ELECTRICAL MUSIC.

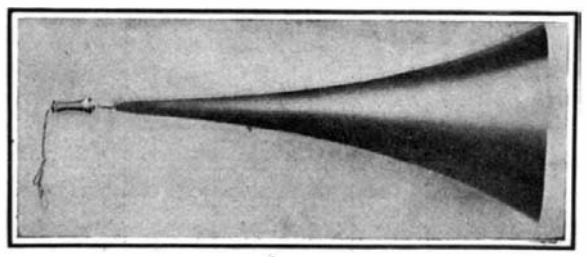
By means of a system proposed by Dr. Thaddeus Cahill, music is generated at a central station in the shape of electrical vibrations and thence distributed by means of wires to a thousand, or several thousand, hotels, clubs, and parlors, in each of which music is heard as if the performers were present in the room. The music is produced at a central station entirely by means of electrical apparatus, and without the intervention of pipe, reed, or string. And it may be heard wherever a wire can be run. The music rendered in hotel or parlor is not the whisper of the telephone nor the characteristic sound of the graphophone or phonograph, but pure, clear notes and chords, as loud as if an orchestra were on the spot.

Objectively, sound is merely a vibration of the air, and it has long been known to scientists that there is a definite relation between the frequency of vibration and the pitch of the resulting sound or note. It is possible also to produce electrical vibrations that shall correspond in frequency with a given note.

Dr. Cahill, the inventor of electrical music, appears to have combined the principles of acoustics and electricity and so used them as to produce what may be called electrical music. His music-generating system differs from previous means of producing music in that it is purely electrical. Heretofore music has been produced by strings, reeds, pipes, or other tuned sounding bodies, which set the air in vibration. By the Cahill system, however, the music is initiated as electrical vibrations; the expression is controlled by electrical means; it is distributed in the form of electricity, and, finally, is turned into aerial vibrations or audible music on the premises of a thousand different subscribers, and at widely different points—many miles apart, it may be.

A visit to the laboratory and factory of Dr. Cahill in Holyoke, Mass., reveals an elaborate electrical apparatus. He has been engaged in perfecting this apparatus for years, with the assistance of his brothers, Messrs. George Frederick and Arthur T. Cahill, and it seems now to have reached the commercial standpoint. That the installation has long since passed the experimental stage will be appreciated when it is known that there is now in use in the inventor's laboratory at Holyoke a central station plant containing one hundred and forty-five directly-coupled inductor alternators.

These alternators are arranged in eight sections or panels, each inductor being mounted on an eleven-inch steel shaft. The bed plate of the machine is built up of eighteen-inch steel girders, mounted on brick piers, and is more than sixty feet long. The switchboards are in ten sections and contain nearly 2,000 switches. These are controlled from a distant keyboard through electro-magnetic action. There are numerous transformers, one of which is seen in one of the accompanying illustrations, and many rheostats and other regulating devices, including in the aggregate thousands of coils and sections. The whole plant weighs more than 200 tons and has cost approximately $200,000. A second large apparatus is also well under way.



The Electrical Receiver Which Produces the Sound Waves.

The inventor's first complete apparatus, parts of which are shown in the illustrations, was built in Washington some years ago. The larger work has been done at Holyoke, where the Cahill laboratory has been located for the last four years.

It is not possible in the present article to describe the mechanical details embodied in the construction of so large and complicated a mechanism. A mere outline of the general features can be given in one article. The generating set consists of a number of alternating-current generators—one for each note of the musical scale. Each of these generators produces as many electrical vibrations per second as there are aerial vibrations per second in that note of the musical scale for which it stands.

