I. Introduction

This is a report of a trip I made to Europe in the fall of 1961 to familiarize myself with recent developments in the following aspects of contemporary music:

(a) New music, both instrumental and electronic. Since the end of World War II, a great change in compositional style and technique has occurred in Europe. Younger composers of the "post-Webern" school have become a dominant force in European music circles and yet few of their scores have been heard so far in this country. One objective was to hear some of this new music at concerts, especially at contemporary music festivals, and to discuss this music with its composers as circumstances might permit.

(b) Electronic music studios. I planned an itinerary that would permit me to visit almost all the studios for electronic music in Europe. My purpose was two-fold: First, to see their equipment and to assess it in terms of our needs here in our own electronic music studio at the University of Illinois. Second, to hear new electronic music and to acquire tapes, articles and other material for our collection whenever this was possible.

(c) Recent computer music studies. Reports of a number of recent investigations of the use of computers to compose music and of studies of applying information theory to the analysis of music had come to my attention recently. Consequently, a further objective was to discuss these matters first hand with the persons involved to obtain accurate recent information. Little concerning this type of work has yet been reported in the literature. This also included a visit to Bell Telephone Laboratories, Murray Hill, New Jersey at the termination of the trip.

(d) To present through lecture-demonstrations some of our recent work under the following general topics:

(1) Recent developments in American electronic music
(2) Musical applications of electronic digital computers
(3) Information theory and music

I gave presentations on topics (2) and (3) in Warsaw, Poland on Sept. 23 and Sept. 25 under the auspices of the University of Warsaw and the Electronic Music Studio of Radio Polskie; on topic (1) at RTF (Radiodiffusion-Television Francaise), Paris, France on Oct. 3; on topic (1) at Amerikahaus, Berlin, Germany on Oct. 17; topic (2) at Amerikahaus, Hamburg, Germany on Oct. 19; topic (2) at SWF (Südwestfunk), Baden-Baden, Germany on Oct. 24; topic (1) at Amerikahaus, Stuttgart, Germany on Oct. 25; and topics (1) and (2) at Cambridge University, Cambridge University, Cambridge, England on Nov. 3 and Nov. 7, respectively. In addition, I prepared a short discussion of computer music for INR (Belgian Radio) in Brussels that was supposed to be broadcast at a later date. I also made arrangements to publish one or two articles on our recent work in European music periodicals.

With this general outline in mind, I will describe below those aspects of European contemporary music that are in accord with the above set of objectives. The arrangement following, of course, does not follow the chronological order of the trip but is arranged into appropriate topic groupings.

II. Recent European Music

The beginning of the twentieth century is often considered an important turning point in the history of musical expression because it represents the close of the Romantic era and the point at which the major-minor system of tonal writing ceased to be the only recognized system of structural logic. The major composers of the first half of the twentieth century gradually replaced obsolescent attributes of Romantic style and expression with new techniques of composition. Since this story is so familiar, I do not need to discuss it here. Rather, for the present report, I will take the close of World War II as another possible breaking point in European art music, perhaps also of considerable impact on developing historical style.

The particular changes that have preoccupied the new European "avant-garde" have thus far had relatively little parallel in the United States. In Europe a group of younger composers, now mostly in their thirties, dominate the more "advanced" European musical manifestations; because their activities are highly publicized and of great influence, it is important to assess some of the reasons why and to attempt to evaluate their work provisionally, particularly because much of the recent interest in experimental style and technique that existed in the United States now seems to have reverted to Europe for reasons that are not entirely purely musical.

A. Change in Style and Aesthetic

The generation of European composers following that of Schönberg, Stravinsky, Bartok and Webern, a group of men now in the fifty-to-sixty years old group, failed with few exceptions to establish a position of comparable importance to those older men. Although some of these composers, notably Olivier Messien in France, Boris Blacher in Germany, and Luigi Dallapiccola and Goffredo Petrassi in Italy have

written interesting and perhaps significant music, the leadership in new ideas was taken instead by composers still a generation younger. Only Olivier Messien among the older men seems to have had much influence on this younger group and that in large part through his function as a teacher of composition in Paris. These younger composers write music that has certain attributes more-or-less in common, of which the following are perhaps the most characteristic:

(1) The music of Anton Webern considered the ideal prototype. Webern was little known or understood and without significant influence prior to his death in 1945. In the post-War period, however, his music, though still infrequently played in ordinary concerts, has become the point of departure for much new music, so much so that one speaks today of a "post-Webern" style of composition. This new style takes over and extends salient features of Webern's style, namely, atonality, serialism, pointillistic texture, non-harmonic structure but only sometimes brevity. More traditional sttributes of music such as tonality, harmonic drive, melodic line as ordinarily conceived, conventional forms like sonata and fugue, are totally rejected.

(2) Total organization. Up to about 1958 at least, serialism became virtually the only acceptable organizing principle for musical structure at least among the "avant-garde" in West Germany, where this revived interest in serialism led to particularly dogmatic stylistic attitudes. In compositional practice, total serialism was evolved in Europe by taking Olivier Messiaen's "serial rhythm" concept of the late 1940's (1) as a point of departure and developing it to the

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(1) O. Messiaen, Technique de mon Langage Musicale, A. Leduc, Paris, 1949.

point that a series of numbers is permitted to determine all the usual aspects of a compositional structure. Thus, a sequence of twelve integers associated not only with pitches of the scale but also with other parameters such as rhythms, dynamics, instrumentation, tempi, and so forth, are utilized to build up a total sound structure. It has been claimed that the first totally organized composition is Pierre Boulez's Polyphonie X. Actually, however, as recently pointed out by Allen Forte (2), total serialism was developed by Milton

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(2) A. Forte, "Review of Since Debussy: A View of Contemporary Music, by Andre´ Hodeir, transl. by Noel Burch, Grove Press, Inc., New York, 1961," J. Music Theory, 5:144, 1961.

Babbitt in this country some years before Boulez, a fact that European musicians seem unwilling to recognize. In any event, one of the best-known examples of such "totally organized music" is Structure for Two Pianos--Book I, written in 1955 also by Boulez (3).

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(3) This composition, published by Universal Edition, is analyzed in detail by G. Ligeti, "Pierre Boulez," Die Riehe, 4:36, 1960. It is performed by Alfons and Aloys Kontarsky on Vega C30A278, 12" LP Record.

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(3) Music by chance procedures. At the Darmstadt Ferienkurse in 1958, John Cage gave a series of seminars and demonstrations that made a strong impression primarily because his aesthetic is precisely the opposite of "total organization," i.e., essentially "total disorganization", as used in his "I-Ching" and other chance music. Many European composers have subsequently abandoned the rigid restrictions imposed by total serialism, so that in very recent music, one observes the incorporation of many of his ideas of chance combinations, chance methods of composition and of chance methods of presentation.

(4) Neo-impressionism. I employ this term to characterize an increased interest in sound texture as such. It incorporates an extension of Schönberg's and Webern's concept of klangfarbenmelodie and a revived interest in the music of Debussy and, more recently, of Varèse. Unusual instrumental combinations, both of chamber music and orchestral size that frequently emphasize percussion and wind instruments have become almost the norm. New playing techniques are explored that take advantage of the fact that a considerable group of instrumentalists of exceptional technical facility regular perform at festival concerts.

(5) Use of electronic techniques. Almost all these composers have used (or would like to use) electronic means, either to produce electronic sounds or sound transformation into instrumental textures. Thus, the use of one or more tracks of tape-recorded sound, either electronic, concrete or instrumental in origin is becoming common, either as is, or presented in combination with instrumental performance. Since the investigation of European electronic music was a particular purpose of my trip, I deal with this topic separately in Part III later.

B. Composers and Audience

Musical activities involving the more experimental types of music are concentrated to a considerable extent today in West Germany, because this is the one country in Western Europe where writing music possessing extreme style and preferably even sensational attributes seems to be a paying proposition. "Advanced music" is very much dominated by two composers, Karlheinz Stockhausen and Pierre Boulez, whose music and ideas are systematically promoted with great thoroughness by commercial and professional interests such as music publishers, music periodicals, the government radio stations, and so on. I have heard enough of the music by these two particular composers to concur in the opinion that some of

their music is very interesting. However, they are by no means the only talented composers with new ideas working in Europe today. Moreover, although I will concentrate in this report on the more experimental type of music, it is necessary to emphasize in order to present a balanced picture, that more traditional music, some of it also interesting, is also of course still being written today in Europe.

In Europe, normal concert programming, derived almost entirely from the "standard repertory", is most often hackneyed and sterile just as in this country, and excludes most new creative work in musical composition. The average ordinary concert audience, most music critics and most performers, in Europe, just as here, are hostile to new music. Consequently, this outlet for new music is largely closed to the more controversial or experimental type of composers. However, certain other opportunities exist at least for certain younger European composers that place their works in at least limited circulation.

West Germany, in particular, is the focal point for these activities for several reasons I shall enumerate. In so doing, I shall note that this situation has also been recently discussed by Gunther Schuller (4) in enough detail so that I need only comment on it briefly.

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(4) G. Schuller, "The New German Music for Radio," Sat. Rev. of Lit., 45: No. 2 (Jan. 13), 62-65 1962. Schuller's opinion of German musical activities, incidently, is quite negative.

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(1) In Germany, government subsidization, largely through the government owned and operated broadcasting network (Westdeutscher Rundfunk in Cologne, Norddeutscher Rundfunk in Hamburg, Südwestfunk in Baden-Baden, etc.) provides large sums of money for the presentation of music--again including

much new music. The musical director of a radio station has become a powerful figure who can commission new compositions, not only paying composers substantial sums of money for their work, but also covering the costs of production. An extreme but nevertheless illustrative example of this was the presentation by Norddeutscher Rundfunk (NDR) in Hamburg of a Stockhausen's composition for four orchestras, in 1960; a production I was told cost more than DM 100,000.

(2) The existence of periodic music festivals for contemporary music, some of which are organized in conjunction with courses of study and seminars. Many new compositions are regularly presented at these various festivals and exhaustively reported on and reviewed. This is advantageous to the younger European composer because it means that his scores are brought to the attention of music publishers, quite possibly published and then displayed at contemporary music festivals, brought to the attention of possibly interested performers, critically reviewed, and distributed throughout the world. For example, many such published scores are purchased by our music library at the University of Illinois.

(3) A number of periodicals in Europe afford the European composer a chance to write about contemporary music, either analytically or polemically. Influential periodicals include Die Reihe, published by Universal Edition, primarily an organ for the promotion of serial music, Gravesaner Blätter, a more technical publication underwritten and edited by Dr. Hermann Scherchen, Melos, a magazine on contemporary music edited by Dr. Heinrich Strobel, the music editor of B. Schott Söhne as well as a director of the Donaueschingen music festival.

(4) Recordings of new music by commercial record companies has been carried out to a limited extent, particularly of electronic music. In Germany, however, the record companies have not been too venturesome on the whole, in fact, notably less so than record companies like Vega in France or Columbia or CRI in the United States.

(5) A final point not to be underestimated is the relatively compact area within which most significant musical activities take place in Europe. Germany is more or less at the center of this area. This permits the development of a specialized audience for contemporary music drawn from various European countries that can attend, without undue travelling and expense, the major festivals of new music that periodically take place. A similar audience cannot be created in the United States simply because the population from which it must be drawn is too dispersed. This situation has its obvious dangers of course, too. A portion of this audience is faddist. Another portion is made up of people with vested interests in the situation,--publishers, radio station programming directors, and so on. That all this can be destructive to the free development of musical ideas need hardly be commented on. Again, in the distribution of commissions from the radio stations, in the question of who gets his music published and performed all sorts of abuses can and undoubtedly do occur. On the whole, however, there seems little reason to suspect that this aspect of the situation is any worse than what goes on in the United States.

With respect to Germany specifically, the amount of new music performance, the kind of music performed, and by whom is most easily seen in a new documentary publication now issued annually (5).

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(5) Neue Musik in der Bundesrepublik, Vol. 1 to 4 (to date), Bärenreiter Verlag, Kassel

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With regard to the most other countries of Western Europe, the same general situation prevals though in much less extreme form. The other countries with significant activity in new music include France and Italy, principally, and to a much lesser extent, England, the low countries and the Scandinavian countries. In France, a great deal of financial support is provided in particular to Pierre Schaeffer and his research group located at Radiodiffusion-Television Francaise (RTF). Both RTF and RAI (Radio Italiano) underwrite contemporary music activities, including festivals. In the rest of Western Europe, the contributions of new musical ideas from places like Spain and Portugal, Greece and other similar more peripheral countries seems to be almost nil.

The Eastern European countries constitute a somewhat special problem. In Poland, since the 1956 Posnan riots that placed the present Gomulka government in power, considerable artistic freedom is permitted (except for overtly political topics). This has led to a remarkable amount of creative activity in composition that is advanced in style and much influenced by the West. This apparently provides a stimulus for new ideas to percolate into other Eastern European countries such as Hungary and Czechoslovakia, where the regimes and the cultural activities are still much more restrictive, and perhaps even eventually to Russia--assuming that amelioration of the total political situation gradually occurs.

C. Festivals and Conferences

There are certain festivals of contemporary music held periodically in Europe to present concerts and in some instances seminars, lectures and conferences devoted to new music. On my trip, I attended three of the best-known of these festivals, namely, at Darmstadt, Donaueschingen and Warsaw. In addition, in Paris I attended one of Les Domaines Musicales, the series of four concerts of contemporary music conducted each year there by Pierre Boulez. This year the series consisted of one retrospective program of Stravinsky's music (the concert I heard), one retrospective program

of Schönberg's music and two programs containing an assortment of newer music. An important by-product is a series of records issued by Vega records under the general series "Presence de la musique contemporaine." Several records in this series present performances deriving from Les Domaines Musicales (6).

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(6) Vega-C30A65, music by Henze, Messiaen, Stravinsky; C30A66, music by Boulez, Nono, Stockhausen, Webern; C30A67, music by Boulez; C30A120, music by Stravinsky, Webern; C30A139, music by Berio, Boulez, Messiaen, Stockhausen; C30A278, music by Boulez, Kagel, Pousseur, Stockhausen.

I shall describe briefly each festival I did attend and also just remark in passing about several other events of roughly the same type.

(1) Internationale Ferienkurse für Neue Musik, Darmstadt, Germany. This annual event has become probably the most influential contemporary music manifestation in Europe, both because of its scope and because it is around its study program and concerts that much of the activity that has led to the "post-Webern" style of composition has been organized. Darmstadt has been dominated by musicians like Stockhausen, Boulez and Bruno Moderna, and more recently, David Tudor. Much of the early history of this annual event has been described in recent publications (7).

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(7) See, for example, A. Golea, Rencontres avec Pierre Boulez, Rene Juillard, Paris, 1958.

These Ferienkurse were inaugurated in 1946 and are run by the Kranichsteiner Musikinstitut, Roquetteweg 31, Darmstadt, the director of which until recently was Dr. Wolfgang

Steineke.* The institute, incidently, is also organized to maintain an extensive library of scores, disk and tape recordings, and books and periodicals on twentieth century music. A catalog of its contents is available (8)

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(8) W. Steineke, (ed.), Katalog, Kranichsteiner Musikinstitut, Darmstadt.

The institute also publishes an annual monograph made up of articles mostly projecting what might be called a "Darmstadt aesthetic." Thus far, four volumes of this annual have been published (9).

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(9) W. Steineke (ed.), Darmstädter Beiträge zur Neuen Musik, B. Schott's Söhne, Mainz. Vol. 1-4 (to date).

The Ferienkurse itself takes place in the summer (in 1961, from August 28 to Sept. 9). It is organized in terms of a set of concentrically disposed activities as follows:

(a) A series of seminar courses for students that occur each morning and afternoon, held at the headquarters of the festival proper, the Klubhaus, Dieburgestrasse 241 or nearby. These seminars deal with composition, analysis and performance of contemporary music. Students register for these course for which they pay a fee. Many younger European composers now getting performances of their music have enrolled in these courses over the years.

(b) A limited number of less technical public lectures open to all people attending the festival given by well-known musicians or critics such as, this year, Boulez,

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*Dr. Steineke was killed in an automobile accident in December 1961 after my visit.

Stockhausen and Theodor Adorno.

