N 0011-7145

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THE SOUND ENGINEERING MAGAZINE

AUGUST 1975 $1.00

IN THIS ISSUE:

- A View of Electronic Music
- Operations of Moog Synthesizer Modules and Components
- In the CD-4 Groove

coming next month

- Ingenuity in the use of microphones is the theme of two workshop articles coming in September.
- Michael Rettinger tells us how to *Calibrate Microphones by Reciprocity*. The secret is in using rapid alternation of loudspeaker transducers.
- *A Simple and Superior Microphone Preamplifier* is described by R. S. Mintz. The device uses an integrated circuit and a minimal number of external passive components.
- The first of a three-part series on *Feedback* by Norman H. Crowhurst deals with its effect on gain, distortion, and impedance as well as negative and positive feedback, and phase.

about the cover

- That's Roger Powell at the Moog Synthesizer. Photo copyright 1974 by Alan F. Blumenthal and used with permission.

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THE SOUND ENGINEERING MAGAZINE

AUGUST 1975, VOLUME 9, NUMBER 8

db is listed in **Current Contents: Engineering and Technology**

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db letters

THE EDITOR:

Towards the end of May, we wrote to you asking for possible manufacturers of RC-10 caplugs. As per your suggestion, we have written to both Atlas and Beyer, only to receive "No" answers. Perhaps one of your readers might have this information?

BILL BEATTY
DAVE BEATTY STUDIOS
1414 S. 5th
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THE EDITOR:

In the June issue, a letter from George W. Hamilton on page 2 caught my eye. I have Mr. Hamilton beat by a long time!

I was the first chief engineer of the Syracuse Radio Workshop, the predecessor of WAER during the years 1937-1938. The installation was built in the basement of the library building and consisted of two studios and a control room. The equipment was Western Electric, vintage of the early 30's, donated by WFBL when that station replaced it with more modern gear. The amplifiers used the old round bulb tubes, whose type numbers I cannot recall. The microphones were the Western Electric condenser microphones with the small vacuum tube amplifiers built into them. They were built into cylindrical cans which weighed a ton (so it seemed).

There was no f.m. in those days. Programs were produced for both WFBL and WSYR. When we went on WSYR, the call sign, WSYU, was used (same transmitter, different call sign). Their transmitter was located on the university campus in those days, and was 250 watts to a single vertical radiator. The transmitter had formerly been one which was built by Clive B. Meredith of Cazenovia, N.Y., who started WSYR as WMAC in his home.

Professor Kenneth Bartlett, later to become Dean and then Vice-Chancellor, was the director of the Radio Workshop. Operating that setup, antiquated as it was, was good fun, and we took it very seriously. The Workshop produced some very famous people in broadcasting, too numerous to mention here.

Just a bit of nostalgia from those old days.

PAUL H. LEE, President
P. H. LEE ASSOCIATES, INC.
Thousand Oaks, Ca.

THE EDITOR:

With reference to your listing of suppliers of audio gear in the San Francisco area in your June issue, please accept an indignant "You left me out" complaint. The Langevin Company, Inc. is the oldest firm in this area, supplying and installing professional audio systems and equipment since 1927. We represent many of the top quality professional audio equipment manufacturers as well as custom-building systems for specific requirements.

Thanks for the opportunity to correct this oversight.

H. A. WOLLENBERG, President
THE LANGEVIN COMPANY, INC.
1050 Howard St.
San Francisco, Ca. 94103

THE EDITOR:

Just read Bob White's article, "A Simple High-Quality High-Speed Tape Duplicator," in the May issue and I want to inform you that I have a model 970 Ampex if anyone is interested in buying it.

D. M. Wesenberg
1904 Harlan Rd.
Toledo, Ohio 43615

you write it

Many readers do not realize that they can also be writers for **db.** We are always seeking meaningful articles of any length. The subject matter can cover almost anything of interest and value to audio professionals.

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CALENDAR

SEPTEMBER

15-17 **NOISE-CON '75** National Conference on Noise Control Engineering. Gaithersburg, Md. Pre-seminar at the Shoreham Hotel, Washington, D.C. Sept. 11-13. Contact (914) 462-6719.