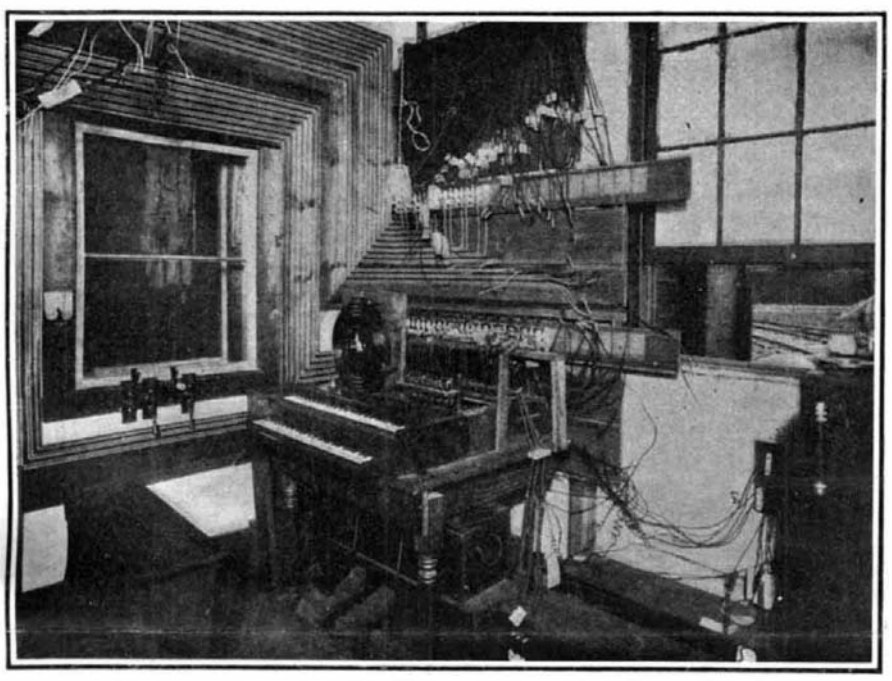
The generators are inductor-alternators and of very simple construction. The fixed or stator part of each carries both the field and the armature windings. The rotors are mounted upon shafts; the shafts are geared together; and the number of teeth or poles in the several rotors and the angular velocities of the shafts are suitably arranged so as to produce the notes of the compass through five octaves. The tuning is remarkably good, and from the nature of things, absolutely unchangeable. It is interesting to note that while in the past it has been very difficult to measure, with scientific accuracy, the energy of any note or sound, the power of these generators can be easily determined with the ordinary electric measuring instruments. Several of the generators for single notes are said to have an output of from 15 to 19 horse-power. When it is remembered that one man can supply energy for a great pipe organ, with its many pipes speaking at once, some idea may be obtained of the number of receiving stations that can be supplied from an apparatus in which a single note has many horse-power behind it.

From the battery of generators one naturally goes next to the keyboards on which the musician plays. These are in a different room from the running parts of the machine so that the player may not be disturbed by the hum of so many generators. From the latter a maze of wires lead through the walls to the keyboards, at which the performer sits.

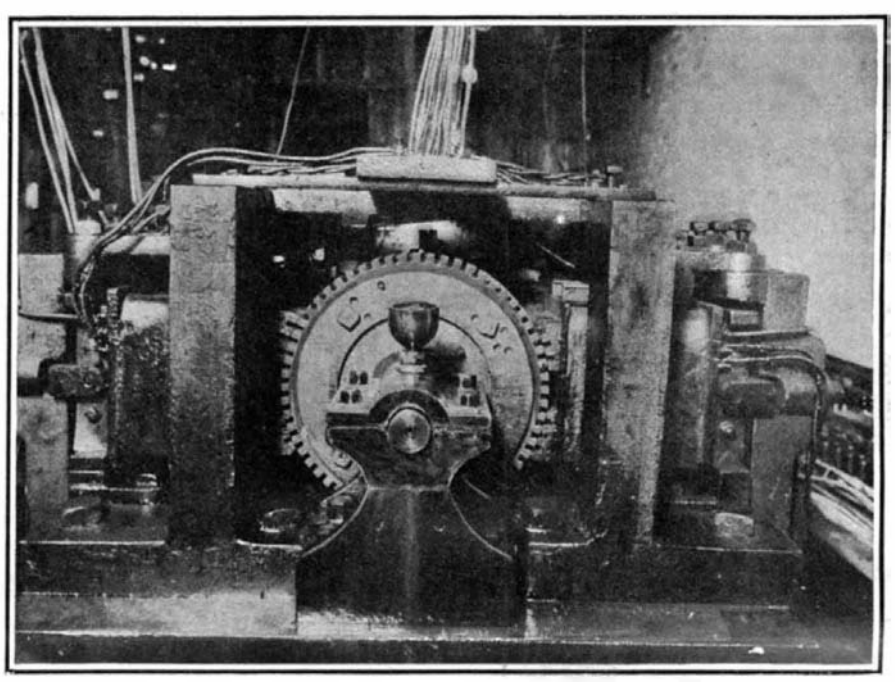
The keys operate electric switches so as to bring the several alternators into action on the lines or mains, as required. Across these lines or mains receiving telephones are connected in parallel, similarly to the way incandescent lamps are wired. With each receiving telephone a large paper horn is used. Thus, the depressing of a key throws upon the line the set of electrical vibrations corresponding with that note of the musical scale for which the key stands, and a loud, clear tone sounds forth from the receiver. The alternators are especially constructed to produce sounds whose purity and musical beauty strike the ear instantly.

