MUSIC AND TECHNOLOGY IN THE EUROPE OF 1970

by

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THE relationship between music and technique has always been a close one, and up to the late eighteenth century musicians in Europe were certainly aware of this fact. This cannot be said of the following generations, which from then onwards were increasinghy permeated by Rousseau's idea of a « natural » kind of music. If I were to attempt even to give an idea of the curiously intertwined paths which have led to the prevailing occidental concept of music I should digress far beyond the limits of this study ; this concept is a mixture of ideas which — anchored more dogmatically than logically — might be briefly characterized by the view that, on the one hand, music is of naturel origin and therefore generally and directly comprehensible, and that it cannot distance itself from its origins with impunity ; on the other hand, that music has a higher value, the more labour a composer has invested in his works. It is only a step from this to the concept that natural is the same as « good », and invested labour the same as « moral ». This step has been taken, and has led western aesthetics to the curious motley of dogma and nonsense that still determines to a great extent our current opinions about music. Mechanical bowing, plucking and striking of strings and skins does not happen to be more beautiful, but better — because closer to nature — than the electronically produced sound ; the same mediaeval diligence of the monks, with which the composer still writes his scores today, is to be preferred to working with the computer, because toil and (manual) labour have always been much more moral.

What is more, the western world has succeeded in effortlessly combining these strange ideas about music with its liberal-commercial concept that everything can be measured according to its market value. Artistic production is just as precious as gilt-edged securities in our western world today, and the composer's value is estimated in the same way as that of any industrial undertaking. It is an open secret that the composers of « serious » music, just as is the case with their colleagues from the sector of light music, are evaluated according to their gramophone record sales, which brings us into the centre of the net of publicity, trade, technique and music which is as eminently typical of our present-day musical life as it is exceedingly mendacious. By this I mean the attitude that still proclaims music as the antipode of technique, as a virgin untouched by the

evils and unculture of technique, a virgin who at the same time only has a real chance of wooing public appreciation if she bedecks herself with all the refinements of electro-acoustic recording, storage and playback techniques.

We shall be forced to deal with the question of how it was possible for this to happen if we are to attempt to find out if there is still today the same fruitful give-and-take between music and technique that has always been registered in the history of music. I mean a relationship that does not have to be shamefully hidden and argued away for the single reason that it has caused music to be completely sacrificed to technique ; the question should rather be whether music has succeeded anywhere or at any time in integrating the means which technique has to offer, and to use them to enlarge its own artistic spectrum, its own possibilities.

The progress of technique has affected the development of music in the twentieth century in three sectors : in storage technique, in telecommunications and in the development of computers.

Storage technique

The storage of information is essential to music. We do not concede (rightly or wrongly) any musical talent to a bird which twitters without there being any laws, repetitions, etc., recognizable in its utterances. If fixed elements are present, such as signs with particular meanings, we then of course speak of birdsong. Man has made use of several techniques in order to store his musical signals. But whenever he enters a stage which we call historical, he has employed *graphical* signs which served him as information storage. Graphical storage by means of *notation* and its development became the most important factor of music in the musical history of Europe, finally to become music itself. The deeply-rooted belief in the identity of music and notation can still be easily recognized today in the attitude with which a « serious » musician reading his music regards the « improvising » jazz-player. And indeed it cannot be denied that graphical storage is inseparable from the development of European music and has determined the progress of this development to a high degree.

However, we must not overlook a second information storer which is no less essential for music : the *musical instrument.* Just as writing is identical with music for the initiated, the instrument is identical with music for those simple beings who cannot read music, and who often simply call the instrument « the music ». The idea of improving the kind and capacity of the musical instrument's storage and of building automatic instruments with *cylindrical storage* is an old one and well-known. The method was occasionally superseded by the phonograph and its descendants, but appears again today in the guise of punch-card or punch-tape storage with mechanical or optical sensing.

The serious music of the west, then, has been identified to a great extent with notation, but cylindrical storage and punch-cards and tapes were first left

to barrel-organs and musical boxes. Serious music's attitude to the *phonograph* and *gramophone record,* however, was quite different. Here are some data (and a reference date : 1877 Brahms, First Symphony ; Grieg, « Peer Gynt ») :

1877 : Edison and Cros : phonograph.

1887 : E. Berliner : gramophone (lateral recording).

1897 : E. Berliner : shellac record.

1902 : Caruso makes a vocal recording.

1903 : Verdi's « Ernani » recorded.

1905 : Melba makes a recording.

1909 : A. Nikisch records Beethoven's Fifth Symphony with the Berlin Philharmonic. At this time several operas were recorded for silent films.

The first phase of the development was completed, then, as early as 1909. Its technical characteristic is the method of mechanical sound recording ; it is typified artistically by the tendency of having world-famous stars record standard repertoire.

(Second phase and memo : 1924, A. Honegger, « Pacific 231 ») :

from 1925 : transition from mechanical to electrical recording (1926 Harris and Maxwell) extends the available bandwidth from 3 to 7 octaves. Standard recording speed is 78 r.p.m. ; 12-inch record gives a recording duration of 4.5 minutes.

1926 : Handel's « Messiah » recorded electrically. Complete recording of « Boris Godunow » with Chaliapine (Covent Garden).

1927 : The gramophone record comes into its own in the Beethoven year : Columbia puts 100, His Master's Voice 50 Beethoven recordings on the market.

The second phase is closely connected technically with the development of radio (amplifiers and loudspeakers had been in general use since around 1927, the year in which radios with mains attachment were put on the market). Artistically, the example of the first phase of development was followed : the reproduction of standard works by world-famous stars. Neither the long-playing records introduced in 1948 nor the stereo recordings which started in 1950 have changed anything there. And the composers ? It is infinitely more important to them to have their works on records today than it is to have them played in the concert hall, as they very well know. And none the less nearly all of them continue to pretend that they are writing for the concert hall. The exalted art of mechanical sound production by means of traditional musical instruments is neatly separated from the merely technical process of electrical sound conversion for purposes of storage and playback ; the one is the strictly sacred domain of the composer and his interpreters, the rest is up to the sound engineers and technicians. There is no artistic bridge, nor is one required. Indeed, this is no flourishing musical life, but the last journey of a dying musical culture into the vaults of the discothèques.