21-24 **International MUSEXPO '75,** Las Vegas, Nev. Contact: Roddy Shashoua, International MUSEXPO, 1350 Ave. of the Americas, New York, N.Y. 10019. (212) 489-9425.

28-Oct. 3 **SMPTE Technical Conference and Equipment Exhibit.** Century Plaza Hotel, Los Angeles. Contact: SMPTE Conference, 862 Scarsdale Ave., Scarsdale, N.Y. 10583.

29-30 **N.Y. Chapter of ERA, Commercial Sound & Communications Show,** Statler-Hilton Hotel, New York City. Contact: GIM Sales Corp., 375 N. Broadway, Jericho, N.Y. 11753 (516) 433-4080.

First Congress of the FASE on Acoustics. Groupement des Acousticiens Francaise (GALF). Paris, France, Secretariat: C.N.E.T., Issy-les-Moulin-eaux 92, Paris.

OCTOBER

Fall Conferences, National Association of Broadcasters. Contact: NAB, 1771 N St., N.W., Washington, D.C. 20036. (202) 293-3500.

12-14 Atlanta

15-17 Boston

21-26 **International Audio Festival Fair.** London, England. Contact: British Information Service, 845 Third Ave., New York, N.Y. 10022. (212) 752-8400.

NOVEMBER

3-31 **Audio Engineering Society 52nd Convention,** Waldorf-Astoria Hotel, New York, N.Y. Contact: AES, Room 929, 60 E. 52nd St., New York, N.Y. 10017. (212) 661-8528.

4-7 **Meeting of the Acoustical Society of America,** San Francisco, Ca.

NAB Fall Conferences. Contact: NAB, 1771 N St., N.W., Washington, D.C. 20036. (202) 293-3500.

9-11 New Orleans

12-14 Chicago

16-18 Denver

19-21 San Francisco

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MEASUREMENTS

PORTABILITY . . . And Your Best-Buy Instrumentation for Sound & Vibration Measurements is the title of this brochure. Material includes graphic comparisons of analyzers, meters, specialized measurement equipment, and recorders. Mfr: B&K Instruments, Inc.

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VIDEO CASSETTE PROCEDURES

Proper handling and storage procedures for video cassettes is the topic of the Spring issue of *Scan*, a four-page newsletter published for video tape users. Mfr: Memorex.

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METERS AND RECORDERS

This 60-page instrumentation catalog describes over 2,000 stock ranges, sizes and types of analog, digital and AnaLed panel meters, chart recorders, meter relays, pyrometers, controllers, digital and analog test equipment, and portable instruments. Mfr: Simpson Electric Co.

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Catalog contains over 200 cassettes on Management. Data Processing—Technical, Computer Design/Computer Aided Manufacture, Instrumentation, Production and Inventory Control. Metals, and Software Industry Development. Mfr: Information Cassettes, Inc.

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SPECIALTY ALLOYS

Vacuum-melted alloys for electrical and electronic applications are described in bulletin EA-03. Mfr: Magnetics Specialty Metals Division.

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INTERCONNECTION MOLDINGS

Specialty moldings, test fixtures, test sockets and die stamping and die forming are described in this brochure. Mfr: Plastronics.

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D.C. POWER SUPPLIES

Covered in this catalog are bench-type units for circuit testing and development, modular supplies to power systems, high-power supplies used in industrial processes and special purpose units. Mfr: Hewlett-Packard Co.

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POWER DARLINGTONS

Graphs and diagrams illustrate this data sheet on 125 watt high voltage monolithic Darlingtons. Mfr: International Rectifier.

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MICROPHONE USE FOR MUSICIANS

"The Music-Maker's Manual of Microphone Mastery" describes in non-technical terms how to mic professionally voices and instruments, with listings of proven techniques for handling especially troublesome sound pick-up situations. Specific microphones for various instruments and situations are specified. Mfr: Shure Brothers, Inc.

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AM STEREO SYSTEM

Evaluation criteria for a.m. stereo broadcast systems are discussed in this booklet. It describes the system which RCA demonstrated at the 1975 National Association of Broadcasters convention. Mfr: RCA.

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db theory&practice

NORMAN H. CROWHURST

• The more we get into educational use of media, which involves some really wonderful opportunities to use one's creativity, the more we also run across the same obstacles. And as readers of this column will undoubtedly get into the same spots sooner or later, it should be helpful for me to pass on some of my own experiences.