In the Cahill music room there are no musical instruments in the sense in which that word has been understood heretofore. There is not a string or reed or sounding pipe in the whole apparatus. The vibrations produced by the performer's playing are wholly electrical, and it is not until such electrical vibrations reach the telephone receiver that any sound is produced. Yet if one had an electrical ear adapted to perceive electrical vibrations as one has an ear of living tissues to catch aerial vibrations, he would hear the music anywhere on the lines or mains without the necessity of a telephone receiver and horn to transform the electrical musical vibrations into audible music.

The electrical music has been sent several times from the laboratory in one part of Holyoke, to the ball-room of the Hotel Hamilton in another part of the city, over ordinary telephone wires. Two receiving telephones in one of the dressing rooms transform the electrical vibrations into aerial vibrations and the whole ball-room is filled as with the strains of an orchestra. In violin and 'cello pieces the listener hears the bow gliding across the strings—or thinks he hears it, for there is in fact neither bow nor string. The whole is purely electrical, yet the ear is almost right in its guess, for though the horsehair bow be absent, the living hand of the performer is controlling what answers to an electrical bow. The performer himself hears only the electrical music. He listens to

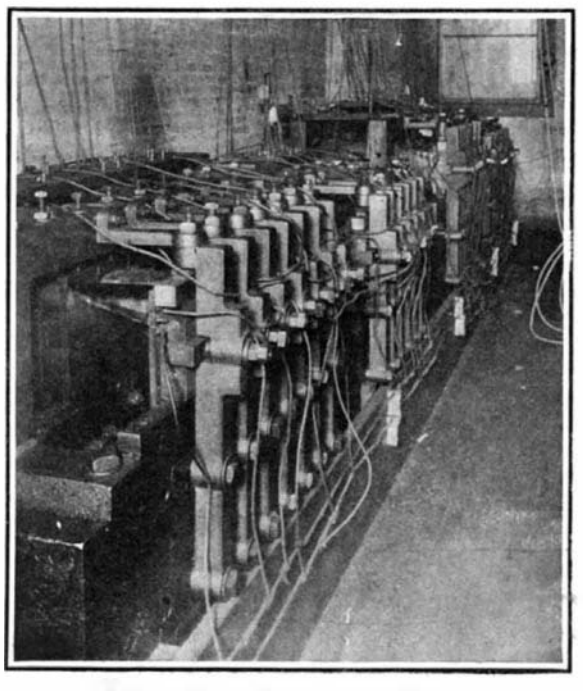


The Electrical Keyboard Upon Which the Musician Plays.



The Rotor of One of the High-Frequency Inductor Alternators.

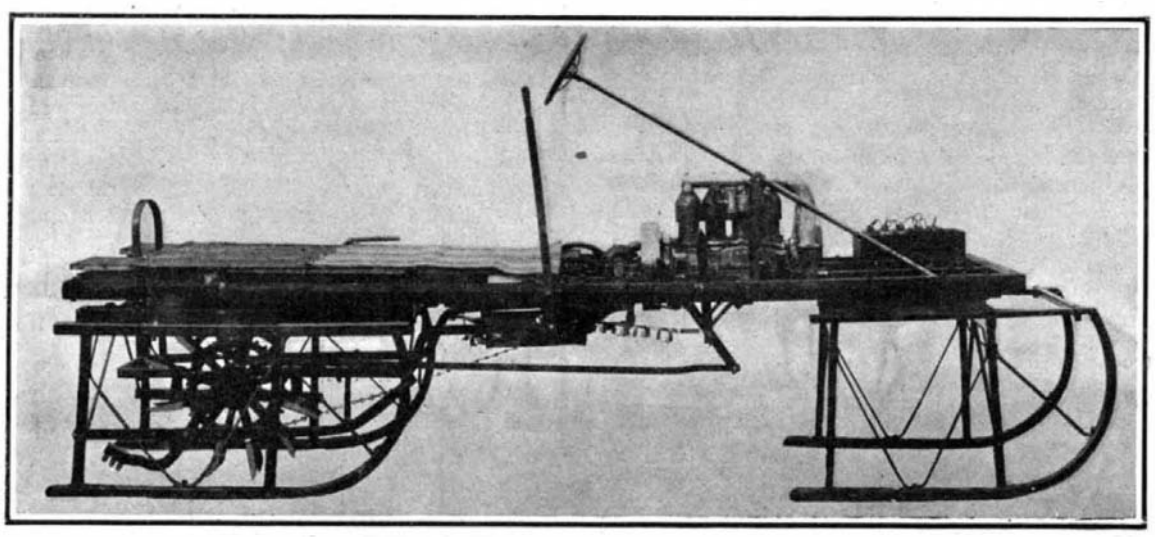
One of the Tone-Mixing Transformers.