Still, there have been composers who soon saw the gramophone record as more than a means of preserving the music of the past. Darius Milhaud, who

composed the cinema-fantasy « Le Bœuf sur le Toit » as early as 1919, made experiments with records in the twenties ; Hindemith and E. Toch did so at the end of the twenties, the Bauhaus artists and Edgard Varèse in the thirties. They all had one aim, which Stockowsky lucidly formulated in 1932 : « One can see coming ahead a time when a musician who is creator can create directly into tone not on paper » (New Horizons in Music). This aim could not, however, be realized by the gramophone record, but had to wait until after the second world war for *magnetic tape*. Although work according to the Poulsen method (1901) was done in the twenties (for example at the experimental radio department at the Musikhochschule in Berlin 1928-1929) and although AEG constructed a *tape recorder* in 1935, the tape being contributed by IG-Farben, it was not until pre-magnetization (Weber and v. Braunmühl 1940) that valid results were achieved. Today tape-recording is relieving notation as a form of storage, if this has not already happened.

Telecommunications technique

(a) *Radio.* 1876, the year in which the Festival Theatre was opened at Bayreuth, was also the year in which Bell and Gray both, although independently of one another, patented the telephone (it had actually been invented by Reis in 1861, but not exploited). The development that followed is of interest to us only in as much as it involves wireless transmission of information ; the following data provide a brief outline :

1887 : Hertz discovered electric waves and supplied the experimental proof for the work of Faraday and Maxwell. (1886, death of Liszt ; Saint-Saens : Symphony in C.)

1896 : Marconi (basing his findings on Hertz, Popov and Branly) demonstrated the practical use of electric waves for wireless transmissions of signs.

1906 : The efforts to produce sustained oscillations were brought to a successful completion (F. Braun, A. Slaby, M. Wien, V. Poulsen) and the problem of wireless transmission of speech and music was fundamentally solved. Telefunken transmitted speech and music over a distance of 25 miles by means of an arc transmitter. (The same year, 1906, Mahler's Sixth Symphony.)

But not until the electron tube (J.A. Fleming 1904, R. v. Lieben 1906, L. de Forest 1907) and the subsequent development leading to feedback (1913 Meissner, Reiss, Strauss, Franklin and Round, Armstrong and Langmuir) and frequency modulation (1922 J. Carson, 1935 E.H. Armstrong) did *radio* assume its *modern form*. Its beginnings are somewhat obscure. It is certain that several experiments were made during the first world war. As early as 1914 the French army engineer, Victor Colin, said the following after an attempt at speech transmission by radio at Voves-Paris : « Pour parler d'application plus gracieuse, rien ne nous sera plus aisé que de faire entendre à une heure déterminée un

concert complet à tous les habitants de la région parisienne pourvus de récepteurs. » From 1917 the French, English and Germans experimented with radio programmes for their troops on the western front. And it is also said that private experiments with radio broadcasts were carried out in Holland from 1919. More concrete details are available after 1920. According to witnesses the following concerts were broadcast :

1920 : 23 February : in England by the Marconi Company (1).
15 June : Chelmsford, England.
October : Eiffel Tower, Paris.
2 November : Anacostia, Washington, United States, Pittsburgh, United States.

1921 : 8 June : Königswusterhausen, Germany : first-ever opera broadcast (« Madame Butterfly » with the Berlin State Opera) (2).

Starting in 1921, broadcasting stations began to be organized (Radiola Paris and Röhrensender (valve transmitter) of the German Reichspost 1921, forerunners of the BBC 1922, entertainment broadcasting Berlin 1923, RAVAG Vienna 1924, and many more). On 5 April 1925 the International Broadcasting Union was established in Geneva, and eight days later the first congress of the Comité Juridique International TSF took place in Paris. One year later, 1926, Heinrich Pfitzner conducted his « Armer Heinrich » in the Berlin broadcasting studio. All the choryphées of the period followed suit ; in 1930 Richard Strauss, Karl Schuricht, Hermann Scherchen, Max v. Schillings, Hermann Abendroth, Willem Mengelberg, Bruno Walter, Stravinsky, Kleiber, Toscanini, Furtwängler all conducted for German broadcasts. In that same year the Salzburg Festival was broadcast for the first time, and a year later Richard Wagner's Festival Theatre also opened its portals to the radio : « Tristan und Isolde » was transmitted by 200 European and American stations over the entire world in 1931 (cf : 1931 « Ionisation » by Varèse). « Wir würden uns an den Grenzen menschlicher Glückseligkeit glauben und aufgehört haben, weitere Verbesserungen zu erstreben, könnten wir eine Einrichtung ersinnen, die jedem Musik ins Haus sendet... » (I). This hope expressed by the writer E. Bellamy in 1888 had been fulfilled (3).

But the musician still stood aside and gratefully accepted economic aid from the radio... G. Schünemann said this in 1929, and it typifies an attitude which is still adopted to a great extent by the musician today (2). We have the concerts, apparently as flourishing as ever, and we have radio, whose task it is to transmit concerts and operas as truly and faithfully as possible. Henri Busser : « Il faut bien établir le principe que ce ne sont pas les musiciens qui doivent écrire pour les disques et la radiophonie, mais bien au contraire ce sont les

(1) Lord SIMON OF WYTHENSHAWE, « The BBC from Within », London, 1953.
(2) Quoted from H. BREDOW, « Aus meinem Archiv », Heidelberg, 1958.
(3) E. BELLAMY, « Looking Backwards ». Quoted from K. STEINBUCH, « Die informierte Gesellschaft », Stuttgart, 1966.

inventions nouvelles qui doivent se perfectionner pour rendre les auditions musicales aussi fidèles que possible » (4). On the other hand, the question soon arose in broadcasting circles « ob der Rundfunk immer nur einen Ersatz für Konzerte und Oper bieten, oder ob er neue schöpferische Kräfte erwecken kann ? » (2) (II). At the end of the twenties an experimental radio department was set up at the Hochschule für Musik in Berlin, in the hope « junge Musiker mit den Grenzen, Eigenheiten und Möglichkeiten des Funks so vertraut zu machen, dass sie zu einer Musik aus Sinn, Geist und Technik des Rundfunks kommen können » (III), and it was also pointed out that the musician can « auch auf die elektrische Tonerzeugung zurückgreifen » (2) (IV). There were therefore at a very early stage ideas of the type later cultivated in the Studio d'Essai (since 1942) in Paris and which eventually led to *Musique Concrète* and to the Cologne concept of music which should do justice to radio. Pierre Schaeffer in an interview : « Ce que m'intéresse en réalité, c'est d'expliquer à des jeunes musiciens que les moyens électroacoustiques, synthétiques ou provenant de sources acoustiques, renouvellent entièrement la manière de faire la musique et aussi de l'entendre » (5).