COMPATIBILITY

Audio people have met this gent before when we made the step from mono to stereo, first in disc, later in multiplex f.m. and more recently as we became involved with various things called *quadriphonic*. So the problems of achieving compatibility are not new to us. But they sure are to educators and teachers.

Sometimes this poses tougher problems than at others. For example, for my mediated English course, and my physics course, there was not much problem: just give the course the traditional name, and handle it differently. Maybe that only postpones the compatibility problem until the teachers have it in the classroom, but it does at least get things started.

With mathematics we had a much tougher problem. There are already what should be more than enough courses on mathematics: old, many kinds of new, and all kinds of in-between. Yet none of them seems to have made mathematics either enjoyable, or convinced people who have already been turned off by the very word that it's not beyond them at all when you approach it in a sensible way.

The only place you will find mathematics being approached sensibly so people are turned on by it and start learning easily, is in the classroom of an individual teacher who has that capability. We have already proved that it is impractical to start trying to change all existing teachers. We have also proved that a well-written textbook can work, provided some obnoxious teacher doesn't get in the way, and that individualized mediated instruction, which helps keep the teacher out of the way, can also make it happen.

But then the compatibility thing comes in, a little differently than with other subjects. If you call it "mathematics," the very word conjures up a barrier against you. Most of the students have seen such horrid things as fractions, algebra, geometry, etc., and you cannot sell *mathematics* to them anyhow. And really you cannot blame them. Learning math that compartmented way makes no sense whatever.

But learning *Problem Solving Arts* gets to be fun, for anyone. However, administrators, teachers and others now mess things up by throwing a whole bunch of compatibility problems at you. Oh, they won't call them *compatibility problems*—as we said, they don't know the word, yet! But the way they've been trained, after a student is exposed to a certain course, he must be given a test to prove that he's absorbed an adequate amount of instruction.

TESTING AND TESTING

There are different attitudes to tests. First, there is this compatibility question: if the student learns it the Problem Solving Arts way, will he be able to satisfy the traditional form of test, based on the algebra, geometry, algebra 2 sequence? If you are preparing a course, such as the Problem Solving Arts course I prepared, then this must be one of your requirements. You design the course, as we did, so that as well as coming to grips with the subject, and knowing it much better than he would by learning it the traditional way, the student can also satisfy any test based on the traditional method of learning it.

That may sound like a tall order. Actually, it is a piece of cake, provided you accept the fact that you must do it. The only thing that could conceivably throw the student in a conventional test is not knowing what some of the words mean. There is no doubt that he could solve the problem, but he may not understand what the question means. Of course, that situation is not new—plenty of students who learned by the traditional courses have run into that!

So you design the course so while primarily covering the subject, it also gives the student confidence in his own ability to solve problems. Then you fill in with the fancy words he may meet in conventional tests, and that won't take long when he knows the subject anyway. We have always found that you can help the student learn the basics of the subject, fill him in on all the possible variations he may encounter in various tests, and still have time to spare over that taken by teaching it the conventional way.

Before leaving conventional tests, we should comment a little more on what such tests mean against their more common background. Almost nothing, as we have said before. All they show is that the student can regurgitate what he has recently been shown. A parrot or a monkey, properly trained, could probably do better than most human students.

Added to this is the fact that students conventionally work, often quite hard, at being able to pass tests, rather than at learning the subject. When you realize that learning to pass tests is much harder than learning the subject so you can pass any test on that subject, you will wonder, as we did, how so many people could be so stupid!

TITLE COMPATIBILITY

What we have just been saying could apply equally well to a course in English, physics, or just about any subject you could name. The case we were discussing happened to be mathematics vs. Problem Solving Arts. However, regardless of whether the student ultimately learns the same thing or not, or whether he learns it better, titles are very important in education.

When you look at a school or community college catalog, you find there are two kinds of courses: credit and non-credit. Credit courses pay the instructor more, for one thing. But students are also more interested in credit courses, because those little numbers called credits count toward some paper qualification that seems vital to him, whether or not it means he knows something.

So, given this alternative we are talking about, the already accepted math courses, some of them at least, carry credit, but give the same acquisition of knowledge and skills the name "Problem Solving Arts," and bang goes the credit, for both instructor and student. So what can you do?

