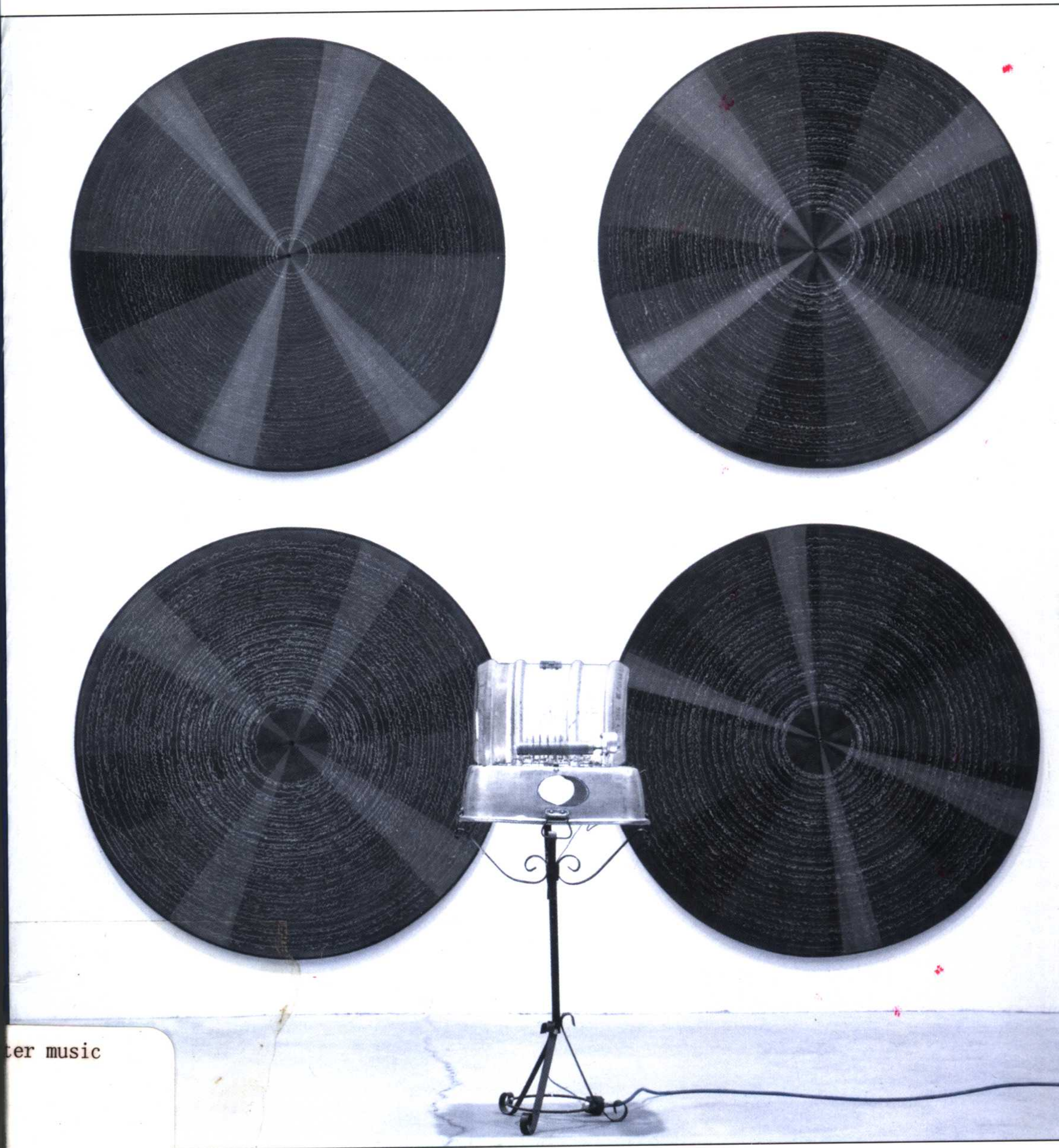
Revised and Expanded Edition

ELECTRONIC AND COMPUTER MUSIC



Peter Manning

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OXFORD
UNIVERSITY PRESS
2004

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Oxford New York
Auckland Bangkok Buenos Aires Cape Town Chennai
Dar es Salaam Delhi Hong Kong Istanbul Karachi Kolkata
Kuala Lumpur Madrid Melbourne Mexico City Mumbai Nairobi
Sao Paulo Shanghai Taipei Tokyo Toronto

