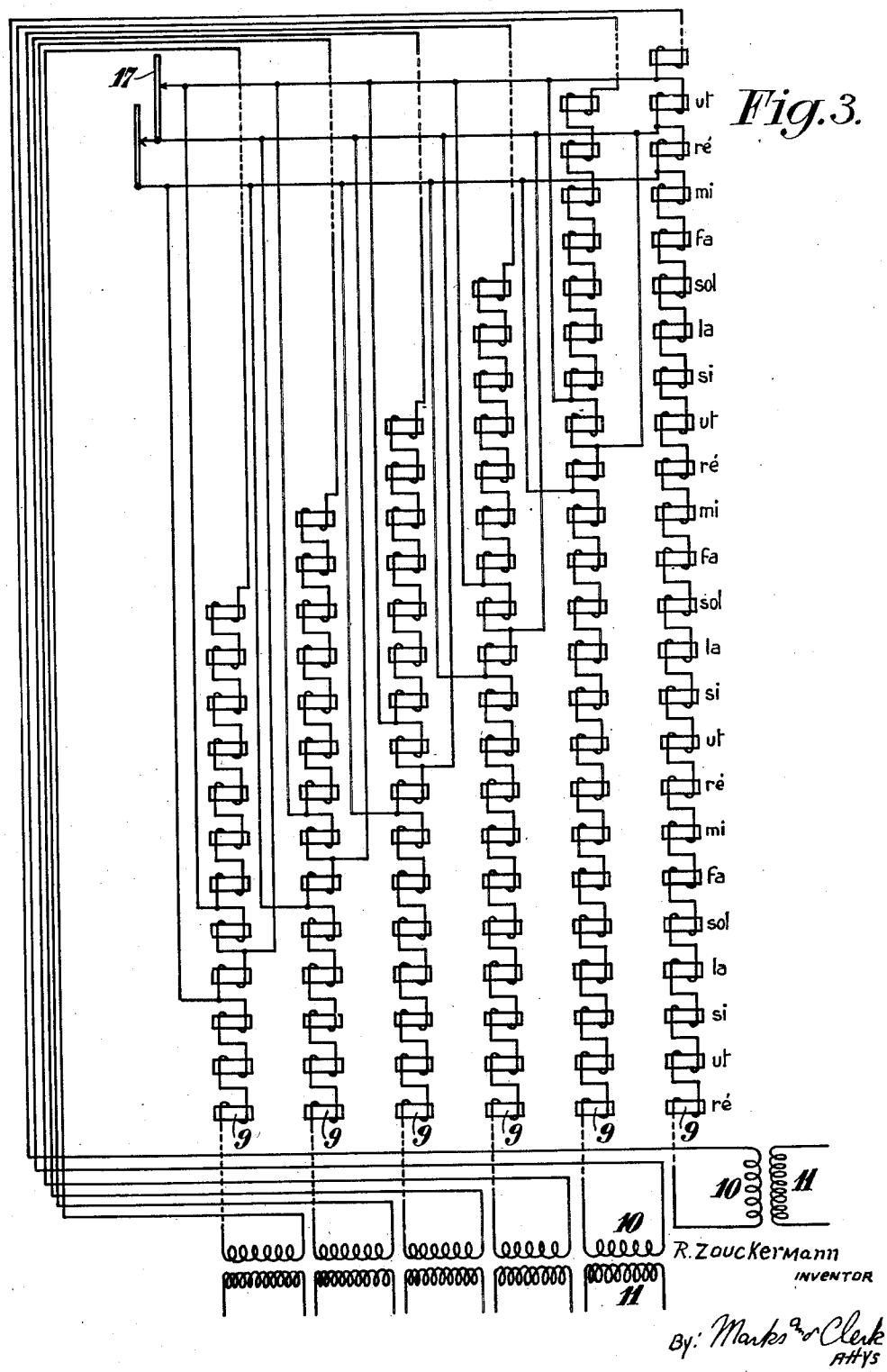


Fig. 3.