The understanding that radio has caused completely new situations to be created for music has asserted itself in many places thanks to the work of a few outstanding figures, and resulted in the establishment of numerous studios for electronic music in the fifties which will be discussed presently. This naturally does not change anything about the fact that radio, although it has taken hesitant steps to develop itself (radio operas, plays, etc.) and in many cases made it possible for electronic studios to be built, and even encouraged them, has up to now mainly been satisfied with the rôle of supplier and large-scale distributor of recordings and reproductions of conventional music. The arguments which are brought into play are discrepant. In 1929 Hermann Scherchen spoke at a conference of the German programme committee on 22-23 May in Bremen about radio's task and possibilities of encouraging public concerts and of creating a community of listeners who understand music, a community in which audiences will be educated through the ether « unmerklich zum idealen Rundfunkhörer » (imperceptibly to become ideal radio listeners) (2). However, every progressive suggestion about change is countered by the radio with the information that programmes have to be orientated to the taste of the majority (Who, other than the radio, has formed this taste « unmerklich » — imperceptibly ?). This is indeed a questionable viewpoint if one considers that it was necessary to have the success of pirate transmitters such as « Radio Caroline-Sud » and their successors in order to force the worthy BBC to set a new programme course (6).

(4) R. PRADALIÉ, « L'art radiophonique », Paris, 1951.
(5) *Le Monde* of 24 January, 1969, Paris.
(6) *La Suisse* of 4 March, 1970, Geneva.

Very little can be said as yet about the extent to which television will take new paths and, in particular, provide the visual aspect of music which the loudspeaker lacks. Here, too, everything depends on the initiative of a few individuals, since the organizations themselves are fully occupied with administrative tasks and their own Parkinson-like increase. The Groupe de Recherche de l'ORTF is intensely concerned with the image. Pierre Schaeffer : « Nous sommes partis ici de la technique et de la musique, physique et esthétique de la musique étant mélangées, puis de la radio... pour finir ces dernières années par nous intéresser à l'image » (5). West German and Swedish television have also experimented in this direction (Kagel, Bussotti, Foresting).

(b) *Electro-acoustic musical instruments.* If one is to believe all one reads in manuals of music history, the development of European musical instruments ended with the saxophone at the very latest. Of course this is not so. The mechanical instrument of the past was succeeded by the electro-acoustic instrument in the twentieth century, and in this development the achievements of electric telecommunications technique were exploited musically the moment they became practically available. The Telharmonium or Dynamophone of Dr. Th. Cahill (1906) used as its sound sources the cogwheel generators employed at that time for the transmission of information, and the concerts were transmitted by means of the telephone. This solitary forerunner had no successors until the development of radio, i.e. until the twenties. But then all available basic types of electro-acoustic sound production were used one after the other in one decade : the Spherophone of L. Theremin (1929) and the Ondes Martenot (1928) work with buzzers and highfrequent oscillations ; the keyboard-spherophone of J. Mager (1924) and the organ of A.J. Givelet and E. Coupleux (1928) are based on feedback generators, the Trautonium on a glowing valve generator, which is doubled and extended by frequency dividers in the mixture trautonium, and so forth. Timbres are produced partly by the addition of partials (as in the case of the Telharmonium), partly by the filtering of a complex basic sound (as with Givelet and Coupleux). Photo-electric methods were also used (for example the superpiano 1930, Welte organ 1936).

The official musical world took hardly any notice. Here, too, it is again only a few individuals who react ; Busoni, on hearing about the Cahill organ, formulated with the foresight of one who had estimated the situation correctly from the very start : « Plötzlich, eines Tages, schien es mir klar geworden : dass die Entfaltung der Tonkunst an unseren Musikinstrumenten scheitert » (V). And Edgard Varèse 1922 : « Was wir wollen, ist ein Instrument, das uns einen kontinuierlichen Ton auf jeder beliebigen Tonhöhe geben kann. Der Komponist und der Elektroingenieur müssen gemeinsam auf dieses Ziel hinarbeiten. Wir können um keinen Preis damit weiterfahren, in den alten Klangfarben der klassischen Schule zu arbeiten. Geschwindigkeit und Synthese sind die Charakteristika unserer Epoche. Wir bedürfen der Instru-

mente des 20. Jahrhunderts, um diese in der Musik zu realisieren » (7) (VI). The entire construction of electro-acoustic instruments seems to labour under the words already spoken about Cahill's Telharmonium in 1906 : new music for an old world (8). Electro-acoustic instruments *have* provided new possibilities of sound production (and the first work done in electronic music links directly on to Cahill's additive method of sound construction !) ; but the constructors built their electro-acoustic instruments exclusively for an old world. They all tried to articulate the parameters in the same way that was usual for traditional mechanical instruments. This resulted in difficulties in manipulation (all kinds of keyboards, cables, band manuals, aerials, were used) and inferiority of variation of the sound (attack, modulation of the sustained sound, attenuation, etc.). Electro-acoustic instruments were therefore able to come into their own only where the mechanically highly technified organ and members of its family had already been in use. In order to make electro-acoustic sound production musically fruitful, an entirely new start was needed : the musical instrument had to be renounced completely, and the desire for musical expression had to be orientated in a new fashion. Today there are signs that the *computer* will be the musical instrument of the future. The fact that its complexity will have a greater influence on composing than previous musical instruments have had can only be a surprise to those who have never seen the elementary connexion between composing and instrument.

