ELECTRICITY, A MUSICAL LIBERATOR

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THE growth of musical art in any age is determined by the technological progress which parallels it. Neither composer nor performer can transcend the limits of the instruments of his time. On the other hand technical developments stimulate the creation of certain forms of composition and performance. Although it is true that musicians may have ideas which hurdle these technical barriers, yet, being forced to use existing instruments, their intentions remain unrealized until scientific progress comes to the rescue.

Compositions based upon the successive use of the twenty-four major and minor keys were written only after a keyboard instrument incorporating the mathematical idea of equal temperament had been placed at the disposal of the composer. The development of any musical style follows the perfection of the corresponding instrument. The rich orchestration of Wagner was not available to Bach because he could not command the same variety of instruments. If we admit that the creative imagination of the composer may form musical ideas which, under the specific conditions of a given epoch, cannot be translated into sounds we acknowledge a great dependence of the artist upon the technical position of his era, for music attains reality only through the process of sounding.

The same is true of the relation of the performer to his instrument. Paganini reached the highest degree of perfection possible on the violin of his time; Segovia has reached the limit of perfection in guitar playing. But it should be remembered that the difficulties which Segovia overcomes depend on the specific construction of the guitar and that the same compositions offer no technical difficulty when performed on the harpsichord. From the tonal viewpoint the guitar ends where the harpsichord begins.

Much of the performer's energy is spent not on interpretation but in overcoming the inertia of the instrument. In order to get a violin tone of sufficient quality, years of patient effort are required. Many, knowing by experience how difficult this is, make a cult of the tone quality itself, forgetting that it is only the condition *sine qua non* and that the essential thing is the transmission of the musical idea. Musicians accustomed to occupy themselves principally with the production of tone are at a loss when given an instrument possessing perfect tone-quality.

For thousands of years the development of musical instruments has been largely a matter of chance. Little was understood of the principles of acoustics. Experiments in improved construction were empiric. The combination of various types of musical instruments in the different groups of the modern orchestra, to which we have become so accustomed that we do not notice its imperfections, is just as accidental as their origin and development.

However, once the study of sound and of the acoustic properties of existing instruments began, the work of perfecting them made a tremendous advance. Recent discoveries in physics, furthermore, have opened unlimited perspectives in the development of musical art. It is impossible to predict what will occur within the next ten years, but it is obvious that the development of music will go hand in hand with that of science.

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The most important evolutionary step in the entire span of history is without doubt the conquest of electricity. And just as Edison's lamp, literally speaking, shed a flood of light, so the possibility of obtaining sound from an electrical current has illuminated the dark realm of musical phenomena and given us possibilities of observing and studying sound phenomena which before were either unattainable empirically or not subject to control and measurement.

Electrical energy was first employed for musical purposes in 1876, when it was applied to the mechanism of the organ by Charles Spencer Barker. Later electricity was used for automatic pianos, organs, orchestrions and finally electrical phono-

graphs. These were all examples of an indirect use of electricity.

In 1897 an American inventor, Thaddeus Cahill, registered the patent for his first electrical musical apparatus with "sounding staves." It contained the principle which in 1914 became the foundation of a large instrument. The sounding staves are a kind of telephone membrane which is affected by alternators (current inductors). The most important factor is the possibility of changing the timbre by including certain harmonics by means of a second and third set of alternators. Being polyphonic, it was acclaimed as an immediate solution to the problems of an electrical orchestra. But it could not achieve a lasting place because of its unusual bulk and the complexity of its construction. Cahill's ideas however have proved prophetic and in other forms have been brought to a considerable degree of perfection by more recent inventors. A modern adaptation of his principle is a portable device which may be connected to any piano for the purpose of making the strings vibrate with the aid of electro-magnetic induction. This apparatus makes it possible to achieve an indefinitely continuous sound which does not fade; at the same time allowing one to use the piano in the usual manner.

A really "singing" melody with staccato accompaniment may be obtained. Different inventors have worked in this realm simultaneously. In New York such an apparatus, the "Crea-tone," was demonstrated in concerts at Wanamaker's in the spring of 1930. The musical characteristic of the tone, which is produced by the help of electro-magnetic induction of the strings, is the absence of vibrato.

A great step in the perfection of Cahill's principle was the electrical organ of Wilbur Farrington, an American inventor who, working for twenty-five years, built an instrument (at present used for therapeutic purposes) with electrical sound waves of varying form and intensity.

The organ (now in Greenwich, Connecticut) occupies a small amount of space in comparison with its musico-technical possibilities. In this instrument, bars of steel, aluminum, wood, glass etc., besides the usual piano strings, are made to oscillate by means of electro-magnetic induction. It is possible to add to a tone any desired overtones, controlling at the same time the in-

tensity; in other words we can obtain various and easily perceived alterations in timbre and intensity. But whereas the degree of intensity may be altered either gradually or suddenly the change of timbre can follow only within the limits of definite temperaments.