Published by Oxford University Press, Inc.
198 Madison Avenue, New York, New York 10016

www.oup.com

Library of Congress Cataloging-in-Publication Data
Manning, Peter, 1948–
Electronic and computer music / Peter Manning.—
Rev. and expanded
edition.
p. cm.
Includes bibliographical references and index.
Discography
ISBN 0-19-514484-8; 0-19-517085-7 (pbk.)
1. Electronic music—History and criticism. 2. Computer
music—History and criticism. I. Title.
ML1380 .M36 2003
786.7'09—dc21 2002155278

2 4 6 8 9 7 5 3 1

Printed in the United States of America
on acid-free paper

Preface

Since the publication of the first edition of this book, the medium of electronic and computer music has expanded at a breathtaking pace. Back in 1985 the era of MIDI was in its infancy, and few even then could have accurately predicted the true extent of the digital revolution that ensued, bringing increasingly powerful audio synthesis and processing resources to individual users via the personal computer and the Internet. Whereas a single chapter on computer music seemed adequate at that time, this section had already expanded to four chapters for the second edition in 1993. The exponential nature of developments since then is reflected in the expansion of the equivalent section in the new edition to a total of twelve chapters.

The material of computer music retained from the second edition has been substantially rewritten to reflect changing perceptions and experiences of the world of computers and digital engineering in general. In so doing, I firmly prepared the ground for the new material that follows. Many aspects of the technology that were still in their infancy at that time have now achieved their potential, in turn unlocking yet further avenues of exploration and discovery that need to be critically assessed. The expanded perspective takes these issues fully into account, charting developments to the dawn of the new millennium and beyond.

The situation regarding the associated musical repertory is perhaps less certain, for reasons that will become clear in due course. Whereas a close correlation between key technical developments and associated works that fully exploit their creative potential can be maintained up until the early 1980s, the sheer diversification and expansion of activities that occurred subsequently make it impossible to sustain this approach. The perspective thus shifts in emphasis at this point in the chronology more specifically toward the functional characteristics of these technologies, viewed in ways that will facilitate independent study. There is undoubtedly a need for a book devoted exclusively to the repertory of the medium from its birth to the present day, but this is a project yet to be completed.

Viewed in retrospect, it is interesting to note that many of the issues discussed in the earlier editions have achieved new levels of importance. The revival of interest in vintage analog synthesizers is a striking case in point. The growing desire to simulate the functional characteristics of such devices or indeed reproduce the technology itself has generated a demand for information that is no longer generally available. The retention of the original chapter on voltage-control technology in the new edition is thus clearly of more than simply historical value, providing important information for those wishing to revisit this fascinating world of analog synthesis for themselves.

A number of key issues still remain to be resolved, demonstrating that advances in technology do not necessarily result in concomitant improvements in their creative value. There is, for example, no universal language for expressing musical ideas in a format that has a direct equivalence with the technical resources necessary to realize them. This creates many context-specific difficulties that have yet to be adequately addressed.

At the most fundamental level it is the nature of the working relationships established between composers and performers and their sound-producing tools that holds the ultimate key to failure or success. These relationships are ultimately dependent on the modes of communication and interaction that can be facilitated by new technologies, relating the worlds of creativity and subjectivity with the highly objective environment of electronic engineering. It is this point of intersection that provides a constant point of reference throughout this account, and the intention is to provide the reader with a perspective that connects these interdisciplinary strands in the pursuit of common goals within this diverse, complex, and intriguing medium of creative expression.

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The Background to 1945

Buried among the records of the United States patent office for the year 1897 is a rather unusual entry, no. 580.035, registered in the name of Thaddeus Cahill. The invention described has long since passed into obscurity, but in several respects it was to prove as significant a landmark for electronic music as the more celebrated phonograph patents of Edison and Berliner registered some twenty years previously.

Cahill's entry described an electrically based sound-generation system, subsequently known as his Dynamophone or Telharmonium, the first fully developed model being presented to the public early in 1906 at Holyoke, Massachusetts. As the former title suggests, the machine was essentially a modified electrical dynamo, employing a number of specially geared shafts and associated inductors to produce alternating currents of different audio frequencies. These signals passed via a polyphonic keyboard and associated bank of controls to a series of telephone receivers fitted with special acoustic horns.