Calculating machines

In 1833 Babbage provided the idea of the present-day computer (analytical engine) ; in the same year Heinrich Marschner's « Hans Heiling » received its first performance. What might have been conceivable in the eighteenth century, when Leibniz invented his « calculation with zero and one » was out of the question for music at the start of the nineteenth century and for the next hundred years — a possible connexion between the calculating machine and music. In 1808 J.M. Jacquard programmed his weaving machines by means of punch-cards ; Beethoven composed his Fifth Symphony. In 1890 the eleventh United States population census was dealt with in an eighth of the time required previously, thanks to Hollerith's punch-cards ; Borodin's « Prince Igor » was performed for the first time, posthumously. In 1941, when K. Zuse produced the first programme-controlled computer, the Z3, the situation had already changed radically ; the Vienna School had liquidated the heritage of highly complex functional harmony (Schoenberg Op. 23, 1923), and had returned, in structural terms, to primitive abacus calculation for the time

(7) F. OUELETTE, « Edgard Varèse », Paris, 1967.
(8) H. R. BAKER, « New Music for an Old World. Dr. Thaddeus Cahill's Dynamophone, an extraordinary electrical invention for producing scientifically perfect music ». *McClure's Magazine* 27, 1906.

being. Here, too, a new start had to be made, by renunciation. Only in this manner was it possible for composers to get a new grasp of the organization of *musical parameters,* and learn to understand music as « son organisé ». Varèse 1940 (7) : « Jeden Ton, den unsere Fantasie erdenken kann, den können wir auch verwirklichen, seine Farbe, Stärke und Höhe genau kontrollieren und damit völlig neue Klangbezirke erschliessen » (VII).

Subsequent events : 1943 the ENIAC computer, 1945 Zuse's plan calculus, death of Anton Webern whose parameter idea had begun to have a strong influence on the post-war generation of young composers. The next few years saw technical problems of internal programme storage (EDSAC). In 1948, N. Wiener's cybernetics, Schaeffer's « Concert des Bruits ». 1953-1954 the computers STRELA and BESK and the IBM magnetic drum computer 650 ; the first electronic music studios in Europe were opened, strongly influenced by the hope of being able to create scientifically pure music by electronic means and apply the parameter idea consistently.

The musical ideas of the avant-garde, which had already started to diverge with musique concrète, now went entirely different ways. On the one side the *serialists* needed the computer in order to be able to formulate the musical work of art as an algorithm (L. Hiller and L. Isaacson, « Illiac Suite » 1957) which leads to the *algorithmic* music of P. Barbaud. « La pratique de la musique algorithmique consiste donc à établir la liste séquentielle des opérations à effectuer à partir d'un ensemble de données pour obtenir en fin de compte une musique qui soit conforme à celle que souhaite le rédacteur de cette liste » (9). On the other side, I. Xenakis had already pointed out to Hermann Scherchen in a letter of 1954 the contradiction between rigorous serial organization of the parameters and the audible result, and he develops the core of his ideas of *stochastic* music : « La polyphonie linéaire se détruit d'elle-même par sa complexité actuelle. Ce qu'on entend n'est en réalité qu'amas de notes à des registres variés. La complexité énorme empêche à l'audition de suivre l'enchevêtrement des lignes et a comme effet macroscopique une dispersion irraisonnée et fortuite des sons sur toute l'étendue du spectre sonore. Il y a par conséquent contradiction entre le système polyphonique linéaire et le résultat entendu qui est surface, masse.

« Cette contradiction inhérente à la polyphonie disparaîtra lorsque l'indépendance des sons sera totale. En effet, les combinaisons linéaires et leurs superpositions polyphoniques n'étant plus opérantes, ce qui comptera sera la moyenne statistique des états isolés de transformation des composantes à un instant donné. L'effet macroscopique pourra donc être contrôlé par la moyenne des mouvements des objets choisis par nous. Il en résulte l'intro-

(9) P. BARBAUD, « La musique, discipline scientifique », éd. Dunod.

duction de la notation de probabilité qui implique d'ailleurs dans ce cas précis le calcul combinatoire » (10).

Subsequently, many *composing programmes* were written for the computer. « Sie gehen von verschiedenen Voraussetzungen aus und kommen zu verschiedenen Resultaten. Allen Programmen ist aber gemeinsam, dass der Komponist ein Minimum an musikalischen Daten mitgeben muss, über die der Computer dann frei (mithilfe von Zufallsentscheidungen) verfügen kann, möglichst auch noch ein Minimum an Kombinationsregeln, um nicht alles dem Zufall zu überlassen. Je präziser Daten und Regeln sind, desto leichter ist das Resultat voraussehbar, desto weniger Einfluss wird dem Zufall eingeräumt. Das bedeutet jedoch nicht, dass der Komponist das Resultat dann ebenso gut ohne Computer errechnen könnte : die Anzahl der Daten, die Vielseitigkeit der Beziehungen, der Umfang der zu leistenden Schreibarbeit könnten dem sehr wohl entgegenstehen. Den verschiedenen Programmen ist auch gemeinsam, dass sie den Komponisten Zwingen, eine bestimmte Sorte Gedanken zu denken und seine musikalischen Ideen auf eine bestimmte, häufig ungewohnte Weise zu formulieren. Wer mit einem Computer komponiert, wird seine musikalischen Auffassungen nicht stets ändern müssen, sicher aber erweitert sehen. Musikalische Zusammenhänge werden nun nicht mehr von Fall zu Fall realisiert, sondern in verallgemeinerter Form postuliert. Der Computer-Output ist die Probe aufs Exempel » (11) (VIII).

The present situation

The contacts between contemporary music and technique, as I have attempted to demonstrate, are manifold and frequently problematic, because they have not yet been overcome. They occur on more than one front, but seem to group themselves around the studios for concrete and electronic music or at least to take place there *intentionally*. It is therefore interesting to consider these institutes and to outline their activities, without of course going further into details about the historical circumstances.

There are more than twenty studios (see list of studios on page 31) in Europe today which produce regularly. This amount must not be allowed to conceal the true proportions ; their activities occupy a very small space in official musical life. The motives leading to the establishment of the individual institutes are manifold, complex and different in each case. Pierre Schaeffer decisively opposes the naively optimistic scientific credibility of many post-war composers. « Le chemin inverse, qui mène d'une discipline scientifique à l'artisanat artistique, pour être moins fréquenté, n'en est que plus intéressant.

(10) I. XENAKIS, « Letter to H. Scherchen on 1.10.1954 », published in the *Gravesaner Blätter* N°. 6, 1956.

(11) G. M. KOENIG, « Computer-Verwendung in Kompositionsprozessen » (Musik auf der Flucht vor sicht selbst, Hanser Verlag 1969).