A Group of Inductor Alternators.

a receiving instrument just as his hearers do in the next block or miles away.

One of the striking features of the electrical music, as heard in the Cahill laboratory in Holyoke, is the performer's perfect control of the expression. The volume of sound seems to respond absolutely to his touch—in fact, the hearer soon becomes conscious that the soul of the musician is in his music. By the touch of the hand the performer controls the attack and



CHASSIS OF SLEIGH, SHOWING 12-HORSE-POWER, 4-CYLINDER, AIR-COOLED MOTOR CONNECTED THROUGH A CHAIN AND TWO SPEED GEAR TO THE SPIKED DRIVE WHEEL AT THE REAR.

sostenuto and varies the note at every instant. The musicians at the Cahill laboratory produced very good vibrato effects, and crescendos and diminuendos not inferior to those produced by a good violin.

The singularly pure quality of the tones and the remarkable control over them which the performer possesses take the listener by surprise. It is a curious system in which a battery of powerful alternators at a central station may be used to vibrate diaphragms all over a great city, producing music in thousands of homes, while the electrical forces are so perfectly under the control of the performer's fingers that they respond to their musical feelings more perfectly than any existing instrument, saving the violin, viola, and 'cello. It is said to be as easy for a musician to recognize a friend's touch a mile or fifty miles away, as if he were playing a violin in the next room.

Perhaps one of the most remarkable features of this new art is the "tone mixing" or "tone building." Physicists have known for some time that most musical sounds were composed of several parts or elements and that the different tone qualities or tone colors resulted from the presence of different overtones or harmonics in combination with the fundamental or ground tone. Thus, when a single key is struck on the piano, the tone is composed of several different sets of vibrations, from the lowest of which it receives its pitch-designation. This is called the ground tone, fundamental, or first partial, while the other elements are called overtones or harmonics, and it is well known that if the ground tone is represented by n, the overtones for the lower notes of a piano will be $2n$, $3n$, $4n$, $5n$, etc. The timbre or quality of the note, then, depends upon the harmonics which enter into it and their respective strengths. Now, in the musical instruments of the past the tone-color or quality is dependent upon many things. In the piano, for instance, the kind of wire used, the manner in which it was drawn and tempered, the tightness with which it is strung, the manner of attaching to the soundboard, the shape, material, and nature of the soundboard, the weight and hardness of the hammer with which it is struck, the place where it is struck, etc., each plays its part in, and has an effect upon, the sound produced. The same general principle applies to other musical instruments. In Dr. Cahill's electrical music system, however, the different elements of a tone are generated separately and blended at the will of the performer in such combinations as he may desire. A number of inductoriums or tone mixers serve to build up from the simple or sinusoidal waves of the alternators complex resultant vibrations. Thus, several alternators contribute their waves to produce a single note, when that is of a rich or string quality. Several such notes on a single keyboard are combined electrically into more highly composite vibrations, which, when they reach the ear, appeal to it as musical chords of great beauty. In some cases the complex vibrations from different keyboards are further combined into still more highly composite vibrations, so as to produce several voices or parts, as a violin and a 'cello, or a clarinet and flute, in the same receiver at the same instant. Some of these superpositions of vibrations are produced conductively and some magnetically.