The Dynamophone was a formidable construction, about 200 tons in weight and some 60 feet in length, assuming the proportions of a power-station generator. The quoted cost, some $200,000, provides another startling statistic. For all its excessive proportions and eccentricities the machine offered sound-production features that were entirely new and flexible to a degree not equaled by subsequent designs for some considerable time. Cahill saw his invention not merely as a substitute for a conventional keyboard instrument but as a powerful tool for exploring an enlarged world of pitched sounds. He believed it would become possible to produce the notes and chords of a musical composition with any timbre. This claim highlighted the ability of the performer to vary the musical quality of the selected sounds in terms of the relative strengths of each of the primary harmonics associated with a particular note. Such a facility necessitated the use of separate inductors for each overtone, adding greatly to the complexity of the system.

News of Cahill's work traveled far, attracting the attention of no less a composer than Ferruccio Busoni. In an extended essay entitled *Sketch of a New Esthetic of Music* (1907),[1] he championed the Dynamophone as a powerful tool for exploring new concepts of harmony.[2]

Sadly, however, Busoni did not choose to pioneer investigations himself. Cahill, and the New England Electric Music Company that funded the venture, intended to sell production models of the machine to large cities and towns throughout America for the transmission of "Telharmony" to hotels, restaurants, theaters, and private homes via the local telephone exchange. This visionary quest to provide a music broadcasting network for the nation was not to become a reality, however, for in addition to the excessive capital outlay required, it was discovered that the machine seriously interfered with other telephone calls. Faced with such impossible commercial odds the venture ran into financial difficulty, and eventually failed in 1914, just before the outbreak of the First World War in Europe.

Advances in the newly established field of electronics were, nevertheless, preparing the way for less costly and more compact approaches to the generation of synthetic sound. The direct current arc oscillator appeared in 1900, and by 1906, the same year as the first demonstration of the Dynamophone, Lee De Forest had patented the vacuum-tube triode amplifier valve. Progress was slow but steady, and by the end of the war, with the industry well established, several engineers were able to investigate the possibility of using the new technology for the construction of electronic musical instruments. The primary motivation behind most of these designs was a desire to create additions to the conventional orchestral range, with an underlying hope that composers could be persuaded to provide a suitable repertoire. The devices that emerged were thus intended primarily to satisfy traditional ideas of musical writing. Some indeed, such as the Neo-Bechstein Piano (1931), were little more than modified acoustical instruments, using special pick-ups to capture naturally produced vibratory characteristics for the processes of electronic amplification and modification. The best-known modern example of this class of instrument is the electric guitar.

The majority relied on an electronic method of sound generation, for example, the Thérémin (1924), the Sphärophon (1927), the Dynaphone (not to be confused with the Dyna*mo*phone) (1927–8), the Ondes Martenot (1928), and the Trautonium (1930). Most were keyboard-oriented, providing a single melodic output and an ancillary means of controlling volume, usually taking the form of a hand-operated lever or a foot-pedal. The Thérémin was a notable exception, having no keyboard at all. Instead, two capacitor-based detectors were employed, one a vertical rod, the other a horizontal loop. These controlled pitch and amplitude, respectively, by generating electrical fields that altered according to the proximity of the hands of the performer.

Electronic instruments of this type flourished briefly during the interwar period. Despite contributions from composers such as Hindemith, Honegger, Koechlin, Milhaud, and Messiaen, only a limited repertory of works was produced. More sustained interest was shown by writers of film music until the emergence of more modern synthesizer technology, but outside this particular sphere of activity these instruments failed to establish any lasting position of significance. Today, the Ondes Martenot is the only example of these original designs still encountered on the rare occasion in concert use, its position being sustained by works such as Messiaen's *Turangalîla* symphony and *Trois Petites Liturgies*.