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Patented Mar. 4, 1930

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UNITED STATES PATENT OFFICE

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PROCESS FOR THE GENERATION AND SYNTHESIS OF SOUNDS

Application filed January 12, 1926, Serial No. 81,024, and in France June 2, 1925.

This invention relates to electrical musical instruments of the type comprising alternators which generate alternating electric currents the frequency of which correspond to given fundamental and harmonic notes, means for combining certain of these currents for obtaining a given sound, the resulting current operating a telephone receiver such as a loud speaker.

The apparatus which forms the subject of the invention, comprises in the well known manner alternators each constituted by a toothed iron disc rotating in front of a coil with a magnetized core, in such a manner that the rotation of the toothed disc induces in the coil an alternating current, the frequency of which depends on the speed of rotation of the disc and on the number of teeth of the disc. The apparatus according to the invention, differs from those already known in that each alternator comprises several coils each with a magnetized core, each coil corresponding to a fundamental (or a first harmonic) or to a harmonic of a given order of another fundamental, the coils of the various alternators which correspond to a harmonic of the same order, being all connected to the primary winding of a transformer, the secondary winding of which is connected to an amplifier operating a loud speaker, the apparatus comprising moreover contacts which short-circuit each of the coils, each contact short-circuiting at the same time the various coils corrresponding to a fundamental sound and to the harmonics of the latter, as well as means for independently regulating the ratio of transformation of the transformers and the resistance of their secondary circuit.

A construction according to the invention is illustrated, by way of example, in the accompanying drawing:

Figure 1 is a diagram showing the constitution of an alternator;

Figure 2 is a diagram of connections between the windings of the alternators and the primary windings of the transformers;

Figure 3 is a diagram of connections between the secondary windings of the transformers, the amplifier and the loud speaker.

In the apparatus illustrated, and in accordance with a method already known, electric vibrations corresponding to pure sounds, fundamental or harmonic are produced separately; certain of the harmonics of the said vibration are combined with one fundamental vibration, the choice of these harmonics, as well as their relative intensity, depending on the timbre of the sound, which it is desired to obtain; and finally the resultant electric current is transformed into acoustic vibrations.

It has been found that in order to obtain pure sounds, that is to say sounds as little charged with harmonics as possible, it was necessary to produce the electric vibrations corresponding to the said pure sounds, with a small intensity, these vibrations being amplified after their combination had been effected as stated.

In the apparatus illustrated, each electric vibration corresponding to a fundamental sound or to a harmonic, is produced by a small alternator. Each alternator is constituted as shown in Figure 1; it comprises an iron toothed wheel 8^1 keyed to a spindle 1 which is rotated at a given constant speed by any desired means.

The teeth of the wheel 8^1 are uniformly distributed over the periphery of the said wheel and given such a shape that the rotation of the said wheel 8^1 should produce in each of the coils 9 arranged radially round the said wheel, an alternating current, the frequency of which depends on the constant speed of rotation of the wheel 8^1 and on the number of teeth of the said wheel.

The current generated in each coil 9 corresponds to a given sound.

It must be pointed out that a fundamental sound of the frequency f is the first harmonic of the sound of the frequency $\frac{f}{2}$, the second harmonic of the sound of the frequency $\frac{f}{3}$, and so on. In the apparatus illustrated, it has been assumed that each sound to be obtained, was to be the result of a combination of a fundamental and of five harmonics of the said sound, the relative intensitv of the

fundamental and of the harmonics being regulated at will. Each alternator comprises therefore in principle six windings such as 9. Exception is made for the alternators which correspond to the sounds of the first octaves in which the number of the windings is obviously a smaller one. There is only one winding for the first octave, two windings for the first four notes of the second octave, three windings for the last three notes of the second octave, four windings for the first two notes of the third octave, five windings for the third and fourth notes of the third octave, and six windings for all the other notes.