Il comporte, lui aussi, des dangers symétriques. Au musicien amateur de science, on peut opposer un contre-type aussi équivoque : le scientifique amateur de musique. Nous voilà pris entre deux types d'homme, également avertis et pervertis. En réalité, qui n'assume pas à la fois l'ambivalence et l'équivoque, la fusion et la distinction, ne se trouve pas au cœur du problème... Ce qui caractérise les recherches de musique concrète, c'est le parti-pris d'intuition musicale auquel est subordonnée constamment la recherche de moyens techniques » (12). Experimental empiricism is still typical today of the Paris studio (founded in 1948). « L'instinct musical y a constamment le pas sur toute prétention dogmatique, qu'elle soit de caractère scientifique ou esthétique » (12).

The reasons behind the German development are quite different. It must, however, be emphasized at this point that Karlheinz Stockhausen's work at least had a direct connexion with Paris in the sense of an unambiguous influence, for Stockhausen's first electronic piece was composed in Paris, and not later in Cologne (13). But the beginnings of electronic music in Germany are still earlier. In 1951 Bruno Maderna composed his « Musica su due dimensione » for flute and tape, the first piece of electronic music in Europe (14), with Werner Meyer-Eppler. Meyer-Eppler was lecturer in communications technique at Bonn University, and in this capacity was successful in his efforts to represent the phenomenon of music in the light of *information theory*. Meyer-Eppler, familiar with the development of electro-acoustical instruments, integrated this tradition into the beginnings of German electronic music (15). Herbert Eimert, on the other hand, is the man who had the idea of the serial organization of electronic music in the sense of Webern's successors. This marked the stylistic attitude of the works made in the Cologne WDR studio (founded in 1953) for many years.

Information-theoretical ideas can also be heard in the pieces made in the Milan Studio di Fonologia della RAI (for instance in Luciano Berio's « Omaggio »), which was founded in 1954 by Maderna and Berio, who also impressed their artistic criteria on it. In their day, the studios in Cologne and Milan set an example, and are still today models of *classic* electronic studios.

(12) P. SCHAEFFER, « Anamorphose entre musique et acoustique », *Cahier d'Etudes de Radio-Télévision* 19, Paris, October 1958.

(13) R. SUDRE, « Le huitième art », Paris, 1945.

« Avec des lampes comme oscillateurs, on peut... obtenir très exactement et d'avance toutes les notes pures de la gamme. Quant au timbre, on le composera arbitrairement, en ajoutant les harmoniques révélés par l'analyse si l'on veut reproduire celui de tel instrument. On peut aussi créer des timbres nouveaux, à l'exemple de la chimie qui, par les méthodes de Berthollet, fabrique des corps inconnus dans la nature. »

So not only the idea of radiophonic music, but also of synthetic music had by then already been familiar for years in Paris.

(14) W. MEYER-EPPLER, « Die elektrische Klangerzeugung (Elektronische Musik und synthetische Sprache »), Berlin, 1949. Meyer-Eppler lectured together with R. Beyer in Darmstadt in 1950 on « Die Klangwelt der elektronischen Musik ».

(15) W. MEYER-EPPLER, Sound-models produced in 1950 at Bonn with the Melochord. Broadcast on 18 October 1951 by NWDR (« Klangwelt der elektronischen Musik »).

The term « classic » used in this sense has no connexion whatsoever with any artistic evaluation, and refers only to the technical equipment and methods applied. I shall, however, be demonstrating in what follows that compositional and technical problems are very closely connected, and even that compositional-theoretical concepts can be hollowed out from the inside by the possibilities which technique has to offer if they have become meaningless once deprived of their necessity (16). The basic equipment of the classic studio includes sound generators, modulators, storage and playback devices. All the equipment is operated by hand. This results in a lengthy succession of relatively simple operations for the composer, and the work does not appear in its entirety until the very last moment.

There is hardly any justification today for this painstaking method of working, and many studios have abandoned it, on the one hand by veering towards live electronic music, which — regardless of one's Weltanschauung — is neither a technical nor a compositional solution ; on the other hand by gradual *automation*. This last makes it possible for work-processes to be speeded up, since various production operations can occur simultaneously ; for example, several parameters of a sequence of signals can be regulated together. If carried still further, automation even permits real-time reproduction of an entire work during its own production. For this of course comprehensive *programming* is necessary which, in its most advanced stages, will be possible only with a computer. But more of this later. It can be stated now that progressive technification does not mean that the composer's mobility is restricted — it can indeed be enlarged. Not only are his possibilities increased by the mathematical processes of computer technique, but he can also, if the equipment is suitable, simulate in the shortest time any conceivable acoustic event and test it as to its characteristics. This is a method which has always been highly esteemed and exploited by composers (Haydn and his orchestra in Esterhazy !), but which is hindered by the cumbersome techniques of the non-automated studio.

Studios in Europe which have been automated work with *voltage control*. This method makes it possible to automate a classic, conventional studio step by step, and can thus be used, as it were, in individual doses by composers of the most varying convictions. The technical procedure consists of controlling the individual pieces of equipment by means of direct electric voltages which can be altered continuously. In the simplest form, this can be done by hand, using a potentiometer. Instead of conventional apparatus such as oscillators, amplifiers, filters, etc., there is corresponding equipment whose output signal depends on the control voltage, e.g. frequency modulators, amplitude and product modulators, voltage-dependent filters, etc. Even with manual operation it is easy to modulate various parameters of a signal simultaneously.

(16) W. KAEGI, « Was ist elektronische Musik », Zurich, 1967, extended English version UE London, 1970. I pursue here and there the ideas expressed in this book.

The method therefore links directly on to techniques familiar to composers from the conventional studio, and enables them to hear the acoustic result of their operations immediately. Technically relatively simple and financially attainable, voltage control still makes radical automation possible, thus leading the way into a wide field of new ways of composing. For control voltages can be programmed, and they can be stored on tape like audio signals (although they must first be frequency-modulated), they can be reproduced (by means of demodulation) and transformed by conventional means (e.g. tape editing), but also by analogue computer technique methods. The production process has therefore moved from the plane of audio signals into that of *control signals.* For purposes of programming control signals, manual methods and the demodulation of audio signals can be left far behind by the use of *sequencers,* which supply a programmable series of control signals ; but punch-tapes, as in the former studio in Munich (now the Geschwister Scholl-Stiftung in Ulm) and digital computers can be employed. A versatile sequence was developed in the Institute of Sonology at Utrecht University in the form of a *variable function generator.* Basically it consists of 100 potentiometers to be set by hand, and which can be sampled step by step by means of an electronic switch (shift register). Switch frequency, number of steps and manner of sampling (e.g. free run) can be selected and permit series with $n \leqslant 100$ control voltages to be programmed.