(c) A series of orchestral and chamber music concerts open to the general public that constitutes the contemporary music festival proper. These are mostly given in the "Mathildenhöhe" not far from downtown. It is here that many new compositions, commissioned by the Ferienkurse, are first performed. Of essentially new pieces performed this year, there were several compositions that I felt were of more than routine interest, specifically Earle Brown's Available Forms, Bo Nilsson's Scene III for Chamber Ensemble, Stockhausen's Kontacte for Tape, Piano and Percussion, and Olivier Messiaen's Oiseaux Exotiques.

An extensive display of contemporary scores published by organizations such as Universal Edition, Schott, Peters and Boosey and Hawkes, is set up at this festival. I noticed very little American music except for a few recent publications of music of John Cage, Chou-wen Chung and Earle Brown.

(2) A second important German contemporary music festival is the Donaueschinger Musiktage. This well-known festival is much more modest in scope because it lasts only one weekend and consists solely of two concerts plus a lecture. Donaueschingen is a small town in southwest Germany reached by rail from Freiburg. The Südwestfunk orchestra directed by Hans Rosband comes to Donaueschingen for the orchestral concert. The history of the Donaueschingen festival is reviewed in a small book (10).

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(10) M. Rieple, Musik in Donaueschingen, Rosgarten Verlag, Konstanz, 1959.

The artistic directors of the festival are Dr. Heinrich Strobel and Hans Rosband. Like the Darmstadt festival, the Donaueschingen festival has attracted much attention because of the commissioning of new works and many famous modern "classics" have had their first performances here. Of the new compositions played this year, I found György Ligeti's Atmospheres for Orchestra and Boulez's Structures--Book II for Two Pianos the most interesting on first hearing.

(3) Warsaw Autumn. Each fall since 1956 and the establishment of the Gomulka regime, a festival of contemporary music has taken place in Warsaw. This is the Warszawa Jesien, the only major musical event in Eastern Europe in which significant developments in contemporary Western European music are heard by Eastern European audiences. As has been documented elsewhere (11), the Gomulka government

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(11) See, for example, C. R. Barnett, Poland, Its People, Its Society, Its Culture, Grove Press, New York, 1958, or any of several periodicals devoted to Eastern European affairs.

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has sought "a middle way" that has led, to the granting of a considerable degree of freedom of artistic expression to Polish artists. Art is, of course, government subsidized in Poland, but although apparently the government is permissive rather than enthusiastic about new artistic ideas, it does not impose restrictions on expression so long as it is not too highly critical of the government or its idealogical basis. Consequently, Poland uniquely among the Soviet dominated Eastern European countries, has been thrown open to Western ideas that have stimulated, in music, a very progressive school of composition that includes among its manifestations a studio for electronic music (see Section IV). The annual Warsaw Autumn is another important activity, because not only is new Polish music performed there but also much "advanded" Western music,

This has served to free Polish music from the Soviet aesthetic dogma of "social realism" that had had the same reactionary and stultifying effect on music as on the other arts. Moreover, this same change hopefully can be expected to have, sooner or later, an effect also on other Eastern European composers, who attend the Warsaw festival in large numbers from Czechoslovakia, Hungary, Rumania, Bulgaria and Russia itself.

In many ways, the Warsaw festival had the most balanced set of programs of the festivals I attended. There was a fair amount of music from Russia and Eastern Europe, not much of which was of more than cursory interest, much new music from Poland of course and also a large amount of recent music from Western Europe. Performers from Western Europe as well as Poland and Eastern Europe performed in the concerts. However, the only American music played was Cage's Fontana Mix, and some pieces by Varèse. I was told that the difficulty of obtaining American music and information about American music was the principal reason for this.

Among the Polish compositions I head, I thought the following were the most interesting on first hearing: Jeux Venitiens for orchestra by Witold Lutostawski, Poland's leading composer, Vers for piano and orchestra, by Boleslaw Szabelski, a very good piece by an older composer who has kept up with the times, Threne aux Victimes de Hiroshima for string orchestra by Krzystof Penderecki, a talented younger Polish composer with a rapidly growing reputation. Other younger composers of promise are Wlodzimierz Kotónski and Henryk Gorecki, several of whose compositions I have heard. Other compositions played at this festival that interested me included Petrassi's Concerto for Flute and Orchestra, Egisto Macchi's Composizione III, and because of our interest in it for possible computer programming, Boulez's Structures--Book I for Two Pianos.

In addition to these festivals, there are a number of other festivals and conferences that occur regularly. One French festival is the Festival d'Aix-en-Provence with its associated Centre Francais d'Humanisme Musical, organized by André Jolivet. This festival and conference took place in July, too early for me to attend this year. It should be noted that Michel Phillipot and Abraham Moles participated in this conference, both of whom I met later in Paris (see Section V). I also was too late to attend a conference on Music and Mathematics from Aug. 9th to 12th which was organized at Gravisano, Switzerland by Dr. Hermann Scherchen to which I was invited but unable to attend. Papers were given at this conference by Abraham Moles, Michel Phillipot and Yannis Xenakis from Paris, Professor Wilhelm Fucks from Aachen and Newman Guttmann from Bell Telephone Laboratories. The various papers read at this conference have since been published as a group in a recent issue of the Gravesäner Blätter (12).

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(12) Gravesäner Blätter, 23/24:1962

Moreover I have since been able to see all the people involved in this conference to discuss their ideas with them as described in Section V later.

Two well-known festivals and conferences series take place each year in a different location. One of these is the ISCM contemporary music festival, which occurred this past June in Vienna, and will take place next June in London. This long-established festival presents music from many countries including the United States, but as far as I know, music from the United States is chosen by the New York City section of the ISCM, the only chapter in our country that is at all active any more.

Something new is a proposed Biennale de Musique Contemporaine, organized principally by Pierre Schaeffer and RTF. This festival and conference is planned to occur every two years, each time in a different location. This plan was developed at conferences scheduled by RTF such as the Festival de la Recherche, organized by Schaeffer in Paris in June 1960. The first Biennale took place last June in Venice.

A technical conference on electronic music was organized at the same time, to which directors of electronic music studios were invited, including Schaeffer, of course, Alfredo Lietti from Milan, Herbert Eiment from Cologne, Dr. Ludwig Heck from SWF, Baden-Baden, Dr. Vermeulen from Utrecht, and Jozef Patkowski from Warsaw (see Section IV for description of each of these studios). A series of topics were organized, namely: (1) Recording techniques and standards, (2) Spatialization, (3) Special apparatus, (4) Studios. This became the basis for a further conferences that took place in Paris on October 3rd through 6th this year, which I attended. At this fall conference, among other things it was decided to have the first Biennale in Paris, probably in January 1963. Again both concerts and technical seminars would be organized. Schaeffer is interested in considering contributions from our studio on these programs, (see also Section IV).

Finally, the only regularly scheduled contemporary music festival and conference that occurs in England that I know of is the Dartington Summer School in Dartington. Since this festival takes place in July, I did not have a chance to visit it. I obtained my information from Marc Wilkinson, a young English composer who has taught there several summers. This summer school is apparently the principal event in England where new music is played and new ideas in music get presented. Concerts of contemporary music are given about once a week in the context of daily concerts of all types of music. Composition and analysis is taught by various composers

such as, besides Wilkinson, Roger Sessions, Bruno Maderna and Luciano Berio. In addition, since 1960, a small electronic music studio has been established there (see Section IV).

D. American Music in Europe

American popular music and American jazz are played everywhere in Europe, as everybody knows, but new American concert music is seldom heard. Although I occassionally heard compositions by composers like Aaron Copland, Walter Piston, Irving Fine and Charles Ives over the radio, the performance of modern American concert music at, for example the above described festivals was unusual, to say the least. In general, there seems to be relatively little interest in or knowledge of contemporary American music. At the various festivals, the only Americans well-known or frequently played are John Cage and his students and associates such as Earle Brown. Cage has had the advantage of having many of his comsitions performed in Europe by David Tudor, as well as being there himself on extended visits to promote his ideas.

At the Darmstadt festival, David Tudor gave a special program of composition of this sort by Cage, La Monte Young and others. Other than this, the Gregg Singers from Los Angeles included two short choral works by Ives in their program and one short piano piece by Ralph Shapey made up the balance of American composition. At Warsaw, only Cage's Fontana Mix and several pieces of Varèse were programmed and at Donaueschingen, the only American was a piece commissioned from Gunther Schuller. In general, in talking to musicians in Europe, I got the general impression that they were not well informed about recent American music. Besides obvious chauvinism in many instances, I was also told that it was difficult to obtain information, scores and to hear performances of newer American music. As one example of how this situation might be improved, some of the USIS personnel in the American embassies told me they were interested in promoting abroad new ideas in American music, but they lacked information about how

to go about it and found that most of their information came from advisors of conservative taste who suggest music and musicians for American performances abroad that does not interest the younger musicians in Europe. On the other hand, USIS personnel also remarked that they insist that performers presenting programs under their auspices include at least one American composition. This apparently is often done under protest by the performers, who prefer to play or sing standard repertory. It is not surprising then that most of the American music presented under these circumstances is conservative and imitative in character.

There is, of course, no simple solution to this problem, certainly one thing that can be done is to present new materials as I did in lecture-demonstration form, or at festivals like those above, including keeping directors of such festivals informed of newer music here. A more basic approach seems to be related to the question of getting published music and books and articles about music circulating abroad. My own experience suggests that this provides a means of reaching the interested audience in Europe effectively. In regard to published music in this country, this is a serious problem compared to European music publishing schedules. My experience in Europe confirmed my opinion that such projects as our automatic tape-controlled typewriter research that will ultimately ameliorate this situation are absolutely necessary if the dissemination of more provocative types of American music is ever to be accomplished. In essence, it is evident that the question reverts back to the same set of problems that confronts the American composer in this country--how to become established professionally and how to obtain circulation for music in a situation where economic and cultural factors severely restrict the outlets for music of small commercial value. A comparison of the opportunities now available to many of the younger European composers versus the younger American composer, aside from teaching in

universities in this country, is anything but encouraging and I see no reason to hope for sudden improvement. As a rough estimate of the difference, I would guess that there is a twenty year age difference on the average between European and American composers that marks the point at which equivalent professional recognition and acceptance is achieved.

III. Electronic Musical Instruments

By the term "electronic musical instrument," I refer to apparatus employing electronic sound sources but intended for musical performance in the usual sense. Historical reviews of the subject of electronic musical instruments are given by Prieberg (1) who presents the most complete historical

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(1) F.K. Prieberg, Musica ex Machina, Verlag Ullstein, Berlin, 1960, pp. 198-233.

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survey, and more briefly by Le Caine (2) and Moles (3).

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(2) H. Le Caine, "Electronic Music", Proc. IRE, 44: 457, 1956.

(3) A.A. Moles, Les Musiques Expérimentales, Editions du Cercle d'Art Contemporain, Paris, 1960, pp. 25-28, 64-67.

Electronic instruments are also discussed in detail by Meyer-Eppler (4), Lewer (5), Douglas (6,7) and Dorf (8). Meyer-

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(4) W. Meyer-Eppler, Elektrische Klangerzeugung, Ferd. Dömmlers Verlag, Bonn, 1949.

(5) S.K. Lewer, Electronic Musical Instruments, Electronic Engineering Technical Monograph, London, 1948.

(6) A. Douglas, The Electronic Music Instrument Manual, 3rd Ed., Sir Isaac Pitman and Sons, Ltd. London, 1957.

(7) A. Douglas, The Electrical Production of Music, MacDonald and Co., London, 1957.

(8) R.H. Dorf, Electronic Musical Instruments, 2nd Ed., Radio Magazine, Inc., Mineola, N.Y., 1962.

Eppler gives an extensive bibliography of materials up through 1948.

We can now distinguish three separate periods of development. The first occurs directly at the turn of the century and involves Thaddeus Cahill's various models of his Telharmonium (9). This huge device, comprising thirty

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(9). T. Cahill, U.S. Patents 520,667; 1,107,261; 1,213,803; 1,213,804; 1,295,691; also see T. Cahill, "The Generating and Distributing of Music by Means of A.C. Generators," Electrical World, 47: 519, 1906.

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carloads of electrical equipment and developed from 1895 to about 1906, is generally recognized as the first serious attempt at electrical production of musical tones. The experiment was foredoomed for lack of small electronic components despite the advanced stage of Cahill concepts of sound synthesis. Cahill's apparatus is also described in some detail by Miessner (10).

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(10) B.F. Miessner, "Electronic Music and Instruments," Proc. IRE, 24: 1427, 1936.

The most important period for electronic instruments came considerably later and comprises the years, 1920 to 1940, when almost all the important electronic instruments intended for actual performance were invented. Since World War II, developments in this field have been largely refinements of existing instruments. Interest in this field has been overshadowed by the development of synthetic electronic music of the type discussed in Section IV.

From a musician's viewpoint, electronic instruments are grouped into two categories, namely, instruments that provide new timbres and means of tone control and instruments designed

to simulate existing musical instruments. Obviously, the first category is of greater interest to the composer; however, the technical advances realized in producing the latter cannot be overlooked.

Among novel performance instruments, those that seem to have a reasonable chance of survival include the theremin, the ondes Martenot, the trautonium and the Hammond organ. For each of the first of these instruments a substantial musical literature now exists. The theremin or aetherophone is the earliest of these since Prieberg states that Leon Theremin, its inventor, began work as early as 1920. By 1924, he had obtained basic patents (11). The theremin is

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(11) L. Theremin, U.S. Patent 1,661,058; Brit. Patent 244,133; French Patent 612,433.

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simply a beat frequency audio oscillator in which continuously variable frequency and amplitude control is obtained by moving the hands nearer to or farther from two "antennas" that reflect hand-capacitance into the circuit. A recently published theremin circuit was used by the present author to build a satisfactory copy of this instrument for our electronic music studio at the University of Illinois (12). A transistorized

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(12) R.A. Moog, "The Theremin," Radio and Television News, 51(1): 37, (Jan.), 1954.

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version of the same instrument has also been recently described by the same author (13).

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(13) R.A. Moog, "A Transistorized Theremin," Electronics World, 65(1): 29, (Jan.), 1961.

Les ondes Martenot, invented by Maurice Martenot in 1928, unlike the theremin, produces basically a sawtoothwave that contains the complete harmonic series. The current model, manufactured commercially by M. Martenot in France, is activated by both a keyboard to provide even-tempered scale steps and a slide device for glissando. A considerable degree of timbre-control, even down to simple sine tones, is provided by means of elementary filter circuits controlled by the left hand. Even though controlled by a keyboard, the ondes Martenot is monophonic. The keyboard is floated on a spring arrangement that is responsive to attack rate and strength of attack by the performer. With the concert model, three different loudspeakers are provided to give three strikingly different types of timbre. A special switch controlled by the left-hand permits switching back and forth among these speakers.

In Paris, I visited the studio of Maurice Martenot at 23 rue St. Pierre, Neuilly, and examined one of these instruments in detail. I secured there a brochure describing the ondes Martenot in detail. Since this is not only a useful instrument for an electronic music studio, but since there is also a growing body of contemporary music employing the ondes Martenot, it is apparent that it, like the theremin, is one of the electronic music instruments that seems likely to survive as a useful addition to the repertory of musical instruments.

The trautonium, invented by Friedrich Trautwein in Berlin in 1930 and subsequently marketed by the Telefunken Company used a neon-tube (later a thyratron) saw-tooth wave generator as a sound source. Since a saw-tooth wave contains all the overtones of a fundamental, this plus the use of simple filter circuits again provides for considerable timbre variation like in the ondes Martenot. Frequency is controlled by pressing a wire with the finger to a plate to provide variable resistence for the RC time constant of the circuit (14). A recent

(14) F. Trautwein, British Patents 380,470; 403,365.

improved four-voiced model called the mixturtrautonium was developed by Oskar Sala from 1952 to 1957 (15). Oskar Sala

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(15) F.K. Prieberg, op. cit., pp. 228-229; O. Sala, "Elektronische Klanggestaltung mit dem Mixtur-Trautonium," in H. Scherchen, ed., Gravesano, Musik, Raumgestaltung, Akustik, Ars Viva Verlag, Mainz, 1955. Also, O. Sala, German Patent 917,470; French Patent 1,074,838; U.S. Patent 2,740,892; German Patent 1,017,488.