All the windings 9 of the various alternators which correspond to fundamental sounds, are connected in series to the primary winding 10 of a transformer. All the windings 9 of the various alternators which correspond to first harmonics, are also connected in series to the primary winding 10 of another transformer. All the windings 9 of the various alternators which correspond to harmonics of a given order, are thus connected in series to the primary winding 10 of a transformer which corresponds to the harmonics of this order. In the example chosen, where as already stated it is desired to be able to combine a fundamental sound and five harmonics, there are therefore six transformers.

In the diagram of Figure 2 are shown the connections of the various windings to the primary windings of the transformers. In the left hand portion of the figure, are shown the windings which correspond to fundamental sounds, and starting from this left hand column towards the right, the windings which correspond to the first harmonics, to the second harmonics etc. On one and the same horizontal line are shown the windings which correspond to one and the same toothed wheel 8^1.

All the windings are in the beginning short-circuited in the following manner: The winding 18 corresponding to the fundamental sound "doh" of the second octave, is short-circuited by the key 17 of a keyboard connected by the wires 19 and 20 to the terminals of the said winding 18. In the same way, the winding 21 corresponding to the first harmonic of the "doh" of the second octave ("doh" of the third octave) is connected by the wires 22 and 23 to the wires 19 and 20; the winding 24 (third harmonic of the "doh" of the second octave, that is to say "soh" of the third octave) as well as the winding 25 ("doh" of the fourth octave, third harmonic), the winding 26 ("me" of the fourth octave, fourth harmonic) and the winding 27 ("soh" of the fourth octave, 5th harmonic) are also connected to the wires 19 and 20. In this way, the key 17 short-circuits simultaneously the windings corresponding to the fundamental sound given by the winding 18, and to all the harmonics of the said sound.

It will be readily understood therefore that all the windings being in the beginning short-circuited, no current will circulate in the primary windings 10 of the transformers.

If the key 17 is depressed for the purpose of producing "doh" of the second octave, for instance, it will be seen that the windings 18—21—24—25—26 and 27 will be non-short-circuited. Consequently, the current generated in the winding 18, will circulate in the primary winding 10 of the corresponding transformer (which is that on the left in Figure 2). The current generated in the winding 21 will circulate in the primary winding 10 of the corresponding transformer, and so on.

Each of the secondary windings of the transformers comprises, as shown in Figure 3, a number of tapping points on its winding. A portion of the winding 11 more or less great can therefore be connected by means of the switch 28 to the amplifier 29. One of the terminals 30 of the said amplifier is connected by several shunts to one of the terminals of the winding 11 through resistances inserted into each of these shunts as indicated at 14—15 and 16 etc. These resistances make it possible to regulate the strength of the current induced in each shunt at will. The other terminal 31 of the amplifier is connected by several shunts to the switches 28. It is therefore possible, by means of the switches 28, to regulate the ratio of transformation of each transformer and by means of the resistances 14—15—16, to regulate the strength of current in each transformer. The currents of each transformer become superimposed, are amplified by the amplifier 29, transformed by the loud speaker 32 into a resultant sound, the timbre of which will vary in accordance with the regulation effected.

What I claim as my invention and desire to secure by Letters Patent is:

An electrical musical instrument comprising in combination; alternators constituted each by a toothed iron disc rotating in front of coils with a magnetized core, each coil corresponding to a fundamental sound (or a first harmonic) or to a harmonic of a given order of another fundamental; transformers of the same number as that of the harmonics to be combined for producing a resultant sound; means for connecting all the coils corresponding to a given order of harmonics, to the primary winding of the corresponding transformer; an amplifier connected to the secondary windings of the transformers; contacts short-circuiting the coils, each contact short-circuiting at the same time the various coils corresponding to a fundamental sound and to the harmonics

of the latter, and means for independently regulating the ratio of transformation of each of the transformers and the resistance of their secondary circuit.

In testimony whereof I have signed my name to this specification.

RAYMOND ZOUCKERMANN.