This system of building up the quality of tone desired by mixing with the ground tone one or many harmonics, with any strength desired, opens up a new field of timbre control. The wood-wind, brass, and stringed tones of the orchestra are easily produced by mixing the required harmonics in the required proportions. A musician in Dr. Cahill's laboratory showed a staff correspondent that a mere ground tone produces a clear, pure flute note, a ground tone with the third and fourth harmonics of suitable strength produces the sound of a clarinet, while to imitate the violin all the harmonics up to the eighth were useful. Another combination of harmonics, in which the seventh and eighth are strong, gives the characteristic blare of brass. In addition to reproducing the leading orchestral tones, a skillful performer can mix the harmonics so as to produce musical timbres unknown before. These new qualities are a striking feature of the electrical music.

It is impossible within the limits of this article to enter upon any elaborate description of these tone-mixing or tone-building devices. Suffice it to say that there are special forms of inductoriums, having usually a plurality of primary circuits into which vibrations from different alternators are fed, and a combining secondary circuit in which resultant vibrations are produced, equivalent musically and electrically to the several series of vibrations in the several primary circuits. Some of these inductoriums have iron circuits almost closed; others have open iron circuits; while still others are air-core transformers---entirely without iron. One of the illustrations shows a "tone-mixer" in which the electrical vibrations are combined magnetically.

MOTOR SLEIGH SAID TO BE CAPABLE OF MAKING 35 MILES AN HOUR ON SNOW AND 90 MILES AN HOUR ON ICE.

One thing that is to be emphasized in connection with this new music is that while the telephone is employed as a receiver it is not held to the ear. It would be bad for the ear if it were, when a loud note is sounded. The current in the receiver is literally thousands and at times millions of times stronger, measured in watts, than those to which an ordinary telephone receiver responds. Thus, Sir William Preece, superintendent of the British telegraph and telephone system, found that a telephone receiver would respond to a current of six ten-millionths of a millionth (6/10,000,000,000,000) of an ampere, and Continental electricians have found even a weaker current sufficient. In the Cahill system, for loud tones, a current of an ampere is sometimes used for an instant in the receiver.

In consequence, instead of a feeble sound in a telephone held to the ear, feebler often than the slight inductive noises of the line, a musical tone, as loud and clear as it is sweet and pure, fills the whole room, and the inductive noises of the line, which can be heard when a common telephone is pressed to the ear, cannot be discovered even by the closest listening. The sound, on the contrary, is absolutely sweet and pure.

The electrical music is characterized by the following points: Perfect tuning; pure, clear tones that fill the room; qualities so closely resembling the principal orchestral instruments that they would be mistaken for them; new qualities, also, which it is impossible to describe, and which must be heard to be appreciated—a singular attack, which is controlled by the performer's touch, and which seems at one instant to be that of a bow, at another that of a hammer on a string, at another that of a wood-wind, according to the effect which the performer desires to produce on the instrument that he wishes to imitate; and last, and most important, the fact that the music, produced in the form of electrical vibrations, is divisible and distributable and can be produced at a thousand places simultaneously, with as much power in each as if an orchestra were on the spot.

A SIMPLE AND SPEEDY MOTOR SLEIGH.

What appears to be a very promising solution of the motor sleigh problem is a machine of this sort constructed recently by two residents of Springfield, Ohio—Messrs. Temple and Redmond. The inventor of the sleigh appears in the photograph seated in the front on the left. As can be seen from the chassis view, power for driving the sleigh is obtained from a four-cylinder air-cooled motor of about 12 horse-power. The cylinders of this engine are provided with air jackets through which a blower mounted on the crankshaft sends a forced draft for the purpose of keeping them cool. The engine drives a countershaft placed behind it, by means of bevel gears; and pinions on this countershaft mesh with spur gears on a second parallel countershaft. The spur gears may be locked to their shaft by friction clutches, and thus two different speeds are obtained, since the driving sprocket is keyed on this shaft and connected by chain with the snow paddle. This wheel has double rows of strong, sharp, steel blades which successfully grip the snow or cut into the ice beneath. The wheel is spring-pressed against the ground. It can rise 12 inches above its normal level and can drop still further, so that it has a vertical play of something like 2½ feet. The curved bar with teeth on the end, which is seen beside the drive wheel, acts as a brake when pressed against the ground. The long horizontal rod connecting this bar with the brake pedal in front is seen beneath the