The Givelet (1929), soon to be overshadowed by the Hammond Organ (1935), heralded a rather different and commercially more successful line of development, for these instruments were polyphonic rather than monophonic, designed in the first instance as competitively priced replacements for the pipe organ. The Givelet combined the principles of the Pianola or "player piano" with those of electronic sound generation, for it could also be controlled via a prepunched tape. The Hammond Organ, although a more conventional instrument from the performer's point of view, gained a reputation for its distinctive if not entirely authentic sound quality. This was largely due to the method of tone generation employed, involving the rotation of suitably contoured discs within a magnetic field in a manner reminiscent of the Dynamophone. The potential of the Givelet and the Hammond Organ as substitutes for the piano in the field of popular music was quickly recognized and exploited. Applications such as these, however, contributed very little to an appreciation of the artistic potential of this new medium of sound production, and it was perhaps inevitable that the first excursions into such an unknown sphere should be so closely modeled on traditional instrumental practice. There were, nevertheless, a few pioneers who were anxious to explore the possibilities of an expanded sound world in a less restricted manner.

One of the earliest attempts to employ nontraditional sound-generation techniques as part of a communicative art form arose from the activities of the members of the Futurist movement. This was initiated by the Italian poet Filippo Marinetti in February 1909 with the publication of his *Manifesto of Futurist Poetry*.[3] The musical objectives of the movement were outlined by Balilla Pratella in the *Manifesto of Futurist Musicians*, published in October 1910. Echoing the revolutionary spirit of the movement, this document called for "the rejection of traditional musical principles and methods of teaching and the substitution of free expression, to be inspired by nature in all its manifestations."[4]

Five months later to the day, Pratella suggested in the *Technical Manifesto of Fu-*

turist Music that composers should "master all expressive technical and dynamic elements of instrumentation and regard the orchestra as a sonorous universe in a state of constant mobility, integrated by an effective fusion of all its constituent parts."[5] Further, he considered that their work should reflect "all forces of nature tamed by man through his continued scientific discoveries," for example, "the musical soul of crowds, of great industrial plants, of trains, of transatlantic liners, of armored warships, of automobiles, of airplanes." Exactly two years later another Futurist, Luigi Russolo, published a related manifesto entitled *The Art of Noises* as an open statement to Pratella.[6] This document proposed the composition of works based entirely on the use of sound sources from the environment:

> Musical sound is too limited in qualitative variety of timbre. The most complicated of orchestras reduce themselves to four or five classes of instruments differing in timbre: instruments played with the bow, plucked instruments, brass-winds, wood-winds and percussion instruments. . . . We must break out of this narrow circle of pure musical sounds and conquer the infinite variety of noise sounds.[7]

This document is notable for its appreciation of the relevance of acoustic laws to the generation of musical structures from noise sources:

> We must fix the pitch and regulate the harmonics and rhythms of these extraordinarily varied sounds. To fix the pitch of noises does not mean to take away from them all the irregularity of tempo and intensity that characterizes their vibrations, but rather to give definite gradation of pitch to the stronger and more predominant of these vibrations. Indeed noise is differentiated from musical sound merely in that the vibrations that produce it are confused and irregular, both in tempo and intensity. Every noise has a note—sometimes even a chor—that predominates in the ensemble of its irregular vibrations. Because of this characteristic pitch it becomes possible to fix the pitch of a given noise, that is, to give it not a single pitch but a variety of pitches without losing its characteristic quality—its distinguishing timbre. Thus certain noises produced by rotary motion may offer a complete ascending or descending chromatic scale by merely increasing or decreasing the speed of motion.[8]

The practical manifestations of his proposal involved the construction of specially designed noise instruments, Intonarumori, in collaboration with the percussionist Ugo Piatti. The first public performance of the "Art of Noises" took place in June 1913 at the Teatro Storchi, Milan, barely three months after the publication of the manifesto, and with only some of the Intonarumori completed. A second altogether more successful performance using the full complement of instruments was given as part of a concert of Futuristic music, presented by Marinetti and Russolo at the Teatro dal Verne, Milan, in April 1914.

The historical interest in this venture lies not so much in the acoustical design features of the Intonarumori themselves, instruments that in any event have long since been destroyed, but more in the motivation that led to their construction. The Futurist movement did not succeed in its attempt to produce a major revolution in the path of new music, but its challenging of traditionally accepted relationships between the science of acoustics and the art of musical sound production was to prove singularly prophetic.