This instrument is played with the help of two manuals, pedals and stops as in the organ, and offers great practical advantages. The speed of tone production and the accuracy of action of the mechanism generally are such that the instrument is superior to the organ and in some respects to the orchestra. The scale of timbre is varied, dynamic possibilities are limitless; mechanical vibrato and non-vibrato are easily obtained by a change of stops; different forms of attack and change of tone are possible; but one cannot effect a gradual change of degree in timbre or pitch.

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The most important step in this electrical development, opening new territory in the composition and interpretation of music, is the discovery of the principle that acoustical oscillations may be obtained by means of electro-magnetic oscillations. The fundamentals were worked out and patented in 1915 by Lee DeForest, who did not try to solve the problems immediately related to the practice of music.

A more extensive study of this field was undertaken by a Russian physicist, Leon Theremin, who approached the problem of electricity as a scientific basis for the music of the future. He became interested not only in the interpretative possibilities opened up by this entirely novel means of obtaining sound but in the new system of intonation, which not only makes it possible to play music based on any present methods but offers possibilities for new intonations and new systems of notation.

Theremin indicates the essential characteristics which mark his instrument as follows:

1. The method of obtaining acoustical oscillations by means of electro-magnetic oscillations of high frequency—for instance using interference.

2. Methods of singling out harmonics electrically to obtain various timbres.

3. Different ways of playing by means of changing the electrical constants of the chain ($^{R}_{L}_{C}$) and using keyboard, fingerboard or space controlled adjustments.

The first Theremin instrument with a knob control was constructed and demonstrated in 1919. Then there appeared different models of space control and fingerboard instruments (1922). The space control instrument with twelve stops for changes in timbre has been in use from 1924. The latest model, a fingerboard device, used by the Philadelphia Orchestra, makes abrupt and gradual changes in timbre possible. A space control instrument giving the effect of a Hawaiian guitar was constructed a few months ago. Theremin's electric harmonium is a polyphonic keyboard instrument with changes in pitch up to an one-hundredth of a tone (constructed in 1926).

In 1927 simultaneously with Theremin's an analogous keyboard instrument was demonstrated by Jörg Mager. His first model was called the "Elektrophone" and then was renamed the "Spherophone". He then built the "Kaleidophon" on which chords could be produced.

The remaining inventors are more or less indebted to the principles of DeForest and Theremin. There is Maurice Martenot who up to the present has been the best soloist on an electrical instrument. (In America he first appeared with the Philadelphia Orchestra during the present season.) The instrument used by Martenot was constructed by Gaveau in Paris. This is a fingerboard model with stops for different timbres. Mention should be made also of René Bertrand ("Dynaphone"), Hugoniot and Givelet. Special attention must be accorded to Dr. Trautwein who has developed an interesting plan and attained successful practical results with his instrument, the "Trautonium," which is attracting great attention in Germany at present. It can have a flat or round fingerboard. One of the features of his invention is the practical application of the theory he has developed—the "Hallformanten Theorie." Trautwein accomplishes changes of timbre not only with the help of additional harmonics but also with the help of noise formations (obtained likewise through

electrical oscillations) which are the essential equivalent of timbre as well as character of tone.

During the last few years a certain amount of literature on the subject of electrical music has made its appearance, and the radio research laboratory at the Berlin State Conservatory has even begun to publish regular issues devoted to the question. Articles in this publication by Dr. Trautwein deserve special mention as well as his essays in the Berlin Radio Magazine, *Funk.*

Sound production by electrical oscillations has unlimited possibilities for timbre and character of pitch, intensity and duration. Theremin is working along experimental and speculative lines in timbre classification, systems of natural intonation, creation of a scientific basis for future musical theory and also for the reform of the means of recording music upon paper.

Below I append a list of compositions specially written for electrical instruments:

Hindemith: *Essays in Three-Part Polyphonic Compositions* for three monophonic Trautoniums (1930 Berlin). Performed in Berlin with Hindemith and Trautwein appearing.

Kretzmer: *Two-and-Three-Part Compositions for Trautoniums* (1930 Berlin). Performed in Berlin with Hindemith and Trautwein appearing.

Schillinger: *First Airphonic Suite for RCA Theremin with Orchestra* (1929 New York). Performed in Cleveland and New York City by the Cleveland Symphony Orchestra under the direction of Sokoloff, with Leon Theremin as soloist.

Levidis: *Poème pour les Ondes Musicales avec l'Orchestre.* Performed in Paris and in the current season in New York with the Philadelphia Orchestra under the direction of Leopold Stokowski with Maurice Martenot as soloist.