It is obvious to think about practices in serial music, and it is conceivable that composers once wished for technical help which would have simplified the serial calculation of their works. But now, when this help is available, it would be stupid to make use of it in the conventional manner. In the meantime, technique has handed the composer the opportunity not only of treating duration, intensity and pitch systematically, but also timbre. So what would be the sense in having structures consisting of 12 sinewaves, sawtooth waves or noise-bands, all with the same envelope ? But there *is* sense in constructing a single envelope from the available control voltages, an envelope which the composer would never have been able to achieve by other means. There is also sense in using the programmable voltage series of the sequencer to produce sounds whose microstructure is precisely defined.

The programming possibilities of a sequencer could conceivably be extended even further ; but this soon involves prices such as those which must be paid for small computers. And such a computer can be connected by means of a converter to the entire voltage control network, making the highest degree of programming possible. Utrecht and Stockholm are the only studios in the European countries able to work with computers at present ; all other composers and studios wanting to work with computers are more or less dependent right from the start on free moments in the computer centres of universities and industry. This will have to change if serious artistic and scientific work is ever to be done in future. Composers and researchers will have

to have free access to their own computers at all times without having to queue. This can be done in England, where there is a computer-controlled studio for electronic music, built and run, astonishingly, by one composer on a private basis (Peter Zinovieff's studio in Putney, London, which also supplies studios with voltage-controlled and computerized equipment and the necessary software). As opposed to this, universities and radio in England have been completely inactive up to now.

There is no doubt that, of neccessity, the technique of programming always tends towards the computer as the most perfect means. This must not tempt us into thinking that the computer is therefore without further ado the ideal universal and composing instrument. Although its conception makes it logically perfectly capable of being such an instrument, the computer needs, in order really to be one, the knowledge, understanding and experience of the person using it. (The computer must also be told where and when it is to perform the random operations that have gained such fame in the world of music.) This kind of know-how exceeds by far the very summary knowledge of traditional musical theory that is especially poor with regard to psycho-acoustics ; it has always been possible to base this knowledge on the hereditary programmes, tested thousands of times, of its reproduction apparatus (instruments, groups of instruments, solo and choral parts, etc.). Things are different today. The naïvely optimistic post-war belief in progress is finished ; *we are now again at the beginning.* « It would be very odd if, within the next five years, any studio which became computerized did not arrive at the situation where no more hardware was needed. This is not to say that the problem is by any means solved — it is only the beginning, but it is in terms of the programmes and ways of thinking about synthetic music that advances will then be made. I do not think it can be over-emphasized how necessary it is to induce scientists to become deeply involved in these problems » (17).

Discussion

The majority of the problems in the relationship between music and technology can basically be solved ; matters of programming, of connexions between image and sound, of audiophysiology, of psycho-acoustics, and so on. Admittedly, these problems cannot solve themselves ; much ability and initiative are necessary to overcome them. Musicology had a real opportunity of renewing itself from the very core in the sense suggested by the great Helmholtz, but completely missed the opportunity. This increases the obligation of studios for electronic and concrete music to devote themselves not only to artistic production but also to systematic research. There are also

(17) P. ZINOVIEFF, « A Computerized Electronic Music Studio », *Electronic Music Reports* 1, Utrecht, 1969.

problems which, although basically capable of being solved, are closely linked with others, say social or political matters (e.g. music and mass media, music and cultural policy, or the simple question as to whether electronic music studios should be financed from public funds). Here it is all the harder to find solutions, the further the problems move away from objective considerations towards the thin ice of politics and diplomacy or into the jungle of prejudice and emotion.

One question stubbornly resists an answer : what is music ? There can be no answer to this. *What is meant to be music is conceived and fixed in each single case, and what is music can be heard when the works of the composers are played.* Experts on culture, university professors, directors of music departments in radio and television are ceaselessly teeming with ideas about what is supposed to be music (cultural politics, music philosophy, programme arrangements) ; every vocal or instrumental ensemble does the same in its own fashion, as does every symphony orchestra, not to mention its Napoleons. Composers, too, conceive, fix, give music a possible meaning. The post-war generation wanted to see music understood as algorithms, and there was also talk of an information exchange. Today music ought to be understood as a dialogue, as a mediator of contacts, as an urge towards activity, towards meditation, or simply as sound. What music actually *is* today, however, cannot be clear until the compositions are heard.

If we try to make a forecast for the relationship between music and technology for the future, we are forced to do so according to a possible model of what music could be. We must not overlook the fact that the field of all possible concepts of music is logically neither limited nor can it be staked out in an arbitrary fashion. In this context it appears to me to be worthwhile to define music as a *message,* with the intention of making this the basis of an attempt to find out what music can be at all. For any conclusions at which we might then arrive must surely give us information about the combination of music and technique. Music causes *information* to be exchanged, of that there is no doubt. If we disregard the logical space which must always surround an exchange of information by means of music, the listener's *uncertainty* can still be reduced at least by the information, « now sound » or « now no sound », or at any rate by the information : high, low, soft, loud, bright, dark, long, short.

Compared to the expenditure, this is admittedly a very slight exchange of information, but it is incontestably an exchange. It can be increased if people communicating with one another have a common stock of symbols of whose power they are aware. We shall use the three symbols I, K and L. The recipient can now conclude from the information I that I is meant, but also that K or L are not meant. If he did not know the power of the store of symbols, he might just as well conclude from I the negation of any other object, or the symbol representing it (e.g. not the Eiffel Tower and not Bangkok either and not...).

It is a good idea to restrict ourselves here, however, to musical categories. If transmitter and receiver both know the same *rules,* the information exchange can be increased further ; for example, the information « 6/8 measure » makes the musician think of 2×3, but not of 3×2, which would be difficult for a mathematician to see. Or when listening to a fugue : now Dux, so Comes must follow, from which it is possible to derive any number of predictions. The work of Bach makes it possible to judge the extent to which music can be operated as a logical language (18). Of course, Bach's logical networks are child's play compared to the logical inventions of the circuits of contemporary technology. It is thus impossible for this alone to be responsible either for the sublimity of Bach's fugues or for the value of European music.