Busoni had already attacked traditional nineteenth-century musical practices in his *Sketch of a New Esthetic of Music*, advocating a reappraisal of the whole language of music "free from architectonic, acoustic and aesthetic dogmas."[9] This book caught the attention of a young French composer, Edgard Varèse, who, having rebelled against the traditional outlook of the Paris Conservatoire, was eager to explore new concepts of musical expression. Varèse, perhaps more than any other composer of his time, pioneered in his instrumental music the aesthetics that were necessary for the acceptance of electronic sound-processing techniques in musical composition. It is thus particularly tragic that it was not until the 1950s, toward the end of his life, that he gained access to the facilities he so fervently desired.

As early as 1916 he was quoted in the New York Telegraph as saying: "Our musical alphabet must be enriched. . . . We also need new instruments very badly. . . . In my own works I have always felt the need for new mediums of expression."[10] He was quick, however, to deny suggestions that his efforts were directed toward the Futurist movement.

> The Futurists (Marinetti and his noise artists) have made a serious mistake. . . . Instruments, after all, must only be a temporary means of expression. Musicians should take up this question in deep earnest with the help of machinery specialists. . . . What I am looking for are new technical means which can lend themselves to every expression of thought.[11]

Varèse had become acquainted with the electronic designer René Bertrand in May 1913, and this marked the start of a long and lasting friendship.[12] In 1922, during the composer's first stay in America, he declared in an interview for the *Christian Science Monitor*: "What we want is an instrument that will give us continuous sound at any pitch. The composer and electrician will have to labor together to get it. . . . Speed and synthesis are characteristics of our own epoch."[13]

During the 1920s, Varèse continued his search for new sound textures, but without the aid of any suitable technical facilities. His work with natural instrumental resources in his first published compositions was nevertheless singularly prophetic, for he was concerned to use procedures that were to become primary characteristics of electronic sound processing: analysis and resynthesis. He experimented, for example, with altered attack characteristics for brass instruments, where the initial transient would be suppressed by making the entry of a sound piano, and its central portion or body heavily accentuated by means of a rapid crescendo. Such an effect is remarkably similar to that achieved by playing recordings of normally articulated notes backward, the decay thus becoming the attack. He was also particularly concerned to use instruments as component building blocks for sound masses of varying quality, density, and volume, in contrast to their traditional roles as sources of linear counterpoint.

His philosophy of musical expression, to use his own term, was based on the concept of "organized sound," with no prior restrictions as to the choice or use of the component sound sources involved in the process of synthesis. Percussion instruments figured prominently in his works. *Ionisation* (1930–1), for example, is scored entirely for instruments of this family. With the aid of effects such as sirens, whips, a lion's roar, and sleigh-bells, he struggled to develop a compositional art that integrated the natural sounds of the environment with more traditional sources of musical expression. This was not the somewhat crude Futurist "Art of Noises" exploring the exotic, but an attempt to extract an artistic perspective from the universe of sound.

Varèse was not immune from imitators. The American composer George Antheil required the use of car horns, airplane propellers, saws, and anvils in his *Ballet mécanique,* first performed in Paris in 1926, and again in New York in 1927. The work of Joseph Schillinger is also of interest in this context. Schillinger, a Russian composer and theorist, advocated the development of new musical instruments based on electrical principles in a similar vein to Varèse as early as 1918. A decade later he traveled to America in response to an invitation from the American Society for Cultural Relations with Russia, remaining in the United States until his premature death fifteen years later. Soon after his arrival he embarked on a collaborative venture with his countryman Thérémin, designing a domestic version of the Thérémin for commercial manufacture by RCA. As an aid to promotion Schillinger composed his *Airphonic Suite for RCA Thérémin and Orchestra*, the work receiving its first performance at Cleveland, Ohio, in November 1929, with Thérémin as soloist. His interest in fostering the creative application of science for musical ends is illustrated by the following extract from an article entitled "Electricity, a Musical Liberator," which appeared in *Modern Music* in March 1931:

> The growth of musical art in any age is determined by the technological progress which parallels it. Neither the 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. . . . 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 sound.[14]

During the remaining years of his life he became increasingly preoccupied with aspects of music theory, producing a set of twelve books describing *The Schillinger System of Musical Composition* (1946),[15] followed two years later by a monumental treatise, *The Mathematical Basis of the Arts*.[16] Neither of these volumes, unfortunately, was published until after his death. Despite some rather curious aspects, including the use of statistical data as a basis for measuring the degree of stylistic consistency displayed by major classical composers, and the formulation of a set of compositional rules based on empirical analyses of musical structures, his theories contain some features of particular interest. In particular, his attempt to analyze sounds in music-acoustic terms, using such identifying features as melody, rhythm, timbre, harmony, dynamics, and density anticipated the type of methodology to be applied from many quarters in the search for a morphology to describe the elements of electronic music.