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was once a student of Trautwein and Hindemith at the Berlin Hochschule für Musik. He now occupies a private studio in the film studio of MARS Film, Berlin-Spandau, Charlottenberg Chaussee 51 bis 55, where he has the only existing actual mixturtrautonium. I visited Sala's studio to see this instrument. It contains several sound generators, sine wave, square wave, sawtoothwave and white noise, giving a quite complete set of sound sources. It has formant filter circuits, a loudspeaker and direct connections to a tape recorder and a special film editing unit for montaging sound onto movies that is manufactured by W. Steenbeck and Co., Hamburg. This entire apparatus has just recently been described in detail by Sala (16).

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(16) O. Sala, "Mixtur-Trautonium and Studio Technique," Gravesaner Blatter, 23/24: 42, 1962.

The mixturtrautonium is played on two identical "manuals" each of which consists of a "bar," a flat channel iron which, when depressed, increases loudness, and a wire stretched above this bar that when pressed closes a circuit as in the simple trautonium. This wire can be touched down at any point one wishes with one's finger or by a series of movable keys that can be set at any pitches or tuning. Naturally, with one's

finger, it is possible to produce glissandi and related glide and ornamental effects.

Timbres are chosen by "stops," ordinary switches. The instrument also has provision for additive synthesis whereby either harmonic or dissonant upper particals can be added to a fundamental. Two pedals also provide a binary choice between two different formants.

Sala is convinced of the necessity of performing music to achieve the results he wants. He improvises much of his music for films directly on the instruments while watching film proofs in the Steenbach apparatus mentioned above. He composes very rapidly and has prepared many scores for recent German films. He and Remy Gassmann have also used the instrument for two compositions now available on a disk recording (17). The Gassmann ballet is a basically conservative score,

(17) Oskar Sala, "Five Improvisations" and Remy Gassmann, "Electronic Ballet," Westminster 18962, 12" LP Record.

even though electronic, that was choreographed for Berlin and New York productions last year by Balanchine.

Since this instrument seems unique to Sala's studio, it is unlikely to be used elsewhere by other composers. The simple trautonium is easily built, but its repertory, I believe, can be adapted without too much trouble to the ondes Martenot.

The novel technical aspects of the Hammond organ have often been overlooked because no significant music has yet been written specifically for this instrument. Indeed its commercial exploitation to date as an instrument for performing music of meretricious aesthetic level has militated against its acceptance by serious musicians. In spite of its defects, this instrument, invented by Laurends Hammond in 1934 (18)

(18) L. Hammond, U.S. Patent 1,956,350.

is interesting in that it employs additive synthesis to build timbre, employs tempered overtones and builds shifting rather than fixed formants.

Other novel electronic instruments of marginal or historical interest include the various sphaerophons of Jörg Mager (19), elementary prototypes of electronic organs, and the

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(19) Prieberg, op. cit., pp. 210-214; Moles, op. cit., pp. 25-27.

Bode melochord and the electronic monochord, these latter instruments having been used at one time at the NWDR electronic music studio in Cologne, Germany (See Section IV).

Of all the various electronic instruments designed to imitate conventional instruments, only the electronic organ seems to merit consideration because only it has been developed to commercial and technical reality. The period of greatest development of this instrument occurred during the 1930's. Almost all electronic organs, except the Hammond organ mentioned above which was never intended to stimulate a pipe organ, operate on the principle of subtractive synthesis. Complex tone generators that are purely electronic, photoelectric, or electromechanical, produce complex electrical currents that are shaped by filter circuits that simulate various organ stops. These are amplified and converted to sound through loudspeakers. The principal advantages of electronic organs appear to be cost, smaller size, simple installation and maintenance. The authors already cited describe electronic organs in great detail. They also provide references to the enormous literature of the subject.

IV. Electronic Music

As noted in Section I, a major objective of my trip was to visit studios for electronic music to see their facilities, to learn of their recent activities, to examine unusual pieces of equipment that might be of interest to add to our studio, to acquire tape recordings of recent compositions and to talk with composers and technical personnel about problems of mutual interest. I managed to visit all the important electronic music studios in Europe and to meet the majority of composers engaged in activities in this field. The only places omitted that I had hoped to visit included a small electronic music studio at APELAG in Brussels and at the University of Delft, Holland and the facilities for acoustics research built up by Hermann Scherchen in Gravesano, Switzerland. However, I met Henri Pousseur at the Donaueschingen music festival, where I discussed briefly with him his work at APELAG. On the other hand, though Dr. Scherchen had invited me to visit him in Gravesano, I was unable to arrange a time that was mutually convenient.

The only other activities that I did not investigate comprise, as far as I know, some work in electronic music in Sweden and facilities that will be developed into a small electronic music studio in Ankara, Turkey. Substantial work in electronic music also is being carried out in Israel and Japan but both these places were too far away to travel to on this trip. For general background I will give literature references to various writings that have been extremely useful, particularly a recent book by F.K. Prieberg (1). This

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(1) F.K. Prieberg, Musica ex Machina, Verlag Ullstein, Berlin, 1960.

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book is a thorough historically oriented survey of developments up through about the end of 1958 in electronic instruments, electronic music and even computer applications to music.

Though this book has, to my view, some defects in terms of style and organization, it is nevertheless a unique source of data that seems to be quite accurate.

For reasons of concision, I will assume familiarity of the reader with the general processes of electronic music. By definition, the term electronic music will mean music realized in final form on recorded tape without recourse to musical performance in the usual sense. The source of sounds may be either electronic signal generators of one sort or another or real sounds, either musical or otherwise, obtained by means of microphones. Musique concrète, which is derived from real sounds only, is thus conveniently regarded as a special form of electronic music. In addition, there now exists a hybrid category of music that requires performance because it is written for recorded sounds on tape plus instruments. With this music, an instrumental performance in which one or more tape recorders that playback previously prepared tapes are required, is the end result conceived by the composer. Considerable music of this type is now being written in Europe.

Though almost countless numbers of articles on electronic music have been written during the past ten years, there is very little written that systematically presents the processes and techniques of electronic music in an objective and useful form. Exceptions include a recent book by Moles (2) that

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(2) A.A. Moles, Musiques Expérimentales, Editions du Cercle d'Art Contemporain, Paris, 1960, pp. 61-90; 111-135.

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presents a general survey of many of the processes and pieces of equipment currently used in various electronic music studios, and an article on the techniques of electronic music that is based upon our experience at the University of Illinois that

is in the process of publication in a special issue of the Journal of Music Theory to be devoted to electronic music (3).

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(3) L.A. Hiller, Jr., "Electronic Music at the University of Illinois," J. Music Theory, in press, November, 1962 issue. This issue will contain about twenty different articles on various aspects of electronic music.

By all odds, the two most important countries in experimental music are France and Germany. However, significant activity also exists in Italy, England, Holland, Belgium and Poland. In the Western Hemisphere, electronic music activities are being carried out in a limited number of centers in both the United States and Canada.

A. France.

In France, as everyone knows, cultural activities such as music are concentrated in Paris as contrasted to a situation like Germany, where musical activities, including work in experimental music, goes on in many locations. In electronic music, the chief activity in France is the synthesis of musique concrète as developed and defined by Pierre Schaeffer. Facilities for preparing this restricted form of electronic music are located at 37 Rue de l'Université, Paris, 7^{e}, in a building belonging to Radiotelevision Française (RTF). The only other electronic music studio in Paris (also a studio for musique concrète) Studio Apsome, is run by Pierre Henry, who up to a couple of years ago was the chief collaborator of Pierre Schaeffer. I visited both these studios during my visits to Paris and, in addition, spent the week of October 3rd at RFT at the invitation of M. Schaeffer, at a conference he had organized among directors and technical personnel from various electronic music studios in Europe and America.

1. Service de la Recherche, RTF

This is the present name of the organization sponsored by Radiodiffusion-Television Francaise (RTF) and directed by Pierre Schaeffer. The history of this studio and the development of musique concrète has been given in many places, not only in general sources (4,5,6) but also in writings by Pierre

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(4) L.A. Hiller, Jr. and L.M. Isaacson, Experimental Music, McGraw-Hill Book Company, New York, 1959, pp. 39-40.

(5) F.K. Prieberg, loc. cit., pp. 76-94 and pp. 125-136.

(6) A.A. Moles, loc. cit., pp. 31-33.

Schaeffer and his colleagues (7,8). Schaeffer, who was an

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(7) P. Schaeffer, A la Recherche d'une Musique Concrète, Editions du Seuil, Paris, 1952.

(8) Radiodiffusion-Television Française, Groupe de Musique Concrète, Sept Ans de Musique Concrète, 1948-1955, Centre d'Etudes Radiophoniques, Paris.

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engineer employed by Radiodiffusion Française, with his technical assistant, Jacques Poullin, carried out his first experiments in sound alterations employing disk recordings, as early as 1948. Before much longer, he was able to build up the present studio and by about 1955, the present arrangement of equipment was achieved which has not been substantially altered since. As described in the various publications cited above, the principal items of technical interest comprise several special tape handling units that permit (a) synchronous playing of several tapes for collage preparation, (b) variable and stepwise speed changes that produce pitch-duration alterations, and (c) electronic reverbation. At the present time, Schaeffer is searching for a new location, preferably in the

environs of Paris. When this proposed move is effected, considerable modernization and expansion of the technical resources of the organization will presumably be carried out.

As mentioned above, the principal co-worker with Pierre Schaeffer for many years was Pierre Henry, a former student of Olivier Messiaen. Individually and together, Schaeffer and Henry created most of the "classic" compositions of musique concrète that were once available on disk recordings (9).

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(9) Panorama of Musique Concrète, Vol. I, London DTL 93090; Vol. II, London DTL93121 12" LP records.

The two best-known of these compositions are undoubtedly Symphonie pour un homme seul and Orphée. Other composers working in musique concrète at that time included principally Phillipe Arthuys and Michele Phillipot.

Since then, not only Schaeffer and Henry, but numerous other composers, have used these facilities to prepare musique concrète compositions. This has been effected under various arrangements, such as by invitation or by employment of the composer at the studio. Some of the more recent compositions produced there have been collected in a recently issued disk recording (10). It should be noted that considerable emphasis

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(10) Musique Concrète, Groupe de Recherches Musicales de la RTF, BAM LD070, 12" LP Record.

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has been given in recent years to the use of musique concrète for films, theater, ballet and broadcasting, in all of which applications, its very effective use is by now clearly evident.

About two years ago Pierre Schaeffer drastically reorganized his organization, at the same time enlarging and diversifying its activities. It must be remembered that Schaeffer was originally an engineer, not a musician and, in fact, the

continued production of musique concrète constitutes only one of his interests. As described in detail in recent publications (11,12), the present organization is devoted to "research"

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(11) P. Schaeffer, et al., Le Service de la Recherche de la Radiodiffusion Television Française, RTF, 37 Rue de l'Université, Paris, 1960.

(12) P. Schaeffer, et al., Situation de la Recherche, Flammarion, Paris, 1960.

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in four basic fields, research being broadly defined rather broadly to include the preparation of music, films, broadcast, etc., as well as in the more usual restricted sense of the term. The four fields are, specifically: (a) musical research, (b) image research, i.e., TV, films, etc., (c) technical research, (d) critical research, i.e., theory, criticism and documentation. In engaging in this ambitious program of activities, Schaeffer has at his disposal extensive financial backing from RTF, so that his organization consists at present of about 100 people. His chief administrative assistants are Jacques Poullin, who has been with him from the beginning, as noted above, and who now directs the work in "applied" areas -- TV, films, etc., A. de Chambure, who directs research in all fields, and Louis Mesuret, who directs activities in musique concrète composition. Each of these areas is further subvided as, for example, under composition, research is directed by Luc Ferrari, teaching by Phillip Cousin, and applied music by Bernard Parmigianni. There is now organized at RTF a two-year course of training in musique concrète composition open on a competitive basis to young composers. About twelve composers are accepted for the program each year and upon completion of the program of study, they may use the facilities of the studio. Typical composers who have completed this program include Ivo Malec and Yannis Xenakis. Outside composers are seldom invited to work at the studio any more as

in earlier years. Employment at the studio in other areas, i.e. technical or documentation research, is done also on a competitive basis, choices being made largely from recent university graduates.

I heard a number of recent compositions at a meeting at the studio and saw some recent films employing musique concrète in the sound tracks. Some of the recent scores are interesting since they reflect the ideas of younger composers like Ferrari and Xenakis, but technically they disclose nothing particularly new. Some of the scores combine or contrast musique concrète with instruments, a new procedure that is in line with a general trend toward this means of expression that I also observed elsewhere in Europe. Xenakis' music reflects also his interest in statistical composition (see Section V).

The theoretical research studios at RTF are stringently conditioned by Pierre Schaeffer's philosophy. This is a complex matter to describe, but briefly Schaeffer's concepts are rooted in a somewhat mystic and Bergsonian context that has led to the notion of musique concrète representing "man and his environment." It also led to a rather useful acoustic definition, namely, l'objet sonore, which is defined in terms of measurable parameters of pitch, amplitude, and duration in such a way that both steady-state and transient effects can be depicted graphically in a simple manner. In defining l'objet sonore, Schaeffer worked closely with Dr. Abraham Moles, who now is expanding this idea in terms of information theory (see Section V).

The documentation program is important and interesting. Schaeffer hopes to publish a yearly monograph that will contain research articles in experimental music of all kinds and will contain a yearly resumé of activities in electronic and experimental music studios around the world. I agreed to keep him informed on activities in the University of Illinois and the United States, since they seemed poorly informed at

RTF on American music and wish to depend on myself and Vladimir Ussachevsky for current information. The first issue of this annual, scheduled to come out in early 1962, contains a report of a meeting of technical personnel held in Venice earlier this year and of the meeting I attended at RTF. In addition, it contains a full description of the facilities, the compositions produced, and the articles written about electronic music studios all over the world. This is a valuable bibliographical and reference source. The information for this documentation was obtained primarily by means of a questionnaire mailed to known experimental music studios last summer. The University of Illinois studio was included in this list.

Pierre Schaeffer now also hopes to organize a "Biennale" -- a music festival of experimental music to be held every two years. At these biennale festivals, not only concerts, but also technical sessions would be held. These technical sessions would follow the general pattern of the meeting at RTF, but with larger participation. The next biennale is tentatively planned to be held in Paris in January, 1963.

At the actual sessions of the October meetings mentioned earlier, besides discussion of the above matters, a number of more technical papers and conferences were held. These are all contained in the issue of the new annual publication mentioned above. . Briefly, there were papers on the following topics, each followed by a discussion period: (a) Recording standards, by Dr. Lietti of RAI, Milan, (b) Spatialization, by Dr. Vermeulen of the University of Utrecht, (c) Special apparatus, by Dr. Heck of SWF, Baden-Baden, (d) Design and administration of electronic music studios, by A. de Chambure. In addition, Vladimir Ussachevsky described recent work at Columbia University. I gave a talk on our work at the University of Illinois as noted in Section I, and Pierre Schaeffer gave two talks, one outlining his recent theoretical

and aesthetic ideas and his plans for the future and the other concerned with the problem of pedagogy and how to achieve effective intercommunicatinn between musicians and technicians. This was, of course, of particular interest to me in view of our program at the University of Illinois.

2. Studio Apsome (Pierre Henry)

As mentioned above, the best-known name associated with the development of musique concrète, outside of Pierre Schaeffer, is Pierre Henry who was for a period of about ten years, the chief collaborator of Schaeffer. About two years ago, this long-established partnership broke up and Pierre Henry left RTF to found his own studio for concrete and electronic music. He has managed to support himself and his studio by commissions and by preparing sound materials for films, commercials, and so on. This studio, called Studio Apsome, is a large basement room at 80 Rue Cardinet, Paris 17^{e}, and is run by Pierre Henry and Jean Baronnet. Henry has managed to obtain basic equipment, though, for obvious reasons of cost, the amount of expensive special purpose apparatus he has is still quite limited. Besides tape recorders, amplifiers and speakers (in two-channel stereo), he posses a small mixing panel, a Krohnhite push-button oscillator and two Krohnhite variable band-pass filters.

Henry played me samples from some of his recent compositions such as Co-Existence (1958), of which I heard one movement out of five; Investigation (1959), which was music written for an exhibition of paintings, and another recent composition called Entité. He promised to send us tapes of his recent works.