In this context reference is often made to the *direct* effect of music on people in the sense that something other than exchanged information is meant. Even the simple examples of inexterminable martial music, but also of primitive dance music, show that information is exchanged without, of course, the recipient's being free to decide whether to accept or reject it. Music of this type goes to the feet. If this were the only kind of effect of which it could boast, there would be an exchange of information, but the music would have to be regarded as both incredibly primitive and dangerous to the common good, since it would be used for no other purpose than that of conditioning people and — against their own will — of abusing them. This is what Plato meant. This aspect of music, blown up into world-wide proportions by the means of technology, is exploited to a huge extent ; there is no escape today from the dangerous and levelling influence of the loudspeaker (19). (During a recent journey to the Far East, on which I wrote most of this study, I was regaled in Japan, Hong Kong, the Philippines, Thailand and India with the same music which I cannot escape in Europe.) *Artistically* seen, the number of direct effective mechanisms is so limited, though, that it is not even sufficient for the simplest piece of music.

We have a fragmentary comprehension of what music can be ; but we know that music goes far beyond this. However, I must point out here that the most penetrating structural analyses, blown up by scientific superstition and presumptuously presented to us, are based on nothing more than this type of fragments. Even the simplest configuration looks extremely complex if it is to be presented to anyone. (Anyone who has written programmes for the computer can write reams about that.) In terms of sounding music, however, the mountain has given birth to a molehill. From this we must conclude that the

(18) W. KAEGI, « Die simultane Denkweise in J. S. Bach's Inventionen, Sinfonien und Fugen », thesis Basle, 1951.

(19) A. HITLER, « Ohne Kraftwagen, ohne Flugzeug und ohne Lautsprecher hätten wir Deutschland nicht erobert ». (« We should not have conquered Germany without the automobile, without the airplane, without the loudspeaker ».)
Manual of the German Radio, 1938-1939.

chief effects of music are to be sought in *redundancy,* that is in the amount — seen in the light of the established logical function of music — of the symbols not used. It is interesting to observe, though, that musical works are always exposed to the temptation of being subsequently explained by means of an extension of their established logical conception, in a desire to reduce the redundancy of their symbols. No matter how much western ideas flee behind a veil of secrecy as soon as the words « cultural values » crop up, the Cartesian origins of these ideas take offence at leaving things unexplained logically.

However, I feel that such efforts go far from their mark because of music's complexity, for they ignore the *logical space* in which every exchange of information is of necessity situated. We are familiar with the antipathy, also in the case of the musician, against everything « technical » in music (although as I have already shown, gramophone records and radio are willingly accepted as « not belonging to music »). The concept of technology still acquires its meaning for most people from statements which connect everything technical with the cumbersomeness and brutality of iron and steel, with the stubborn stupidity of imperfect machines and the threatening danger of high-voltage transformers. If a piece of electronic music is heard, no matter if it is as clearly and lucidly conceived as a Haydn minuet, and no matter how lightly it makes its progress, its redundancies are infallibly enriched by meanings whose selection, coming from the listener's logical space, is defined by the keyword « technique ». The meanings will of course change with time, for the experience that technique has developed from its inflexible beginnings, when it had to represent bone and muscle, into the incredibly subtle differentiation of a nervous system, this experience will gradually make its mark on the concept of technique in future. The redundant signs of music will then be given other meanings from the logical space surrounding them. According to reports from the tenth century, the organ at Winchester roared like lions at the people of that time, and Rossini, Berlioz and Wagner are supposed to have made shrill clamour with whistles and thundered with canons like Nelson's heroes and the Grande Armée.

It is necessary for our train of thought to establish that music appears to occur mainly in a sector in which it has to be redundant, regarded in the light of its intentional logical conception. The artist is obviously capable of formulating information which on the one hand is so complex that its logical construction can *not* (or perhaps not yet with our present-day means) be completely analysed. On the other hand its information contains enough redundance to provide the recipient with a chance of obtaining contexts of meaning from the logical space whether these be generally established or individually formed. One does not have to be gifted with a vivid imagination in order to see the incredible complexity which a network of logical relationships of this kind must have, and it can definitely be assumed that

such a network contains all the nuances from confused, emotional complexes to the lucidity of what can be completely analysed logically.

Prospects

In what way can music, seen as a possibility in the sense described, be influenced by technology ? In opposition to prevailing opinions, I tend towards the view that the music of the pre-electro-acoustic age has few chances of survival. Just as the soirées of the ancien régime have disappeared, just as one no longer goes to the opera every evening to meet others, the bourgeois concert hall of the nineteenth century will also gradually disappear or lose its significance to an increasing extent, and atrophy into a museum-like sanatorium for a past culture. Big television orchestras and an increasingly huge gramophone record industry satisfy the demand for works of classical music by means of recordings and reproductions, and their activities will be even more securely underpinned by market research and advertising than is the case right now.

I feel that it is unjust to put the blame for this development on technology, as Sir Thomas Beechman did in 1928 : « If the wireless authorities are permitted to carry on their devilish work, in ten years' time the concert halls will be deserted » (Musical Times) (1). Not only has this prediction not been fulfilled, technology is not at all the cause, but an expression for the enormous change which is taking place now in man's social development. We must also recognize that we owe the benefit of outstanding reproductions to technology in cases where there is a danger of our losing the originals for ever. In any case I should like to quote Ernest Ansermet's more optimistic view, since it formulates an idea which is widely accepted and has been received in cultured circles with warm understanding :

« Dans sa *Psychologie de l'art,* Malraux met en évidence ce fait que l'institution des musées ainsi que la reproduction photographique des œuvres plastiques ont créé un rapport tout nouveau entre l'homme et l'art, car au musée comme dans la photographie, l'œuvre apparaît détachée de sa fonction pratique, du cadre historique où elle est née, et ne se présente plus que pour sa valeur propre, en tant que témoignage humain. C'est le sort que l'évolution du concert a fait aujourd'hui à la musique. Le concert — et l'émission symphonique par radio en est un — n'est plus, comme il a été autrefois, l'expression musicale d'un certain moment historique ni d'un cercle de culture fermé ; il puise sa substance dans un immense horizon de temps et d'espace et en vue d'un auditeur indéterminé. De ce fait, plus rien ne justifie les œuvres que leur valeur propre. C'est là une vue un peu trop absolue de la situation et qui, pratiquement, doit faire la part de certaines contingences,

mais c'est la vue qui s'impose » (20). A few remarks must be made to that :

(a) « Emission symphonique par radio » is placed on the same level as the concert, which establishes a different concept of what music ought to be from that which the composer of the pre-electro-acoustic age can have established for his work : one-way transmission now takes the place of two-way communication in the concert-hall.