Varèse, unlike Schillinger, continued to press actively for practical facilities. Toward the end of 1927, he became restless to learn more about the possibilities of electronic instruments, and contacted Harvey Fletcher, the director of the acoustical research division of Bell Telephone Laboratories, with a view to acquiring a laboratory for research in this field. Fletcher took an interest in his proposals but could not offer the funds necessary for such a venture. In desperation, Varèse departed for Paris in the autumn of 1928 to ascertain from Bertrand what potentially useful technical developments had taken place in his absence. One product of his visit was the formulation of a project to develop what might have become the first sound synthesis studio, and an associated school of composition. Although details were never officially published, his biographer, Fernand Ouellette, managed to obtain a copy of this document from Ernst Schoen, Varèse's first pupil. The proposal ran as follows:

> Only students already in possession of a technical training will be accepted in the composition class. In this department, studies will concentrate upon all forms required by the new concepts existing today, as well as the new techniques and new acoustical factors which impose themselves as the logical means of realizing those concepts.
>
> Also under Varèse's direction, with the assistance of a physicist, there will be a working laboratory in which sound will be studied scientifically, and in which the laws permitting the development of innumerable new means of expression will be established without any reference to empirical rules. All new discoveries and all inventions of instruments and their uses will be demonstrated and studied. The laboratory will possess as complete a collection of phonographic records as possible, including examples of the music of all races, all cultures, all periods, and all tendencies.[17]

The scheme was not to materialize, for Varèse was unable to find an adequate source of finance. On 1 December 1932, while still in Paris, he wrote again to Fletcher requesting access to the facilities of the Bell Telephone Laboratories in return for his services to the company: "I am looking to find a situation where my collaboration would have value and pecuniary return."[18] Varèse was so eager for laboratory facilities that he was even prepared to sacrifice his career as a composer, at least for a time. He also applied to the John Simon Guggenheim Memorial Foundation for a grant towards his work. In response to a request for more details, he wrote again to the Foundation on 6 February 1933 offering the following proposal:

> The acoustical work which I have undertaken and which I hope to continue in collaboration with René Bertrand consists of experiments which I have suggested on his invention, the Dynaphone. The Dynaphone (invented 1927–8) is a musical instrument of electrical oscillations somewhat similar to the Thérémin, Givelet and Martenot electrical instruments. But its principle and operation are entirely different, the resemblance being only superficial. The technical results I look for are as follows:
>
> 1. To obtain absolutely pure fundamentals.
> 2. By means of loading the fundamentals with certain series of harmonics to obtain timbres which will produce new sounds.
> 3. To speculate on the new sounds that the combination of two or more interfering Dynaphones would give if combined in a single instrument.
> 4. To increase the range of the instrument so as to obtain high frequencies which no other instrument can give, together with adequate intensity.
>
> The practical result of our work will be a new instrument which will be adequate to the needs of the creative musician and musicologist. I have conceived a system by which the instrument may be used not only for the tempered and natural scales, but one which also allows for the accurate production of any number of frequencies and consequently is able to produce any interval or any subdivision required by the ancient or exotic modes.[19]

This application, unlike his previous proposal, laid down for the first time the acoustical principles that would serve as the basis for a program of research, investigating the musical applications of electronic sound synthesis. The Dynaphone, despite his assertions, did not differ significantly from its relatives. Its ability to generate timbres in an additive manner using harmonic stops, for example, was matched by a similar facility within the Ondes Martenot. Nevertheless, since Varèse was well acquainted with its designer, he was aware of the potential of developing its circuits to produce not merely an enhanced electronic instrument, but a versatile sound synthesis system serving a wide variety of compositional demands.

The Guggenheim Foundation, unfortunately, did not understand the purpose of Varèse's proposal, and despite repeated requests Varèse failed to win financial