Pierre Henry is also now the editor of a new series of disks of experimental music to be issued by Philips Fontana at the rate of about two to three disks a year. This series will be entitled "Panorama des Musiques Expérimentales". The contents of the first two disks to be issued will be as follows:

Disk No. 1

Side One - Music from RAI (Milan): L. Berio - Momenti, L. Berio - Thema (Omaggio a Joyce), and B. Maderna - Continuo.

Side Two - Music from RTF (Paris): L. Ferrari - Visage V, Y. Xenakis - Orient-Occident, and Baronnet and Dufrene - U47.

Disk No. 2

Side One - Music from WDR (Cologne): H. Eimert - Selection I, and M. Kagel - Transición I.

Side Two - Various Studios: P. Henry - Entité (Apsome - Paris), G. Ligeti - Artikulation (WDR - Cologne), A. Boucourechliev - Texte I (RAI - Milan), and H. Pousseur - Scambi (RAI - Milan).

Subsequent disks will include music from all over the world, including Japan and the United States. He hopes to edit a disk that will include music from the University of Illinois. I have, therefore, entered into an informal arrangement to supply him my still unfinished Seven Electronic Studies and the Second Illiac Suite being prepared by R.A. Baker and myself.

B. Germany.

West Germany is now the scene of considerable activity in the field of electronic music specifically, just as it is in contemporary music in general. In Germany, three types of institutions underwrite the existence of electronic music studios. The first are two of the government-owned and operated broadcasting studios, namely, Westdeutscher Rundfunk (WDR) in Cologne and Südwestfunk (SWF) in Baden-Baden. In general, the involvement of broadcasting organizations with electronic music is unlikely to increase; if anything, the reverse will

probably occur. One reason for this is the establishment of a technically very well equipped studio at the electronics firm of Siemens and Halske in Munich. This is an example of the second kind of support of electronic music activities, namely by private industry. It is highly probable that this new studio will become the principal electronic music studio in Germany in the coming years. The third location for electronic music studios is in the universities or similar institutions where this kind of activity is usually coupled with acoustic research. The most important such studio at present is at the Technische Universität in Berlin.

1. Westdeutscherrundfunk, Cologne (WDR)

The electronic music studio at WDR in Cologne (formerly called NWDR) is the most celebrated in Germany, having received tremendous publicity over the past ten years. The history of this operation up to 1958 has been given in considerable detail by Prieberg (14). Very briefly, this studio was organized about

(14) F.K. Prieberg, loc. cit., pp. 156-172.

1950 by Dr. Herbert Eimert, with technical advice by Dr. Fritz Enkel, the chief engineer of NWDR and Dr. Werner Meyer-Eppler, of the University of Bonn (see Section V). Two "staff composers", Karhleinz Stockhausen and Gottfried Michael König were subsequently employed at the studio. Guest composers like Hermann Heiss, Ernst Krenek and many others have used the facilities over the years. The output of the studio is closely geared to Dr. Eimert's firmly held conviction that only serial procedures are applicable to electronic composition. The earlier compositions produced in this studio up through 1956, most of which are available on records (15) and of which the

(15) DGG16132, 16133, 16134, three 10" LP recordings of electronic compositions, by Eimert, Stockhausen, König, and Krenek.

best is, by critical consensus, Stockhausen's Gesang der Junglinde, reflect this aesthetic doctrine. My main objectives in visiting the WDR studio were (a) to examine its present technical facilities and (b) to find out what had been produced in this studio since 1956. I visited the studio twice, interviewing principally Dr. Eimert, but also György Ligeti (see below) and the present technician in the studio, Leopold von Knobelsdorf. I also briefly saw Mr. Stockhausen after a performance of his new theater piece (see below) and would have seen Mr. Köenig also, except that he was ill the day of my visit.

The technical facilities of the Cologne studio are surprisingly limited. No unusual equipment is used, and the various electronic instruments such as the Bode melochord and the electronic monochord described in earlier literature from the studio (16) have been thrown out.

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(16) See Tech. Hausmitt. NWDR, 6:4-54, 1954. Translations of these articles have also been made: National Research Council of Canada Technical Translations TT-601 to TT-612, Ottawa, Canada, 1956 (translations by D. A. Sinclair and H.A.G. Nathan).

The present electronic music studio occupies a small recording room. It contains the following apparatus:

a. Generators: commercial generators for producing sine tone, square wave, impulses and white noise. No sawtooth-wave generator.

b. Filters: complete Albis filter, Teilton filter F427, a commercial broadcasting octave filter.

c. Springer time compresser-expander.

d. Simple mixing panel.

e. Three ordinary tape recorders and one four-channel tape recorder.

An electronic music concert given in May, 1956 that included Stockhausen's Gesang der Junglinde seems now to represent a culmination of the first period of activities at this studio. Since then, more diffuse and at the same time more diverse objectives have been pursued. Also, certain complications have arisen which have made the activities less concentrated in focus. First, many composers have attempted to work at the studio, but only a few younger composers sympathetic to Dr. Eimert's attitudes have managed actually to do so. Second, this same assertion of serialism as the only "true way" has naturally caused antagonism among other composers with more flexible attitudes. Third, the recent deaths of both Dr. Enkel and Dr. Meyer-Eppler have hampered activities at WDR since both these men were called on for technical advice. However, work continued at the studio at a reasonable rate and Dr. Eimert is now more inclined, apparently, to modify the studio's attitudes towards similar groups elsewhere. In addition, principally through David Tudor's influence, the rigid formulae of total serialism have been much modified by the introduction of chance and improvisational methods of composition. Finally, some of the recent compositions from the studio, as the list below shows, are for tape recorder and instruments, so no longer is just the use of the "pure" electronic medium particularly stressed.

The principal compositions produced at this studio since 1956 are the following:

1. Mauricio Kagel, Transición I (1957)
2. Franco Evangelisti, Incontri de Fasce Sonore (1958)
3. Gyorgy Ligeti, Artikulation (1958)
4. G.M. Konig, Essay (1958)
5. Bo Nilsson, Audiogramme (1958)
6. Bo Nilsson, Zellen (1958)
7. Mauricio Kagel, Transición II (1958), for two tape recorders, piano and percussion.

8. H. Eimert, Selektion I (1958)

9. K. Stockhausen, Kontacte (1960) for four-channel tape, piano and percussion

10. G.M. König, Ballet (1961)

Unfinished works now being completed include:

11. H. Eimert, Epitaph

12. Roland Kayn, ? ?, a score by a Hamburg composer partially realized at Radio Polskie, Warsaw, and now being finished at WDR.

13. G. Ligeti, Electronic Composition No. 3

The above compositions are all electronic music, as far as I know, except as indicated otherwise. Recordings of several of these pieces will be made available in the near future. DGG will release a recording of Stockhausen's Kontacte and the Philips-Fontana series, being edited by Pierre Henry will include Eimert's Selektion I, Ligeti's Artikulation and Kagel's Transición I, as already noted.

I have not heard many of the above compositions yet, except Kontacte under the rather unusual circumstances of it being used as part of the musical accompaniment for Stockhausen's Musikalische Theater. This was an evening of improvised theater according to a "score" of Stockhausen that resembled in many ways the Theater Piece of John Cage performed at the University of Illinois last spring. The reviewer in a Cologne newspaper called it a "fin-du-siècle goulash". Stockhausen composed no new music for this occasion but employed a melange from Gesang der Junglinde, Kontacte and a recent orchestral composition, I believe, Drei Gruppen. Insofar as I could judge under the circumstances, Kontacte seemed very effective. I might point out that performances of it elsewhere seem to have drawn a favorable response even from many people not previously disposed toward Stockhausen's music.

Other composers I met at WDR included first, Nam June Paik, a South Korean composer who has recently attracted some notice for extravagantly violent "performances" of his own music. He performed in Stockhausen's Musikalische Theater in such a way, hurling himself head first into a tam-tam, pouring rice and water all over himself, and so on. At the studio, however, he talked about his work in electronic music in a normal and intelligent way. I also spent a morning with Gyorgy Ligeti discussing information theory and music. His recent works such as Artikulation above, and Atmospheres which I heard at Donaueschingen, are consciously constructed on a basis of varying degrees of "order-disorder" in the information theory sense. Ligeti is interested in this problem analytically too. For example, he is the author of a useful and thorough analysis of Boulez's Structures for Two Pianos-Book I (17), that Robert Baker and I are using as a guide to

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(17) G. Ligeti, "Pierre Boulez", Die Reihe, 4:36 1960. (English language edition of Theodore Presser Co., Bryn Mawr, Pa.).

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programming the ILLIAC for a movement of totally organized music for the Second Illiac Suite. Since Mr. Ligeti is also writing a book on Anton Webern, he requested that I send him all the material we have on our analysis of Webern's Symphony-op. 21 by information theory, employing the ILLIAC for computations.

2. Südwestfunk, Baden-Baden (SWR)

Südwestfunk (SWR), located in a series of new buildings on a hill overlooking Baden-Baden, is an active musical center where Dr. Hans Rosbaud, the conductor of the SWR orchestra, performs much new music. Moreover, SWR is closely associated with the Donaueschinger Musiktage, as mentioned earlier (Section II). Dr. Heinrich Strobel, the editor of Melos and musical editor of B. Schott Söhne, is also musical director for SWR. Pierre Boulez and F.K. Prieberg, who wrote the book

Musica ex Machina that I have referred to several times, live in Baden-Baden. I visited SWR at the invitation of Dr. Ludwig Heck, the technical director of production, who showed me the facilities of SWF and described their work to date in electronic music. Actually, there is no regular electronic music studio at SWF but since they have a very large quantity of modern recording, broadcasting and test equipment, it is easy for them to assemble on short notice most of the more conventional items found in the average electronic music studio. Thus far, this has only been done on two occasions, once for Vladimir Ussachevsky who worked there assembling sound materials that have not yet resulted in an actual composition, and once for Pierre Boulez who prepared there with Dr. Heck's assistance the performance tape for his composition Poesie pour Pourvoir that was commissioned for Donaueschingen in 1958. This composition, which I have not yet heard, was written for tape and instrumental groups. It did not meet with critical favor. Dr. Heck, and Dr. Fritz Winckel of Berlin (see below) who also advised Boulez, both objected to the way Boulez handled his tape materials, both saying that they told him that some of the effects he was attempting would not work acoustically. They both state that this was one major reason for the failure of the composition and that Boulez intends to revise the composition when he finds time.

Dr. Heck says that SWR does not plan to establish an electronic music studio because he feels that the Siemens studio in Munich is so much superior to anything they could set up that it is simpler for them to cooperate with that organization in the future. They plan to limit their activities to the preparation of simple sound effects and musique concrète materials for broadcasting purposes. However, he emphasized their sympathetic view towards experimental music.

Dr. Heck has designed an unusual and interesting piece of electronic music equipment called the "Tonumsetzer" or "Klangunwandler". This apparatus has been described by Heck

and Bürck (18,19) and patents on it have been issued to these

(18) L. Heck and F. Burck, "Klaugumwandlungen durch Frequenzumsetzung", Gravesaner Blatter, 4:35-56, 1956.

(19) L. Heck and F. Burck, "Klangumformungen in der Rundfunkstudiotechnik, inbesondere durch Anwendung der Frequenzumsetzung", Z. Elektronische Rundschau, 1956, No. 1, p. 1.

same authors (20), This is a modulator-demodulator unit which

(20) L. Heck and F. Burck, "Verfahren zur Erzeugung von Klängen für elektronische Musik", German Patents Nos. 1051100, issued August 13, 1959; and 1080386, issued Oct. 6, 1960.

permits the shifting of the frequency of a tone, i.e., transposition--obviously, a very useful device for an electronic music studio. This unit works on a simple principle, as follows: An audio signal of, say, frequency f_1, is modulated onto a carrier signal, f_2. Since the unit responds only to a constant frequency difference Δf, initially equal to $f_2 - f_1$, if f_2 is changed to some other frequency, f_3, the original audio signal becomes $f_4 = f_3 - \Delta f$ so that on final demodulation, the audio signal is shifted from f_1 to f_4, i.e. it is transposed. Moreover, the unit creates very interesting effects when the carrier frequency is shifted to zero cps. This causes frequency reflection from from the zero cps axis.

Dr. Heck gave me reprints of the articles and patents listed above, also a small demonstration record. It seems to be a piece of equipment meriting careful examination on our part with a view toward acquisition. At present only two such units exist, both built by Siemens. One is at the Siemens studio in Munich described below and the other is at SWF.

Dr. Heck has also investigated other apparatus that he feels is of potential interest for electronic music studios. He described several such items both when I was in Baden-Baden and earlier at the RTF meeting in Paris (see above). For example, in the case of filters, he does not like the Albis filter of Albiswerke, Zurich, because he objects to its frequency response characteristic, i.e., its non-linearity in its reject region. Two filter circuits he has decided

are decided are useful and reliable are the following: (1) Universal Entzerrer UE-100, made by Klein and Hummel, Stuttgart Postfach 402, and (2) Klangfilm Universal Equalizer, Model KIR 2062a and b, made by Siemens and Halske AG, Wernerwerk für Messtechnik, Karlsruhe. Finally, Dr. Heck described a time-envelope control apparatus designed by Dr. Backhausen that permits the control of each individual partial of an overtone series, thus approximating the decay characteristics of real sounds. Dr. Heck played some samples of sound controlled by this apparatus at the RTF meeting in Paris that were very interesting. As might be expected the apparatus is quite complicated and not cheap to build, requiring, I presume, a separate circuit for each overtone.

3. Siemens Electronic Music Studio, Munich

This relatively recently organized electronic music studio is probably now the best equipped studio in Europe. It is located at the headquarters of Siemens in downtown Munich. Its full name and address is: Siemens and Halske Aktiengesellschaft, Zentrale Entwicklungsaufgaben, Studio für Elektronische-musik, Oskar von Miller Ring 18, München. It is operated by Siemens as a "cultural service" of the company, which is, of course, a large electronics and electrical equipment manufacturer with many operations including, for example, Deutsches Grammophon Gesellschaft records. The electronic music studio is directed by Dr. Ing. Hans-Joachim von Neumann, a musician who also has a technical background in physics. He is helped by Dr. Helmut Klein, his technical adviser, and Dr. Scharf, his musical adviser. Several technicians and assistants are also employed by the studio.

The facilities in this studio are excellent. They are located in a series of four to five rooms that include two rooms with sound generating equipment, a recording room with numerous tape recorders and auxillary recording equipment, a small recording studio, a sitting and conference room with shelving

for storing tapes, books and so on, a good workshop, and offices for personnel.

A brief description of the studio is given by Prieberg (20)

(20) F.K. Prieberg, loc. cit., pp. 100-103.

and special purpose equipment (Item 1 below) is described in greater detail in mimeographed form by Dr. Klein (21). Briefly,

(21) H. Klein, "Elektronische Klanggestaltung mittels lochstreifen".

the available equipment includes the following:

(a) A paper-tape encoding unit. This is the most unusual item in the studio. It is a five-channel tape punch unit that prepares two tapes simultaneously. Four such tapes are used to encode instructions as to pitch, octave of the pitch, rhythm, and tone-color. This encoding unit is operated from a conventional keyboard limited to equal temperament. It has provision for repeating instructions semi-automatically so that such things as rhythmic ostinati are readily encoded onto the tapes. When the four tapes are ready, they are taken to a special reader that decodes them and activates various items of electronic hardware contained primarily in a drastically rebuilt electronic organ. This organ was supplied originally, as most commercial electronic organs are, with saw-tooth wave generators as sound sources, various filters for simulating the various conventional organ stops, and organ manuals. The tape reader has been hooked up to the organ to activate it in accord with the instructions on the tapes. The circuits in the organ lead in turn to the recording heads of ordinary tape recorders.

Thus, this simple system -- encoder, coded tape, decoder and electronic organ, tape recorder -- is an efficient apparatus for producing many kinds of precisely defined electronic sounds.

When skillfully used, it eliminates much of the tedious tape manipulation and editing that is the most serious technical objection to conventional electronic music preparation. Moreover, this simple system is by no means so elaborate an electronic apparatus as the RCA Electronic Music Synthesizer at the Columbia-Princeton Electronic Music Center in New York City. It is less expensive, less elaborate and much simpler to use, but all-in-all, an apparently practical example of semi-automation.