(b) The recipient is no longer an element of a closed circle, but the message is now disseminated « en vue d'un auditeur indéterminé ». Music as a logical language, but especially as a logical game, is reduced to a minimum because neither a common stockpile of symbols nor common rules for receiver and transmitter can be the premise any longer, but there can at the most be the hope that there is a slight probability of this.

(c) The logical space in which the exchange of information is placed is no longer defined by a particular historical framework (and not by the image of the realization into sound either) but it now appears to have been generalized to a wide, abstract horizon of time and space. The redundant signs of music (and there are lots of them in the abstract position of things !) will also therefore of necessity be given different meanings.

(d) The shifting of the relationships will result in the work's emergence as a purely human testimony, liberated, as it were, from its historical ashes. We can, however, really just come to the conclusion that a network of sensory references must occur in the recipient which are different from those in the concert hall. This new set of sensory references, however, obtains its essential contents from the circumstance that today most listeners at the loudspeaker still have memories of the concert hall and thus associate with it. When memories and knowledge of symbols and rules will one day have melted away, the test will have to be made as to whether information from a different age can be decoded and given contexts of meaning.

Radical interference in information transmission will also occur in contemporary and future music whenever something other than what actually happens is pretended. In such cases, unfortunately, technique will always be given the blame, which should really be attached to the composers alone. For whether one speaks of the concert hall and really means radio and gramophone records and the like, or vice versa, in any case the exchange of information is greatly impeded, if not rendered questionable, by (a) the logical conception of the work being rendered unintelligible or even being completely disavowed by the

(20) E. ANSERMET, « Les programmes symphoniques aujourd'hui. La Radio, déesse au double visage », Geneva, 1951.

composer, (b) the recipient being misled because of incorrect data, which makes extremely questionable the already very feeble remnants of a « linguistic » understanding by means of music, (c) the intentional placing of the received information in a logical space which is defined by incorrect data on the part of the transmitter. I feel that the term « mendacity » can well be used here.

Where this kind of mortal sin is not committed, I see no reason why technique should harm music in any way ; quite the contrary in fact. Technique provides the composer with hitherto unknown means of realizing his musical ideas, and offers him new ways of making contact with his hearers. But above all technique is the *only* means which gives the composer a chance of freeing himself from the fatal embrace of technique.

WERNER KAEGI

TRANSLATIONS

I We should think that we had reached the limits of human happiness and should have ceased striving towards more improvements if we could invent a device which would send music into everyone's home.

II Whether radio should only offer an alternative to concerts and opera, or whether it should arouse new creative force ?

III Of making young musicians so familiar with the limits, characteristics and possibilities of radio that they can arrive at music resulting from the meaning, spirit and technique of radio.

IV Also resort to electrical sound production.

V Suddenly one day it became clear to me : that the development of music is foiled by our musical instruments.

VI What we need is an intrument that can give us a continuous tone on any desired pitch. The composer and electrical engineer must work together towards this end. We just cannot afford to go on working with the old timbres of the classical school. Speed and synthesis are the characteristics of our age. We need instruments of the twentieth century in order to realize these in music.

VII Every tone which our fantasy can imagine can also be realized by us, we can control its timbre, intensity and pitch exactly and thus open up new sound sectors.

VIII They are based on differing premises and arrive at different results. But all programmes have in common that the composer must provide a minimum of data with which the computer can then deal freely (by means of random decisions) and, if possible, a minimum of combinatorial rules too, so that not everything is left to chance. The more exact the data and rules are, the easier it is to predict the result, and chance is given less of an opportunity to exert its influence. But this

does not mean that the composer could calculate the result just as easily without the computer ; he might very well be prevented by the amount of data, the many-sidedness of the relationships, the amount of written work to be done. It is also common to the various programmes that they compel the composer to think in a certain way and to formulate his musical ideas in a particular, often unaccustomed manner. Whoever composes with a computer will not have to keep on changing his musical ideas, but will certainly see them increase. Musical contexts will now no longer be realized in each separate case, but postulated in a generalized form. The computer output is the proof of the pudding.

EUROPEAN STUDIOS

BELGIUM **Brussels,** Inst. Nat. de Radiodiff. INR/Studio de Mus. Electr. BIMES/Studio de Mus. électr. de Bruxelles APELAC ; **Ghent,** Inst. voor Psychoakoestiek en el. muziek IPEM.

FEDERAL REPUBLIC OF GERMANY **Berlin,** Studio TU ; **Bochum,** St. f. konkr. u. elektr. Mus. ; **Cologne,** St. f. elektr. Mus. Staatl. Hochschule/St. f. elektr. Mus. WDR ; **Ulm,** Geschw. Scholl-Stiftung.

EASTERN GERMANY **Berlin,** Exp. St. f. künstl. Klang-u. Geräusch-erzeugung d. Deutschen Post.

ENGLAND **Diss,** Tristram Cary ; **Cambridge ; London,** Peter Zinovieff, Putney/Goldsmith's College.

FRANCE **Paris,** Groupe de Recherche de l'ORTF/Studio APSOME.

NETHERLANDS **The Hague,** Studio Raaijmakers-Boerman ; **Utrecht,** Inst. of Sonology STEM/Studio Ton Bruynèl.

ITALY **Florence,** St. di Fonologia Musicale ; **Milan,** St. di Fonologia della RAI ; **Padua,** St. di Fonologia Musicale ; **Rome,** Mus. Elettr. Viva/Studio G7.

POLAND **Warsaw,** Studio eksperymentalne.

CZECHOSLOVAKIA **Bratislava,** Experimentalne Studio Radio Br. ; **Brno,** Elektroniche Studio Ces. Radio ; **Prague,** Elektr. St. Ces. Radio.

SWEDEN **Stockholm,** Elektronmusikstudion Sveriges Radio EMS.

SWITZERLAND **Geneva,** Centre de Recherches Sonores (CRS) de la RSR.

For works compare « International Electronic Music Catalog », **Electronic Music Review** Nos. 2/3 1967, M.I.T. Press Cambridge Mass. and London.)

WERNER KAEGI is a composer, living in Zurich, Switzerland. His recent composition, HYDROPHONIE I, created in the studios of the Utrecht Institute of Sonology, was presented at the Fylkingen concert. Mr. Kaegi composed the electronic music presented in the Swiss pavilion at the Osaka world fair.