(b) Control console. Although the above device eliminates a good deal of preliminary editing, apparently it still cannot be used for many types of sounds and sound alternations, so a good console is employed in this studio just as in other electronic music studios. The console in this studio is conventional in design and convenient to operate. With it one can control and direct sounds for various sources toward various sound modifying units, tape recorders, loudspeakers, and so on. The console possesses a large flat work surface, linear attenuators and the most frequently used measuring equipment (cathode ray oscilloscope, frequency measurement equipment, sound level meter, etc.). Any other desired measuring devices are readily available from stockrooms in the building.

(c) Usual electronic music equipment. All the usual sound sources (sine wave generators, complex wave generators including a sawtoothwave generator, and a white noise generator), various filter circuits, reverberation devices (including a mechanical wire mesh reverberation unit) are available; also, normal tape recorders, a four-channel machine employing one-inch tape, and a sprocket-drive 35 mm. tape recorder.

(d) Klangumsetzer. This apparatus, designed by Heck and Bürck is one of two such existing pieces of equipment for frequency transposition. It is the same device described directly above in the section on SWF in Baden-Baden.

(e) Vocodor. Siemens has placed a Vocodor at the disposal of the electronic music studio. This device, originally invented by H. Dudley of Bell Telephone Laboratories (22) permits

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(22) H. Dudley, "Remaking Speech," J. Acoust. Soc. Am., 2:165, 1939; H. Dudley, R.R. Riesz, and S.S.A. Watkins, "A Synthetic Speaker," J. Franklin Inst. 227, 739, 1939.

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a composer to modulate any sound, electronic or otherwise, with a second sound such as speech picked up with a microphone. This permits curious effects such as, for example, speech formants being superimposed upon a constant frequency sawtoothwave.

(f) Photographic Signal Source. This device, developed by G. Holoch (23) and L. Heck (24) permits the photographic

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(23) G. Holoch, "Elektronische Klangerzeugung nach dem Prinzip der Lichtpunktabstastung," Nachrichten technische Z., 14:1, 1961.

(24) L. Heck, "Klangssynthese durch elektronische Bildabtastung," Elektrontechnische Z., B, 13:454, 1961.

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synthesis of any conceivable wave form or time envelope. However, it is not used very much because it depends on a photographic film process and the time lag required for developing the films that record wave forms makes it rather impractical for electronic music synthesis.

Dr. von Neumann gave me a demonstration tape that presents the possibilities of sound synthesis available at this studio. Thus far, the studio has been used primarily to produce sound tracks for industrial and educational films for Siemens. I was shown several of these films with music and sound effects composed by Josef Anton Riedl, a Munich composer, and found them quite effective. It was obvious once again that the electronic medium can be very advantageously used in film,

theater and broadcasting applications.

Dr. von Neumann is now also initiating a program of inviting various composers to work in the studio for, on the average, a period of about a month's duration. The first composer to complete a composition there is Erhard Kolchaska, a composer from Stuttgart. Dr. von Neumann gave me a copy of his composition, Drei Bilder aus der Offenbarung des Johannes. Henri Pousseur was coming to Munich from Brussels to work there next and other composers who have been invited to work there during the coming year include typical well-known names like Boulez, Stockhausen and Maderna. Dr. von Neumann would like to have American composers work there too, but he says he knows so little about contemporary American music that he asked me to send him information that could help him initiate something in this direction.

4. Technische Universität, Berlin.

In Berlin, Professors Fritz Winckel and Boris Blacher have arranged a program of teaching, research and composition that now includes a studio for electronic music preparation. Professor Winckel is a physicist on the humanities faculty of the Technische Universität, along with H.H. Stuckenschmidt, a well-known German music critic, and Boris Blacher, a well-known German composer. All of them teach both here and at the Hochschule für Musik which is conveniently located right next door. I visited the Technische Universität as the guest of Professor Winckel. I was to meet Professor Blacher, who had arranged a talk I gave at Amerikahaus in Berlin but he was unfortunately quite ill at the time of my visit.

This arrangement between these two institutions is quite unusual in Europe in that permits a cooperative arrangement between science and music faculties so that music students can take appropriate science courses and vice versa. One of the special teaching programs Professor Winckel directs, for example, is for "tonmeisters," that is, audio engineers who would work with music professionally. I found this whole

concept more like what we can do in American universities and quite different from the usual pedagogical approach in Europe, where specialization is so emphasized that in a field such as electronic music, as Pierre Schaeffer for example has noted (see above), there can result an almost total breakdown of communication between musicians and technicians attempting to work together. Since Professor Winckel is very much concerned with this pedagogical problem, he was much interested in our University of Illinois course work in acoustics, electronics and experimental music.

Professor Winckel's research is primarily in psychoacoustics with applications to speech and music in particular. A typical research problem his students were studying when I visited the university was the study of the transient pitch fluctuations in vowel sounds. Professor Winckel gave me reprings of several typical research articles including articles on electronic music (25). He is also the author of a short book

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(25) For example, F. Winckel, "Informationstheorische Bertractungen über Gehör und Hörgeräte," in F. Schubert, ed., Theorie und Praxis der Horgerateanpassung, Georg Thieme Verlag, Stuttgart, 1960; F. Winckel, "Die Psychophysischen Bedingungen des Musikhörens", in Stilkriterien der Neuen Musik, Verlag Merseburger, Berlin, 1961.

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on modern psychoacoustics that should be of much interest to musicians since it examines many typical musical problems from a modern acoustical viewpoint (26).

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(26) F. Winckel, Phänomene des Musikalischen Hörens, Max Hesses Verlag, Berlin, 1960.

Professor Winckel has constructed a studio for electronic music that is located next to a large classroom and thus can be used for electroacoustics demonstrations, electronic music

presentations, and the like. His assistants and students build all the equipment. This includes a control console and mixing panel, signal generators for all the usual wave forms, filter circuits, a klangumsetzer derived from Dr. Heck's design (see above), and the usual tape recorders, amplifiers, loudspeakers, and so on. The classroom is equipped with a fine two-channel stereo playback system. Other equipment includes a Springer time compresser-expander and the usual measuring and test apparatus (27). Professors Winckel and Blacher are preparing

(27) F. Winckel, "Hochschul-Universal-Mischpult für Experimentierzwecke," Elektronische Rundschau, 7:247, 1959.

a series of electronic music studies that are not yet finished. They are apparently preparing these pieces with great care because they think that many of the compositions presented at places like Darmstadt as carelessly prepared and motivated by a desire for publicity and for scandalizing audiences. They feel that less of this and more emphasis on such things as professional colloquia on experimental musical problems among professional musicians and technical personnel would be preferable. I hope to obtain the Winckel-Blacher compositions when they are ready. In the meanwhile, Professor Winckel gave me a tape of demonstration samples and one simple tape composition prepared from timpani sounds.

5. Hermann Heiss, Darmstadt

Hermann Heiss is a composer about fifty years old who lives in Darmstadt and who has a small electronic music studio here at Bessungesstrasse 5. Whether it is entirely his own or whether he has outside support I do not know. In any event, he works by himself in this small studio located in a room at a Darmstadt music school at the above address.

As described by Prieberg (28), Heiss has prepared

(28) F.K. Prieberg, loc cit., pp. 173-174.

several electronic music compositions over the past several years. A new composition, Electronic Composition No. 4, was given its first presentation at this year's Darmstadt Festival. Mr. Heiss's compositions, except for his earliest electronic compositions, are serially conceived though, in general, his aesthetic approach is simpler than that of the Cologne composers. I have asked Mr. Heiss to send us a tape of three of his compositions for our file. Briefly, besides the usual recording equipment, Mr. Heiss possesses an Albis filter, which he likes, in contrast to Dr. Heck of SWF, for example, various tone generators, a ring modulator, a small patch panel, amplifiers and loudspeakers. In addition, he possesses an interesting special recording desk of his own design that permits the rapid editing and building up of sound montages and artificial reverberation without the usual tape splicing and cutting. This is a very interesting piece of equipment meriting further investigation. It has been described by Mr. Heiss in a published article (29).

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(29) H. Heiss, "Spezial Aufnahmeaggregat für Tongemische," Gravesaner Blätter, 15/16:, 118, 1960.

C. Italy

The only important electronic music studio in Italy continues to be the Studio di Fonologia musicale at RAI (Radio Italiano), Corso Sempione, Milano. Attempts to start a studio and an information bureau on electronic music in Rome have thus far not succeeded (30).

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(30) A proposal in a form letter sent by Associazione per la Musica Elettronica, presso Casa Musicale de Santis, Via del Corso, 506, Roma.

The studio at RAI was organized and designed by Luciano Berio and Dr. Alfredo Lietti about five to six years ago. Berio was its director until two years ago when he resigned from RAI due to policy differences with RAI management. However, he still uses the studio as he wishes and he is still commissioned by RAI to produce new pieces. The present director of the studio is Sgr. Renzo Dall' Oglio. Dr. Lietti was technical director of the studio. He was responsible not only for its general plan, but also designed some of the more interesting specialized equipment in the studio. However, Dr. Lietti also quit just two weeks before my visit. How this will affect the future of the studio remains to be seen. I had met Dr. Lietti earlier in Paris at RTF and had hoped to see him in Milano. However, I was shown the studio by Signore Berio and Dall'Oglio.

The principal published semi-technical description of the studio appeared some years ago in an Italian journal (31, 32). Prieberg (33) can be cited once again as a useful

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(31) L. Berio, "Prospettive nella Musica, Ricerche ed attivita dello Studio di Fonologia Musicale di Radio Milano," Elettronica, 5: No. 3, (Sept.), 1 1956.

(32) A. Lietti, "Gli impianti tecnici dello Studio del Fonologia Musicale di Radio Milano," Elettronica, 5, No. 3, (Sept.), 116, 1956.

(33) F.K. Prieberg, loc cit., pp. 137-180.

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source of information concerning the activities of this studio up through about 1958.

Even though no significant additions to the studio have been made since the above cited published descriptions of the studio, this studio is still the best-equipped electronic music studio in Europe with the possible exception of the Siemens studio in Munich described earlier. The studio consists of two work rooms plus several offices for personnel. The smaller of

the two studios proper is largely auxilliary space for extra tape recorders and miscellaneous equipment. In the principal studio the electronic equipment is efficiently arranged in a series of relay rack panels, with the tape recorders opposite and a central console standing next to the relay racks. All this equipment is interlocked through the control console so that it is simple to connect together various components of the total apparatus for recording and processing sounds.

In addition to the control console, the studio contains the following equipment:

(a) Nine variable frequency sine tone generators, that are normally used for additive timbre synthesis; each has its own amplitude control and decibel meter.

(b) Square wave, sawtoothwave, impulse and white noise generators. Berio says the sawtoothwave generator is not very good, however.

(c) A Krohnhite variable bandpass filter, various octave filters and an Albis filter. These are used for substractive synthesis.

(d) A "dynamic modulator", i.e., a time envelope control circuit. This was designed and built by Dr. Lietti and is similar in function to a unit we have built at the University of Illinois.

(e) Amplitude filter. This interesting circuit suppresses all sounds below a chosen dB level. It was also designed by Dr. Lietti and has been described briefly by him in a published article (34).

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(34) A. Lietti, "I Fenomeni Acustici Aleatori nella Musica Elettronica," Incontri Musicali, 3:150, 1959.

(f) A Springer time compressor-expander. This unit is not liked at RAI because they say it distorts musical sounds. They say it should have eight, rather than four, heads on its rotating playback head assembly.

(g) Les ondes Martenot. This is the only electronic instrument in the studio.

(h) Six Ampex tape recorders, four monaural and two stereo (two-channel, 1/4" tape). Those machines can be started and stopped in synchronization. Moreover, each has a two-pole switch which permits any or all of them to be controlled if desired by a variable speed control. Variable speed control is obtained by supplying the hysteresis tape drive motors of the tape recorders with variable frequency alternating current from a heavy-duty oscillator.

(i) One four-channel tape recorder employing 1" tape. This is similar to Telefunken and Philips machines, but was built by RAI technicians.

(j) Control and analytical equipment includes principally an oscilloscope and a General Radio harmonic analyzer.

Berio played tapes of several recent electronic music compositions, specifically: (1) Serenata Terza (1960-61) by Maderna. This is tape music prepared from flute and marimba sounds. (2) Momenti (1960) by Berio. I thought this was effective, especially the ending. (3) Fragmenti (1960) by Luigi Nono, Nono's only electronic composition so far. (4) Visages (1961-2) by Berio. This is a new, still unfinished composition utilizing Cathy Berberian's recorded voice and electronic sounds. It is a programmatic piece based on the idea of discovering speech and song. It starts with inarticulate sounds and gradually leads to vowels, syllables, Italian words and speech and finally song. It still needed editing and polishing when I heard it. Berio said it will occupy one side of a new Boston disk that will have his composition Circles on its other side.

In the past, this studio has been used primarily by Berio and Maderna to produce both electronic music compositions and background materials for RAI broadcasts. However, in addition, various other composers have used the studio from time to time upon invitation, notably, Henri Pousseur, Luigi Nono, John Cage and Marc Wilkinson. Cage produced his Fontana Mix for voice (Cathy Berberian) and tape there. I heard this piece at the Warsaw festival and felt the tape part of the composition was unsuccessful. It is a tape of randomly arranged sounds that seems neither particularly interesting nor technically well prepared (35). I understand that this policy of inviting out-

(35) We have a copy of the performance tape in our studio but not of the complete composition with voice.

side composers to work at the studio is still in effect and that if one is interested in working there the persons to contact are either Dall'Oglio or Berio.

D. England

In England, not very much of interest has happened thus far in electronic music. This is a reflection of the conservative state of English musical activities that is well recognized by English musicians and critics themselves (36).

(36) For example, H. Wood, "English Contemporary Music", in H. Herzog (ed.), European Music in the 20th Century, Penguin Books, Ltd., Harmondsworth, Middlesex, England, 1961, pp. 145-147.

This musical inertia is disturbing in light of the fact that excellent audio equipment is manufactured in England, as well as interesting electronic apparatus that might well be adapted to electronic music processes (37). Because of the little that has been

(37) An example of which is the Servomex waveform generator, Model No. LF-S1, manufactured by Servomex Controls, Ltd, Crowborough, Sussex, England; an item I may consider for purchase eventually for our studio at the University of Illinois.

accomplished thus far in electronic music in England, the following activities seem to be the most significant:

1. BBC-Dr. F.W. Alexander

BBC, of course, has resources that might be applied to experimental musical activities. Hope for such activity seems warranted primarily because of the existance of an embryo studio for electronic music under the direction of Dr. F.W. Alexander, who is a sound engineer at BBC. Dr. Alexander has built up a studio for BBC that contains basic equipment such as oscillators, tape recorders, an Albis filter, and so on. I did not actually see the studio due to lack of time, but Dr. Alexander told me it contained nothing unusual. He also gave me a demonstration tape they have prepared of available techniques. He also said that thus far the use of the studio has been restricted to providing continuity and background effects for TV and radio shows. He is reluctant to go into electronic music production per se because he is critical of procedures that require so much tape editing, splicing, and montaging. However, he feels that BBC must become involved in one way or another before too much longer in line with what the German and French broadcasting organizations have done. In such an eventuality, composers would work by invitation for specified lengths of time. Finally, Dr. Alexander remarked that he would prefer to employ digital techniques, perhaps in conjunction with a computer, as soon as the possibility presents itself in practical form.

2. Dartington Summer School, Dartington

In the summer of 1960, Marc Wilkinson and Bruno Maderna started an elementary and highly improvised electronic music studio at the Dartington Summer School as part of the teaching activities there (see Section II). The purpose of this studio thus far is primarily pedagogic. The technical side of the effort has been handled by Frederick C. Judd, an electronics engineer living in London. Apparently, Judd has thus far contributed much of his own personal equipment to the studio. This

past summer, the studio was run by Luciano Berio and Judd. Judd, although not primarily a composer, has developed some interest in this direction and has prepared at least one composition, The Butterfly. Judd has recently written a short book based on his experiences (38).

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(38) F.C. Judd, Electronic Music and Musique Concrite, Neville Spearman, Ltd., London, 1961. See also F.C. Judd, "The Composition of Electronic Music," Audio and Record Review, 1: No. 3 (Nov.), 27, 1961.

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3. Marc Wilkinson

Marc Wilkinson, a composer living in London, has prepared one piece of electronic music at RAI-Milano and is working at present (fall, 1961) on two simple pieces of tape montage for BBC. He has taught at Dartington several summers and was involved in setting up the electronic music studio there (see above).

4. Daphne Oram

Finally, Dr. Alexander and Mr. Wilkinson gave me the name of Daphne Oram (Tower Folley, Fariseat, Near Wrothham, Kent) as someone who is doing something in electronic music. She was a technician at BBC but quit to work on her own.

E. Holland and Belgium

Significant activity in electronic music in the low countries is thus far confined to four locations: The Universities of Utrecht and Delft in Holland and at two locations in Brussels, namely, INR (the Belgium radio) and APELAG (a large electronics firm). Of these, thus far, the most important studio is the one in Utrecht. The studio at the University of Delft I did not visit.

1. University of Utrecht, Utrecht, Holland

Some years ago Henk Badings, a leading Dutch composer, was invited to visit N.V. Philips Gloeillampenfabrieken, the large

electrical and electronics firm located in Eindhoven for a period of three weeks to compose a score of electronic music, even though the attitude at that time at Philips toward electronic music was skeptical. Philips set up a more-or-less improvised studio for Badings that is described in an article in their technical journal (39). The ballet score, Cain and

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(39) H. Badings and J.W. De Bruyn, "Electronic Music," Philips Tech. Rev., 19: 190, 1957/1958.

Abel, that resulted from this collaboration employed all the equipment described in this article in one place or another even though Badings did not care for the effects produced by some of the instruments.

Upon Mr. Badings invitation, I visited his home to discuss his more recent work and to visit the new studio now being installed at the University of Utrecht in Utrecht, that supplants the facilities set up by Philips at Eindhoven. In fact, the Philips electronic music equipment has been moved there and all work at Eindhoven terminated. This new studio is being built and run with Philips support; Philips supplying funds for equipment and maintenance, the University of Utrecht supplying funds for staff salaries. The director of the studio is Dr. Rudolf Vermeulen who, until his recent retirement, was a research director at Philips. Henk Badings will apparently be associated with the studio as a Professor of Music at the University where he will teach electronic music and related topics. However, this arrangement with the university had not been completely worked out at the time of my visit. The staff also consists of three technical assistants and secretarial help. The studio is located at Plompetorengracht 14, Utrecht, in a three-story building that is being renovated to suit the needs of the studio.

At the time of my visit in August, 1961, apparatus from Philips was still being set up and so the arrangement was rather provisional. Several connecting rooms on the ground floor lead from offices to a small conference room, to a workshop, then to a room in which four speakers, one on each wall are used to play back materials prepared on four-channel tape, and finally to the electronic music studio proper. The equipment in the studio is presently set up on conventional laboratory benchwork and consists principally of the following items: (a) A bank of sine-tone generators, normally set at the 12 equal tempered pitches within an octave. (b) Square wave and pulse generators. (c) An Allison variable band-pass filter. (d) A large bank of fixed-frequency resonators that have low fall-off, about -6 to -10 dB per octave. (e) A patch panel. (f) A Stroboconn. (g) About six ordinary tape recorders. (h) A four-channel tape recorder employing one-inch tape. (i) A special playback mechanism in which three tapes can be played back simultaneously over a wide head and driven by the same clutch mechanism. This apparatus, similar in some respects to one of Schaeffer's devices in Paris, is convenient for collage. Moreover, a double loop of a single tape can be threaded through the unit to set up curious and complex loop repetition patterns, (j) A simple reverberation deck on which a simple tape guide can be moved over a track to yield different reverberation times, (k) An ondes Martenot, (l) A Springer time-compressor-expander which has given the studio much trouble, (m) A time envelope control circuit--a "gate circuit" that is derived from a simple circuit described in the article referred to above but is much improved and moreover will handle four channels simultaneously. Technicians at the studio were completing the circuit at the time of my visit. It provides exponential attack and decay curves independently for each channel and is set by an electronic clock circuit. Finally, it might be mentioned that some of the equipment used at Eindhoven, such as the "optical siren" which apparently was not very practical, was not brought to Utrecht.

Badings has completed a number of scores the past several years first at Eindhoven and later at Utrecht. Some of these are available in the United States on a disk recording (40).

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(40) H. Badings, Capriccio for Violin and Two Sound Tracks; Genese; Evolutions; Epic LC-3759, 12" LP record.

In addition to these, he particularly mentioned Salta Mortale, a science fiction opera in two scenes lasting about one hour that requires five singers and tape recorder. Other composers have also used the Philips-Utrecht facilities the past several years. Dr. Vermeulen has sent us a complete list of compositions and tape recordings of the more important pieces. In general, the stylistic position of the Dutch electronic music composers is more traditional that the Germans, particularly in the sense that serialism of one form or another is a technique that has been little used in Holland to date. Badings feels that both the Cologne type composers and the Paris musique concrète composers are too doctrinaire and that an acoustic basis of electronic music is required first of all. Badings background includes engineering as well as music, so he is able also to deal with the more technical aspects of electronic music. He is also planning a series of experiments in computer music (see Section V).

A final point is to note that since the studio is now located in a university, the possibility of exchange arrangements for, say, student composers working there on Fulbright awards, arises. Badings was receptive to this idea.

2. INR, Brussels

Louis de Meester, who is a sound engineer at the studios of INR (Institut Nationale Radio-television) at Place Flagey, Brussels and who supervises the use of sound in the organization, has prepared several scores of electronic music that employ mostly but not exclusively, concrete sounds as original sound

materials. He employs the equipment at INR plus some of his own equipment at home, though INR lets him use their equipment -- tape recorders, reverberation chamber, and audio oscillators, it has not set up an electronic music studio in any real sense of the word, nor would I gather, does it plan to.

Louis de Meester's scores include St. Antonius, a cantata for orchestra, small chorus, soloists and tape; Incantations, a piece employing two voices as sound sources and Industrie a new ballet score for the 1961 Ghent festival. He gave me tape recordings of these last two compositions. The stylistic orientation of de Meester's music is basically French, and is not in a "cerebral German style," as de Meester puts it.

3. Studio APELAG, Brussels

APELAG, a large Belgian industrial electronics firm has provided a small electronic music studio for Henri Pousseur (Address: 24, Avenue des Genêts, Overijse, Brabant, Belgium) who has worked also at Cologne, Milan, and very recently, at Siemens in Munich. Pousseur has composed a number of electronic music scores over the past several years, including a score to Electré which has recently been made available on a disk recording (41). In general, Pousseur's stylistic orientation

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(41) H. Pousseur, Electre, Universal Edition 13,500, 12" LP record.

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is within the German esthetic-total serialism, pointillism, etc. I did not actually visit Pousseur's studio, which he operates in collaboration with Herve Thyé, but I talked to Pousseur and Thyé briefly at Donaueschingen about their work. They told me that, thus far, their facilities were extremely modest and contained only the most basic equipment and no unusual apparatus.

F. Poland

The single electronic music studio in Eastern Europe is a studio located at the headquarters of Radio Polskie in Warsaw. The existence of this studio in Poland is yet additional evidence of the rather independent and active musical and cultural renascence in Poland at present that I commented on earlier (see Section II). As far as I know, this studio is still the only functioning studio in this part of the world though I have been told that a rather elementary photoelectric electronic music synthesizer has been recently built in Russia, a country I did not visit on this trip.

The Radio Polskie studio is directed by Mr. Jozef Patkowski, a musicologist with a background in physics and acoustics who also teaches part-time at the University of Warsaw. He and his technical assistant have designed and built much of the present equipment in the studio. No composers are directly employed by the studio, but various Polish composers use it upon request or invitation. The principal compositions thus far completed include Psalmus 1961 by Krzysztof Penderecki and Etude pour un Seul Coup de Cymbale by Wlodzimierz Kotónski, as well as a number of film scores by both these composers and others. Mr. Patkowski has sent us a tape of several of these compositions.

At present the studio is located in a medium sized room at Radio Polskie and contains the following equipment: (a) several sine wave generators. (b) A sine-square wave generator. (c) A white noise generator. (d) A simple patch panel. (e) An oscilloscope from which a tap also provides a sawtoothwave (the sweep signal) when desired. (f) A homemade time compressor-expander unit like the Faribanks-Everitt and Springer machines that works very effectively over a short range--approximately ±10%. The drive for the rotating playback head is controlled by rotor-disk drive, the position of the rotor on the disk being set by a simple screw mechanism. This drive mechanism appeared rugged and dependable. (g) A home-made reverberation deck that employs a tape loop and a number of heads.

(h) Several ordinary tape recorders. (i) A four-channel tape recorder employing one-inch tape.

The most interesting aspect of the Radio Polskie studio involves the plan of a new studio now being built that was designed after Mr. Patkowski's specifications, by Mr. Oskar Hanson, a well-known Polish architect of considerable international reputation. An unusual feature of this new studio is that the walls will be made up of tall panels that can be flipped over to shift from high sound reflectivity (plaster surface) to high absorptivity (a cellutek-type material) that will be colored red. Thus, the actual acoustic conditions under which a tape is prepared can be precisely specified within certain limits in terms of studio reverberation time. In the new studio, according to the plans and a scale-model that I was shown, the electronic music equipment will all be disposed around a central control panel on conveniently arranged modular racks set at various angles so that all controls are within arm's length of the composer seated at the console. The equipment to be provided will be integrated into an assembly that should make this studio equal in technical facilities to the best studios now existing at Siemens in Munich, RAI in Milano and the University of Utrecht in Holland.

The new control console for the new studio has been completely designed and will be soon constructed. It is a four-channel system throughout and is efficiently arranged in terms of linkages to sound sources, to sound modifying equipment and to tape recorders. It has also provisions for reducing the number of channels by simple controls. I noted that except for the number of channels the basic design and circuitry resembles rather closely the console we are now building at the University of Illinois.

G. Canada

Although my sabbatical trip did not include Canada, it so happened that just before and just after the trip, I was able to obtain up-to-date information regarding electronic music activities in Canada so it seems convenient to includ this information here. The two principal activities to report here concern recent work of Hugh Le Caine in Ottawa and the new electronic music studio at the University of Toronto.

1. National Research Council of Canada, Ottawa (Hugh Le Caine)

Hugh Le Caine, who has worked for a number of years on various applications of electronics to music (42), has spent

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(42) H. Le Caine, "Electronic Music", Proc. IRE, 44: 457 1956.

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the past several years building a special recording and dubbling assembly for editing tapes. This is described in a recently published pamphlet (43). It is my understanding

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(43) H. Le Caine, Revised Specification for a Tape Recorder for Use in Electronic Music Studios Developed by the National Research Council of Canada, Ottawa, Canada, 1961.

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that one of these units is being acquired by Josef Tal for an electronic music studio in Israel. In addition, the facilities at Ottawa have been used by Istvan Anhalt, a composer on the faculty of McGill University in Montreal to produce several electronic music compositions, a copy of one of which we have obtained from Mr. Anhalt.

2. University of Toronto

An electronic music studio has been established at the Royal Conservatory of Music, University of Toronto under the direction of Myron Schaeffer. Although I did not visit this

studio on my trip, Professor Schaeffer, accompanied by Professors Arnold Walter and Harvey Olnick visited Urbana in March, 1962 at which time I was able to obtain a verbal description of their facilities and plans. Apparently, this studio will be well equipped with all the usual electronic music apparatus including sound generators and moderators, control equipment and tape recorders. In addition, Professor Schaeffer has constructed apparatus of original design including a particularly useful time envelope control circuit (44). At the time of

(44) M..Schaeffer, "The Hamograph: A New Amplitude-Rhythm Control Device for the Production of Electronic Music," Abstract of paper presented at the 61st Meeting of the Acoust. Soc. Am., Phila., Pa., 1961.

their visit to Urbana, I was told that their present facilities were being expanded and moved to a new building. They expressed a desire to have me visit the studio after it is set up in its new quarters in June. We discussed curricula for teaching electronic music techniques, including problems of how to organize student access to equipment. Even prior to their visit, Professor Schaeffer had sent us tapes of electronic music compositions prepared both by himself alone and in collaboration with Professors Walter and Olnick.

H. United States

I made no particular point of trying at this time to obtain most recent information concerning various electronic music centers in the United States since I keep in reasonable contact with the Princeton-Columbia Electronic Music Center at Columbia University, the only really highly organized studio in the United States besides our own studio. When I did visit this studio later in April, 1962, the principal new development I saw was the new electronic tape music equipment recently installed there in a room near the studio occupied by the RCA Electronic Music Synthesizer II. This new tape music installation is similar in design to the earlier one built up by Otto

Luening and Vladimir Ussachevsky, but with a much improved console and control panel. Five Ampex tape recorders (three stereo, two monaural) are incorporated into this new arrangement. Oscillators, a Krohnhite bandpass filter, and a variable speed control for the tape recorders comprise the most important other pieces of equipment. An important added feature, however, is that access to circuits in the synthesizer is also provided so that additional sound signals such as a sawtoothwave or white noise may be obtained. Moreover, access to a four-track tape recorder now incorporated into the synthesizer is also possible. One other unit available with this electronic music equipment is an EMT reverberation chamber.

The only other major developments worth mentioning at this point include, first, the recent opening of an electronic music studio at Yale University under the direction this year of Bulent Arel, a Turkish composer and sound engineer who formerly worked at the Columbia University project.

I also visited Yale in April at which time Mr. Arel, Allen Forte and Mel Powell showed me the electronic music facilities they have thus far assembled. They have some oscillators and other sound sources, a Krohnhite bandpass filter and a cathode-ray oscilloscope, but so far only one tape recorder. Thus, their immediate concern is the acquisition of at least two more tape recorders. In August, however, Mr. Arel plans to return to Turkey to set up a studio in Ankara, so I would gather present plans at Yale are rather uncertain.

Second, though nothing official has yet been done at the University of Michigan, two composers, Robert Ashley and Gordon Mumma, who have been students at the school of music there have on their own composed a number of interesting electronic scores, not only concert music, but also music for films and visual presentations. Mr. Ashley has recently sent us tapes of a number of electronic compositions by himself and by Mumma. I do not know at the moment how much equipment Ashley and Mumma

have to work with.

Finally, I might note that Richard Maxfield, a New York composer who has taught at the New School for Social Research, has composed tape compositions that he apparently prepares on his own equipment. I heard some of these at a dance concert in New York City in February and of then the most interesting to me was a piece entitled Radio Overture..

Summary - Technical Equipment

As can be seen by the foregoing, I found relatively few pieces of unusual or interesting equipment of possible interest to us. To summarize, the situation at present seems to be the following:

(1) Sound generators. At the University of Illinois, we are as well equipped with sound generators as any studio in Europe, better than most. Our sound generating equipment is being built following considerations of acoustic necessities and can already provide a full range of timbres from the simplest to the most complex. We hope to improve some of our equipment--particularly our sawtoothwave generator and perhaps eventually acquire the Servomex generator, referred to above (England) or roughly equivalent Tektronix equipment.

In the European electronic music studios, I almost never found comprehensive sound generating systems. More often, it seemed that the available equipment consisted only of commercially manufactured apparatus acquired with little consideration of what is really required. The absence of sawtooth-wave generators is an obvious case in point. As far as I know, no simple audio frequency sweep generators are on the European market (I have yet to discover one in the U.S. either) so this whole important spectrum of timbres (sounds with even harmonics as well as odd ones) produced from such sources is largely absent from European electronic music. In many studios there appeared to me to be an unnecessary duplication of items like sine wave and sine-square wave generators.

(2) Filter circuits. The Albis filter, because it easily provides irregularly shaped formants as desired is clearly a most interesting item. I have acquired technical data on this filter circuit. Though the unit has been subject to some criticism because of certain small irregularities in frequency response, this is probably not too serious. The Albis filter, plus the Allison variable band-pass filter that we already possess would seem to provide sufficient filtering action for any reasonable specifications with regard to subtractive timbre synthesis. The various other filter circuits I saw in Europe, though some are well-designed and useful in other application, simply duplicate functions provided by the two items mentioned above.

(3) Time-envelope circuits. The only studios that were adequately equipped with circuits for controlling attack and decay, i.e., transient control, were the studios in Utrecht, Warsaw, and Milan (plus of course in this country and Canada, the RCA Synthesizer at Columbia University and at the University of Toronto). Mr. Frank Weinstein, a student who has worked in our studio has built a circuit of our own design that is basically as good as all of these except the complex circuit described by Dr. Heck for controlling every single overtone separately. Therefore, with respect to transients, we are as well equipped as most electronic music studios in Europe.

(4) Frequency shifting--Transposition. Dr. Ludwig Heck's klangumsetzer seems to be the most satisfactory electronic unit for this function aside from special tape recorder decks (see below).

(5) Consoles. The two-channel console we are now building is as good as any I saw in Europe and more compactly arranged than most of the good ones. I did not see any unusual or particularly interesting test and measuring equipment.

(6) Tape recorders. We are currently replacing our obsolescent monoaural Presto tape recorders with new professional quality Ampex tape decks that will provide two-

channel stereo recording. Our console, described above, is designed to go with this new recording equipment. I am unenthusiastic about the four-channel tape recorders I saw in a number of the European electronic music studios for several reasons: (1) I can't help but think that their presence in many studios is the result of manufacturers' sales promotions. Many of the studios that own these recorders do not possess more basic equipment, indicating no consistent policy of equipment acquisition. (2) Although a case for four-channel "spatial" music can be made, I think the solution of other problems should take precedence. (3) Already, there is talk of six-channel, eight-channel, and even more complex systems. This obviously becomes very expensive, cumbersome, and can continue without end.

(7) Special tape-handling units. It is here that I found several interesting and important items. Among these, I include: (a) The Springer time compresser-expander as extremely useful and important (or the equivalent Fairbanks-Everitt machine manufactured by Kay Electronics, whichever is better). (b) Reverberation decks. Some of the European reverberation decks seem quite good, However, the decks manufactured by Audio Equipment Company seem entirely adequate for electronic music synthesis. I see no point in using acoustic reverberation chambers or mechanical reverberations. (c) A deck with a multiple clutch operating several tapes at once. This would be most useful, but we would have to build such a unit ourselves. An item of this sort is desirable but not essential. (d) Hermann Heiss's (Darmstadt, Germany) special tape processing deck seems to merit further investigation because of the ease with which it can be used to build up certain kinds of sound structures. (e) Variable speed control of tape decks. In Milan, this is done by driving a hysteresis motor with variable frequency alternating current. The difficulty with this technique is that serious overheating and wear of the motor will occur if the frequency deviates too far from the specified normal frequency for the motor (60 cps in the U.S.). At RTF,

mechanical speed control is employed. Variable voltage drive of a series-wound direct current motor should also be investigated before a system is selected.

V. Computer Music and Related Studies

The application of electronic computers to various musical problems, notably to musical composition, is one recent development in experimental music which we can claim to have initiated at the University of Illinois. In a book written by myself and Leonard Isaacson that was published in 1959 (1), the work which

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(1) L.A. Hiller, Jr. and L.M. Isaacson, Experimental Music, McGraw-Hill Book Co., New York, 1959.

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led to the production by means of the ILLIAC of the Illiac Suite for String Quartet (2) was described in explicit detail.

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(2) L.A. Hiller, Jr. and L.M. Isaacson, Illiac Suite for String Quartet, New Music Edition, Theodore Presser Company, Bryn Mawr, Pa. 1957.

Several other much more limited studies of musical composition carried out elsewhere up through 1958 were also referred to in that same book (1). Since its publication, one other article describing this earlier work has been published (3). Two

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(3) L.A. Hiller, Jr., "Computer Music," Scientific American, 201[6]:109, (Dec.), 1959.

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more recent articles, one a rather general article primarily intended for electrical engineering students (4), and the other,

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(4) L.A. Hiller, Jr., "The Electrons go Around and Come Out Music," IRE Student Quarterly, 8[1]:36 (Sept.), 1961).

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a more technical description of some of our more recent work, (5) have also appeared.

(5) L.A. Hiller, Jr. and R.A. Baker, "Digital Computer Studies of Musical Composition," in H. Borko, ed., Computer Applications in the Behavioral Sciences, Prentice-Hall, Englewood Cliffs, N.J., 1962, pp. 424-451.

Our most recent activities in computer applications to musical problems have not yet been otherwise described in published form but only thus far as annual reports to the University of Illinois Research Board (6). It is my intention to

(6) Letters to F.T. Wall, Chairman, University Research Board from L.A. Hiller, Jr., dated May 14, 1959; May 18, 1960, Apr. 28, 1961.

prepare much of this material for publication this coming spring and summer, starting with two articles already written that will probably be published in the next issue of Incontri Musicali or similar journals (7,8).

(7) L.A. Hiller, Jr., "Musical Applications of Electronic Digital Computers", In preparation.

(8) L.A. Hiller, Jr., "Information Theory and Music," In preparation.

In addition to our own work, considerable activity in applying computers to musical problems is developing in Europe by this time, apparently even in Rusia (9), one country

(9) R. Kh. Zavipov, "An Algorithmic Description of the Music Composing Process," Doklady ANSSB, 132:1283, 1960.

I did not visit on this trip. Other than this, I believe the description of activities following is reasonably complete for

the moment. For convenience, I have divided my discussion into three parts, (a) analytical studies, (b) composition with computers and (c) application of computer to practical musical problems.

A. Analytical Studies

The employment of mathematical procedures, and most usually statistical techniques that may be used, if desired, as data for information theory computations, for the analysis of music (and subsequently, its mathematical synthesis) has generated enough interest among European musicians that Hermann Scherchen last summer organized a conference in "Mathematics and Music" at his studio in Gravesano, Switzerland that was well attended and reported (10). This conference took place too early in

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(10) See, for example, W. Reich, "Gravesano an den Grenzen der Musik," Melos, 28:372, 1961.

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the summer for me to attend. However, I was able to find out about most of the material presented by Abraham Moles, Yannis Xenakis, Wilhelm Fucks and Newmann Guttman by means of separate meetings with these various people as will be described. Moreover, papers presented at this conference have been published in a recent issue of the Gravesaner Blätter and will be referred to at the appropriate places below.

(1) Abraham Moles and the Discussion Group, "MIAM," Paris, France

Dr. Abraham Moles has been closely involved with developments in experimental music in Paris for a number of years. His background includes physics and psychology as well as music, so he has occupied a rather unique position of developing the more theoretical aspects of musique concrète. He has been closely associated with Pierre Schaeffer for many years and was responsible, with Schaeffer, for developing the idea of

l'objet sonore, that appears to be one of the most useful acoustic concepts to come out of French experimental music so far. In addition to assisting Pierre Schaeffer in the preparation of the book A la Recherche d'une Musique Concrète, referred to in Section IV (Ref. 7), he has written a more recent book that summarizes much of his theoretical thinking and speculation about acoustics, aesthetics, psychological perception and information as applied primarily to musical communication (11). Since this book also provides background

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(11) A.A. Moles, Theorie de l'Information et Perception Esthétique, Flammarion, Paris, 1958.

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for much of the theoretical studies and speculation that affects experimental music in France today, notably the musique concrète group, it has seemed desirable that an English language edition of this work would be extremely useful. Dr. Moles is presently preparing such an edition that will be issued by the University of Illinois Press at my suggestion. Finally, Dr. Moles is also the author of a useful book that reviews current work in experimental music that was also referred to in Section IV (Ref. 2). Recent published papers by Dr. Moles are concerned with the "cybernetic" aspects of musical composition and thus disclose his interest in computer applications to musical problems (12, 13).

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(12) A.A. Moles, "The Prospect of Electronic Instrumentation," Gravesaner Blätter, 15/16:21, 1960.

(13) A.A. Moles, "The New Relationship between Music and Mathematics," ibid., 23/24:98, 1962.

I originally met Dr. Moles in Paris in 1957 and have maintained correspondence with him since; and on this trip, I met him first in Warsaw where he was attending a language study

conference and also saw him later in Paris on several occasions. I met with a small informal discussion group that he has organized called "MIAM", that discusses from time to time matters such as information theory and music, the applicability of cybernetics, mathematics and computers to musical problems, and topics of this sort. This group is made up of Dr. Moles, Yannis Xenakis (see below), A. de Chambure, from RTF (see Section IV), and M. Phillipot, a composer living in Paris who has written numerous scores, not only musique concrète but also instrumental music. Also present at one of these meetings was Pierre Barbaud who is currently much involved in computer composition (see below). This group has been meeting for only the past year, and primarily so far has managed to make a number of definitions of terms useful, among other things, in computer programming, and have sketched several models for "cybernetic machines" that might be useful either actually as such for electronic music synthesis or probably more feasibly, as models for machine simulation in a computer. Some of these ideas could well be subjected to testing in the future since both Xenakis and Barbaud are now involved in computer composition.

(2) Professor Wilhelm Fucks, Aachen, Germany

Professor Wilhelm Fucks is the director of the Institut für Physik at the Technische Hochschule in Aachen in which capacity his principal research activities lie in the field of nuclear physics. However, as a strong secondary interest, he is very much interested in applications of statistics and communication theory to both language and music. His published articles include research into language structure (14) into

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(14) W. Fucks, "Mathematical Theory of Word Formation," in C. Cherry, ed., Information Theory, 3rd London Symposium, 1955, Buttersworths Scientific Publications, 1955, pp. 154-170.

speech and music (15) and more recently, into music with par-

(15) W. Fucks, "Gibt es Mathematische Gesetze in Sprache und Musik?" Die Umschau in Wissenschaft und Technik, 2:33-37,

ticular reference to historical style (16). The statistical

(16) W. Fucks, "Mathematische Analyse der Formalstruktur von Musik," Forschungsber. des Wirtschafts- und Verkehrsministeriums Nordrhein-Westfalen, No. 357, Westdeutscher Verlag, Cologne, 1958.

method he has developed is applied to the analysis of a large number of compositions selected from a historical period ranging from the Renaissance to the modern period. The basis of his method, very briefly, is the computation of frequency distributions and related parameters such as mean values, higher moments, variances, skewness, kurtosis, -- as in any statistical study -- and, in addition, entropy or information values as obtained from Shannon's equation:

$$H = -\sum_{i=1}^{N} p_i \log_2 p_i$$

which is perhaps the fundamental expression of information theory (17). Professor Fucks applies these procedures to the

(17) Three convenient references, among the many that might be cited, that present basic discussions of information theory are (a) C.E. Shannon and W. Weaver, The Mathematical Theory of Communication, University of Illinois Press, Urbana, Ill., 1949 and (b) C. Cherry, On Human Communication, John Wiley and Sons, New York, 1957, especially Chap. 5, and (c) J.R. Pierce, Symbols, Signals and Noise, Harper and Bros., New York, 1962.

analysis of note counts, interval counts, and so on, not taking his studies, however, to higher order combinations. When he

plotted the various parameters against historical periods, he found definite trends in, for example, pitch distribution that seems to correlate with the historical clarification of the concept of tonality. In more recent studies that he reported on at the Gravesano conference last summer (18), Professor Fucks

(18) W. Fucks, "Musical Analysis by Mathematics. Random Sequences, Music and Accident", Gravesaner Blätter, 23/24:146, 1962.

extended his analysis to include many very recent compositions, not only of composers of basically tonal music like Bartok and Stravinsky but also of composers of serial music like Webern, Nono, and Boulez and others of the "post-Webern" group. Typical results indicate that recent serial composition apparently produces a reversal of direction of an historical trend in the statistics toward a more uniform distribution. Specifically, he found that the kurtosis* or fourth moment of the statistical distribution of pitches presents a regular trend toward larger values from 1530 until the present, until a sudden drop occurs that is associated with serial music. In general, it appears that this work may correlate very nicely with the work on information theory analysis we are now completing here at the University of Illinois (8).

I believe a certain amount of this analytical work was carried out with a digital computer. Since the time was so short, I did not discuss this with Professor Fucks. This would be, of course, a musical application of a digital computer, but

*kurtosis, χ, is defined as:

$$\chi = \frac{\sum (x-\bar{x})^4 p_x}{\left[\sum (x-\bar{x})^2 p_x\right]^2}$$

where $\bar{x}$ is the mean of some set of experimental values, x, of some quantity such as, for example, pitch in these studies.

only in an indirect way since because the programming involved would be that of standard statistical analysis.

B. Computer Composition

The mathematical composition of music by means of computers is perhaps the most interesting application of computer programming to musical problems. There are a number of such studies either under way or soon to start in Europe, apparently most of them stimulated into existence by our work here at the University of Illinois. The following studies comprise the activity in computer composition in Europe at the present time:

(1) Musique algorithmique of Pierre Barbaud and Roger Blanchard

Pierre Barbaud and Roger Blanchard are two Parisian musicians collaborating on experiments in computer music which they so far have carried out at the "Centre de Calcul Electronique de la Compagnie des Machines Bull" at 94 Avenue Gambetta, Paris, 20^{e}. Pierre Barbaud is a well-known composer of film music, while Roger Blanchard is best known professionally as a choral conductor. They are assisted by programmers at Compagnie des Machines Bull. This company is a large French manufacturer of data-processing equipment of all sorts; in effect, a French company resembling, for example, IBM. The director of the computing laboratory, M. Jean Esmein, is sympathetic to their project. My information about this project was obtained first by a visit with Mr. Barbaud and Mr. Blanchard followed by a visit to Compagnie des Machines Bull and second, from several articles I obtained during these visits (19,20,21).

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(19) P. Barbaud, "Avenement de la musique cybernétique; Les Lettres Nouvelles, 7[8]; 28, (Apr. 22), 1959; P. Barbaud, "Musique algorithmique," Esprit, No. 280: 92, (Jan.), 1960.

(20) Anonym., "Sur Deux Notes les Mathématiciens de l'Avenir Composent un Symphonie Complète," Courrier Bull, No. 49: 16, (Oct.), 1961; Anonym., "La musique algorithmique," Bulletin Technique de la Compagnie des Machines Bull, No. 2: 22, 1961.

(21) A.A. Moles, "La Musique Algorithmique, Premiere Musique Calculée," Revue du Son, 93[1]:28, 1961.

Barbaud (19) remarks that they had the traditional objective of creating order among "musical objects" such as the twelve tones of the ordinary chromatic scale by eliminating the arrangements "considered to be without interest." They proposed to use mathematics to do this, and specifically an electronic computer, after seeing, I believe, an article about our work at the University of Illinois written by Pierre de Latil for Figaro (June 25, 1959). Barbaud also cites the historical precedent of musical games for their work (22).

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(22) Including one new to me, an anonymous 18th century work in the Bibliotheque nationale: Ludus melothedicus [sic] Anonym. s.d. (1754), B.N. V^{8}_{m} 1137 , Dept. de Musique, which contains calculations "par lesquels toute personne composera differèns menuets avec l'accompagnement de basse en jouant avec deux dez même sans sçavoir la musique".

Thus far, Barbaud and Blanchard have completed essentially only one program for music composition. This is a species of twelve-tone music produced by first, the random generation of a tone-row and second the synthesis of extended structures from this tone-row by various combinatorial operations. The various available combinatorial operations are also randomly chosen. Thus, the structure of the resulting music is very much governed by chance. The actual program is based on defining tone-rows,

$$R_1 * R_2 = R_3$$

$$R_2 * R_1 = R_4$$

$$R_3 * R_4 = R_5$$

etc.

and operations, ϕ_1, ϕ_2, ... etc., such that

$$\phi_1 R_1 = R_2$$

$$\phi_2 R_2 = R_3, \text{ etc.}$$

Barbaud and Blanchard have used a standard textbook on combinatorial mathematics as their guide to programming (23).

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(23) J. Riordan, An Introduction to Combinatorial Analysis, John Wiley and Sons, New York, 1958.

As revealed in the two technical publications from Bull (20), the actual operations, ϕ_1, ϕ_2 ...., applied by Barbaud and Blanchard to pitch choices consist of addition and subtraction (transposition musically), multiplication (interval expansion), sign change around a chosen point (inversion), and some more complex operations such as recurrence, circular permutation, etc. Rhythms and octave displacement were chosen completely at random at the same time. The results were printed out in a simple alphanumeric notation rather similar to what we used for the original Illiac Suite and then scored by the composers. The finished music was used for several purposes, principally, a film score and a concert piece. This latter composition has been recorded (24) on an LP

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(24) P. Barbaud and R. Blanchard, Imprévisibles Nouveautés-Algorithme I, performed by an orchestra directed by R. Blanchard, 10" LP, Critere Productions R. Douatte, CRD430-A.

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disk, a copy of which I have obtained.

Barbaud and Blanchard are now working on a scheme for tonal music. They have completed a logical scheme for programming for this admittedly much more complex problem, but the actual programming and generation of the music resulting therefrom has been held up pending completion of a new arrangement with Compagnie des Machines Bull. In the meanwhile they have tested

their scheme by patiently throwing dice. Barbaud played me a sample from this preliminary test on the piano and the results so far sounded quite effective.

(2) Stochastic Music of Yannis Xenakis.

Yannis Xenakis is a Greek composer now living in Paris whose background includes architecture and mathematics as well as music. For a period of about twelve years, he was a principal assistant of Le Corbusier and was responsible, among other things, for the design of the Philips pavilion at the Brussels exposition (25). Soon thereafter, he stopped working

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(25) Y. Xenakis, "Le Corbusier's 'Electronic Poem' (for the Philips Pavilion at the Brussels World Exposition," Gravesaner Blätter, 9:51, 1957; Y. Xenakis, "The Philips Pavilion at the 1958 Brussels World Fair. - I. The Architectural Design of Le Corbusier and Xenakis." Philips Tech. Rev., 20 1 : 2, 1958/9.

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for Le Corbusier primarily to devote himself full time to musical composition. His principal musical instruction over the years has been with Hermann Scherchen, who has also performed several of his orchestral compositions.

Xenakis's instrumental compositions, a tape of some of which we have, disclose, among other things, unusual writing for strings, notably of glissandi, and secondly, in several pieces a structural basis, deriving from stochastic computations that are described in detail in a series of articles published in the Gravesaner Blätter (26). The best known of

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(26) Y. Xenakis, "Manipulation und Konzeption, I", Gravesaner Blätter, 1:15, 1955; "Manipulation und Konzeption, II," ibid., 6:28, 1956; "In Search of a Stochastic Music," ibid., 11/12:112, 1958; "Elements of a Stochastic Music--I to IV," inclusive, ibid., 18:84, 1960; 19/20:140, 1960; 21:113, 1961; 22:144, 1961.

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these is Achorripsis, the score of which is published (27).

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(27) Y. Xenakis, Achorripsis, Bote und Bock, Berlin, 1959.

The mathematical basis for the structure of this composition incorporates the use of the Poisson distribution to scatter the controlled musical elements uniformly over the entire composition.

Xenakis's background also includes the composition of concrete and electronic music, for which he has used the facilities of RTF and of Philips at Eindhoven. His compositions of this type include Volkslied (1956), L'Amen vitrieux (1957), Diamorphoses (1958), PH, (1958), all concrete music; Orient-Occident (1959), concrete film music for UNESCO, and Analogiques (1959), which presents electronic music and a string ensemble alternating. This last piece is also a stochastic composition. A disk recording that includes Diamorphoses is available (28).

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(28) Groupe de Recherches Musicales de la RTF, Musique Concrète, 12" LP, BAM LD070.

Orient-Occident will be released in the Philips series of disks mentioned earlier (see Section IV). We have a tape recording of Analogiques at our studio. It might be mentioned also, that Xenakis assisted Varese in the preparation of his Poeme Electronique for the Philips pavilion at the Brussels fair. Finally, as noted also earlier in this section, Xenakis is also a member of the small MIAM group organized by Moles.

Just recently, Xenakis has worked out an arrangement with IBM in Paris to use their computer (an IBM7090, I believe) to compose music according to his stochastic schemes. He has learned Fortran programming and at the time of my visit (November, 1961) had not only worked out the general logical

programming but also most of the detailed programming. He promised to send us a copy of this material plus his results when they materialize. The work of Xenakis promises to be of considerable interest.

(3) Institut für praktische Mathematik der Technischen Hochschule, Professor Dr. Alwin Walther, Darmstadt, Germany.

Interest in using computers for the analysis and synthesis of music has developed at this computer center in Darmstadt directed by Professor Walther. Unfortunately, I did not know of this development when in Darmstadt and when I later had it brought to my attention, it was too late for me to make arrangements to return to Darmstadt. The work so far carried out there has been reported by Neumann and Schaepper (30). This is an

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(30) P.G. Neumann and H. Schaepper, "Komponieren mit Elektronischen Rechenautomaten," Nachrichte Technische Z., 8:403, 1959.

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extension of some earlier work that Neumann had collaborated in at Harvard University (31). This new study, like that done at

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(31) F.P. Brooks, Jr., A.L. Hopkins, Jr., P.G. Neumann, and W.V. Wright, "An Experiment in Musical Composition," IRE Trans. on Electronic Computers, EC-6: 175, 1957.

Harvard, involves the stochastic analysis and synthesis of hymn tunes with the aid of an electronic computer.

(4) Cambridge University (D.G. Champernowne)

Mr. D.G. Champernowne, Trinity College, Cambridge, is a member of the faculty of economics who has used the computer at Cambridge University for problems in economics. He has also become intrigued, as a side interest, in programming

musical composition. In his spare time, he has developed two programs for musical composition that are quite sophisticated and effective within their sharply prescribed limitations. These are as follows:

(a) Synthesis of Victorian humn tunes. After the inspection of typical hymn tunes, Mr. Champernowne developed a set of empirical rules for composition of such music. He then wrote a computer program that consists of four distinct parts: (1) The generation of random numbers. (2) The generation of the top melodic line. (3) The generation of harmonic support. (4) Printout in alphanumeric notation. He has provision for rhythmic variety, passing notes, neighbor notes, and appogiaturas. Moreover, the program can also be used to harmonize given tunes, since part (2) of the program can be by-passed and independent melodic data used instead. Thus far, however, he can only generate one phrase at a time so awkward transitions can occur between the end of one phrase and the beginning of the next phrase.

Mr. Champernowne gave me several representative examples of the computer output he obtains. These disclose that this programming has thus far been very successful in solving this highly restricted musical problem.

(b) Synthesis of Serial Music. Mr. Champernowne has also written a program for the synthesis of a species of twelve-tone serial music in which a systematic permutation scheme permitted the production of a composition about 200 measures long. He applies some arbitrary rules that eliminate, I believe, certain dissonances. It is interesting to note that this music superficially, at least, bears a resemblance to that of Barbaud and Blanchard. This composition is scored for string quartet. Mr. Champernowne has promised to send us a copy of the score. It will be probably worthwhile to tape a performance of this music for documentation purposes.

Mr. Champernowne has not yet written an article for publication describing his programming but Dr. Mutch, the director of the Cambridge computer laboratory, has urged him to submit an article to the English Computer Journal, of which he is the editor.

(5) Institut für Kommunicationsforschung, Universität Bonn

Over a period of many years up to his recent death, Professor Werner Meyer-Eppler built up an Institute for Communications Research at the University of Bonn. Dr. Meyer-Eppler was a physicist very much interested in acoustics, speech and music. He was the author, recently, of an authoritative book on information theory (32), the author of some years ago of a

(32) W. Meyer-Eppler, Grundlagen und Anwendungen der Informationtheorie, Springer Verlag, Vienna, 1960.

very useful book on electronic instruments and electronic techniques of sound production (33) and, of course, of many research

(33) W. Meyer-Eppler, Elektronische Klangerzeugung, Dömmlers Verlag, Bonn, 1949.

articles. He was also influential in advising Dr. Eimert on the technical and theoretical necessities required in setting up the electronic music studio at NWDR in Cologne.

I had corresponded with Dr. Meyer-Eppler on several occasions during the past several years and had hoped to visit him in Bonn. His successor has still not been named by the University, so when I visited there, I met Dr. H. Schnelle, a physicist, and Dr. G. Heike, a composer, who direct some of the current research activities there. Dr. Schnelle is particularly interested in information theory analysis of language structures as well as speech research in general. The institute is well equipped with electronic

laboratory equipment, such as Tektronix oscilloscopes, x-y function plotters, wave-form generators, Allison filters, electronic counters, digital-analog converters, and so on. Because this is primarily a research institute, they are able to obtain considerable funds from the German government for laboratory equipment.

Drs. Schnelle and Heike are interested in making use of computers for analysis and composition. Dr. Schnelle mentioned that they have access to the University of Bonn computer (a German computer of medium size) and the University of Bonn will soon also have an IBM 7090 to which they will also have access. Dr. Heike would like to use a computer for composition especially since he has already written other music based on "order-disorder parameters" and has written an article on information theory and music (34).

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(34) G. Heike, "Informationstheorie und musikalische Komposition," Melos, 28:269, 1961.

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(6) Other Uses of Computers or Projected Uses of Computers for Music Composition

In addition to the above studies in computer music synthesis that already show results or are in progress, the idea of applying computers to musical composition has also been examined in a more tentative way in several other locations. Of these, the following appear to be of greatest potential interest: First, Henk Badings, at Utrecht, told me, that he will use a computer at Philips in Eindhoven for a project in computer music. Badings had already worked out an arrangement when I saw him in August, 1961, so that a technician at Philips would assist him in programming. In general, his project would consist of two interdependent studies: (a) The analysis of conventional music (by stochastic procedures primarily) and the synthesis of music from the results obtained

therefrom. (b) The composition of music "that I feel is my own".

Second, when I visited the computer laboratory at ZAM, the institute for mathematics research in Warsaw, my host, Mr. Fiatkowski, who is a mathematician and programmer there told me he is trying to program some elementary music problems for their computer. Mr. Fiatkowski has been much interested in this idea since reading my book about a year ago. The computer at this institute, incidentally, rather resembles the ILLIAC superficially. It also operates on a five-channel punched paper tape code similar to ours.

C. Practical musical applications

The two most important practical musical problems that a computer can handle are the synthesis of sound, a process that is competitive with the electronic music techniques reviewed in Part IV and the organizing and printing of musical notation. The first of these two problems has been satisfactorily solved at Bell Telephone Laboratories, as described below. The second problem is one that we are working on at the University of Illinois, principally through construction of a tape-controlled music typewriter. In addition to these two musical applications, I will mention briefly a study of computer-controlled picture synthesis that seems promising.

(1) Computer Sound Synthesis at Bell Telephone Laboratories.

At Bell Telephone Laboratories, Murray Hill, New Jersey, a unique process of electronic sound synthesis has been developed that I believe is superior to any other method of electronic music preparation and should supplant all other processes in due time. In our book (35), Leonard Isaacson and I suggested that

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(35). L.A. Hiller, Jr. and L.M. Isaacson, op. cit., pp. 174-175.

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this technique could be developed as a method of sound synthesis, little expecting that it would become a practical reality so soon. The process consists of two basic steps. The first consists of programming a computer to generate data on digital magnetic tape that provides a digital approximation of a continuous wave form. This programming has been carried out by M.V. Mathews for an IBM 7090 computer and is described in detail in published articles (36,37).

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(36) M.V. Mathews, "An Acoustic Compiler for Music and Psychological Stimuli," Bell System Technical J., 40:377, 1961.

(37) M.V. Mathews, J.R. Pierce, and N. Guttman, "Musical Sounds from Digital Computers," Gravesaner Blätter, 23/24: 119, 1962.

Once a tape of such data is prepared by a computer it is then taken to a digital-to-analog conversion assembly. The tape is played back and the data from it is fed to a chain of components consisting principally of a buffer memory, a Datrac digital-to-analog converter, and a conventional audio tape recorder. This unit can be run at real time. Moreover, it can be run in reverse direction so that analog-to-digital conversion can be obtained if desired. This equipment is described in published articles (38,39,40).

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(38) E.E. David, Jr., M.V. Mathews and H.S. McDonald, "Experiments with Speech Using Digital Computer Simulation," Bell Telephone System Technical Publications Monograph 3405. This monograph is made up of two articles as follows: "Description and Results of Experiments with Speech Using Digital Computer Simulation," Proc. of 1958 National Electronics Conference, pp. 766-775, and "A High-Speed Data Translator for Computer Simulation of Speech and Television Devices," IRE Western Joint Computer Conference (1959), pp. 354-357.

(39) E.E. David, Jr., "Digital Simulation in Perceptual Research", Proc. Nat. Electronics Conference, 15:322, 1959.

(40) M.V. Mathews and N. Guttman, "Generation of Music by a Digital Computer," III International Congress on Acoustics Record, Elsevier Publishing Company, Amsterdam, Holland, 1960.

The group at Bell Laboratories doing this work is directed by Dr. J.R. Pierce and consists principally of M.V. Mathews, N. Guttmann, E.E. David, Jr. and since last August, J.C. Tenney, who obtained his M. Music degree at the University of Illinois and was for two years a research assistant in our electronic music studio. In addition, David Lewin, a composer on the Harvard University music faculty has worked with this group on a couple of occasions. These various people have composed a number of short compositions over the past several years to illustrate the possibilities of control of timbre, rhythm and pitch by this new method. A number of these pieces have been collected on a disk recording issued last year by Bell Laboratories (41). In addition, a disk is now being prepared by Decca

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(41). Music from Mathematics, 10" LP available from Bell Telephone Laboratories, 463 West Street, New York, 14, N.Y. This disk also contains several samples of "stochastic music," plus an excerpt from the Illiac Suite.

Records that will contain all the compositions employing computer generated sound included on this earlier disk plus several new pieces by Mathews, Lewin and Tenney. I understand that it is scheduled for release next fall.

I have made an arrangement with Dr. Mathews that they realize in electronic sound the Second Illiac Suite now being prepared by Robert Baker and myself. In general, the people at Bell expects to continue the study of computer produced music on a modest scale and plan at present to invite composers to work there from time to time in the future.

Tenney is also using this system (computer plus converter) to prepare acoustic examples for psychoacoustic experiments.

One such experiment involves the perception of attack times from 2 to 50 milliseconds.

(2) Computer Control of Music Printing

At the University of Illinois, we have built a coded-paper-tape controlled music typewriter. We started with an ordinary Remington-Rand "Synchrotape" typewriter and with the help of Professor Cecil Effinger and Robert Oliver of the University of Colorado, we modified this unit so that it prints most of the symbols of conventional music notation. In addition, we programmed the ILLIAC so that it accepts and interprets the paper tape prepared on this unit, stores the format of a page of music, repunches a new tape that prints in logical rather than random order with line justifications in the score and automatic performance part extraction. Several times during the trip I visited music publishing houses or talked to their editors for various reasons and during the course of these discussions described our automatic music typewriter and showed them recent results, notably the line justification process. In every instance, not surprisingly, they were most interested. These included, among others, Universal Edition in London, Edizione Suvini-Zerboni, in Milan, and Polskie Wydawnictwo Muzyczne, the Polish state music publishing house in Krakow. Riccardo Malipiero, the music editor of Suvini-Zerboni, was especially interested, pointing out in the course of conversation that engraving is becoming expensive in Italy, too. Also, the visit to the Polish music publishers in Krakow was particularly interesting to me because they have designed a practical typing machine that works on a somewhat different mechanical principle than ours. Musical typeface like ours is held in a circular frame that can be activated by the operator to print a musical symbol on a page of music. The circular frame is rotated to select the desired symbol. Moreover, the typeface slugs are removable to permit the use of unusual symbols. A picture of this equipment is being sent to us by Mr. Ochlewski, the music editor there. An examination of

typical scores produced with this machine shows that it produces elegant results.. However, it is in no way automatic. Moreover, all the page design must be done in advance.

When I was in Munich, I saw Thomas Binkley, who used to be a research assistant at the University of Illinois during the first two-year periods of development of our automatic music typewriter. He expressed an interest in writing a detailed proposal for completing the programming of lute tablature transcription that he had worked on in our laboratory (6). This program is largely finished but when he left we had to put it aside until we completed the basic programming for the typewriter for entry and recovery of music format to and from the ILLIAC. Since this more basic programming is now finished, it is certainly possible that we could return to the lute tablature transcription program in the future, so I encouraged Mr. Binkley to send us a specific outline of his latest ideas.

(3) Computer Control of Picture Design

At the University of Bonn, one interesting series of experiments involves digitally controlled "electronic painting." In these experiments a screen resembling a small television screen is divided into small squares each independently controlled by binary code to be either white or black. Patterns are thus produced depending on how the digits 0 and 1 are distributed over the two dimensional field. Dr. Ludwig Heck of SWF, Baden-Baden, showed me photographs of various patterns produced by this technique, starting with random patterns of maximum information content and proceding to patterns with considerable organization and structure an, of course, redundancy. Related studies of computer generated visual displays have also been described by White (42).

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(42) B.W. White, "Studies in Perception," in H. Borko, ed., Computer Applications in the Behavioral Sciences, Prentice Hall, Englewood Cliffs, N.J., 1962, pp. 280-307.