You have two options. One is to offer Problem Solving Arts, with the promise that, after successfully taking it (and pointing out that it's much easier to take) you will be able to successfully challenge specified math credits or whatever subject is involved. For some purposes this might be best, but we will not digress into the economics and finances involved, because these differ from place to place.

The other option is to offer the course as the math course whose credit will ultimately be achieved, merely changing the approach used in presenting it without altering its title. But here again, you cannot just do this if the institution for which you are doing it happens to specify that the text

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used shall be Admiral Cornwallis' *Mathematics From the Ocean Floor Up!* You will need to get a variance or at least come to an understanding, whereby you guarantee results, or something.

This title compatibility can be a tough nut to crack, but creativity should always prove at least equal to stupidity!

BETTER FORMS OF TESTING

Being able to meet existing test results should not be the objective. We want to produce better learning outcomes and to prove that we are doing so. Relevant to this is a question that my spring class in metric systems asked me, after some of them had confessed to suffering from "exam phobia." Why do people who really know the subject go all to pieces when they hear the word "exam," or "test"?

We discussed it, and concluded that it stems from a particular way in which tests or exams are applied, from the early days, when children are in the lower grades. The problem has a number of superficialities, but perhaps the most dominant one is that of working against the clock. When a test is on, you have 30 minutes (or whatever) to complete the answering of these questions. Another piece is the way questions are asked. Designers of tests seem to have a creed that the student shall not be allowed to guess what answering a particular question correctly tells the examiner about him.

Why not? Why the mysticism attached to testing? The student, as well as his examiner, should want to know, "Can I solve this kind of problem correctly, or can't I?" So why the deep dark secret about it? And at first, that is all the student or examiner wants to know—not how quickly! When the student has established that he *can* do whatever it is, it is quite time enough for him to see *how quickly* he can do it. But that often is not the way things are.

Probably because this has been the way exams and tests have been regarded, that is the way that teachers use them. To get back to what we were talking about last month, I.Q. tests: we have these various tests—aptitude tests, and so forth—each of which is handed down, like a measure designed by God himself, and the teachers rely, with incredible faith, on the results.

By some magic, whatever the words or pictures to which the student responds, that I.Q. test will measure the students' I.Q. And because, according to some psychologists at least, a person's I.Q. does not change, what that test measures is unchangeable, too. We have seen countless examples where a student's scoring, say 75 in a particular I.Q. test, has had that student marked as a moron for life!

A typical teacher response will be like the professor I was talking about last month, "Can't expect any more of him, he has an I.Q. of 75!" Come to think of it, did I say he was joking? I'm not so sure he was. People who *believe* in I.Q. results place implicit trust in those figures as if they magically must be right. Can such a test tell *how much* intelligence a person possesses? Is intelligence a purely quantitative thing, or does it have a quality, differing for every individual? How can a test tell about that?

A difficulty is that people either believe, implicity, in I.Q. tests and what they are supposed to tell, or they don't. The mystique of testing blurs everything. We need tests that tell something, that a person can tell about himself, as well as giving others information about him. When tests are designed with that frank objective they become meaningful and helpful. They also become part of the learning process, rather than a separate entity in themselves.

Space has gotten away from us this time. Another time we must give some dimensions that can be built into mediated material by which such meaningful tests can be made, and integrated into the learning process. One would think that such aspects would be the subject matter expert's domain. But it is apt to fall to the audio man by default: if we don't do something about getting these dimensions in there, education will continue to deteriorate, the way it has the last few decades, media or no media. ■

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MARTIN DICKSTEIN

• Every time we get away from projectors, it seems that our friends out there bring us back again with the mails, and we're glad.

This first letter was written on May 22 by Ken Stoltenberg of Electronic Engineering Services in Rochester, Minnesota.

Regarding your comments on lamp life, in the May db issue, I am wondering if you have ever come across a Sylvania projection lamp slide rule. The rule I have has a copyright date of 1962. This provides the relationship of lamp voltage to socket voltage, percentage watts to change in color temperature, and percentage light to percentage life. So—if lamp voltage equals socket voltage, then you have 100 percent watts, rated color temp., 100 percent light and 100 percent life. Now drop socket voltage 5 volts and you have 93 percent watts, −55 degrees in color temp., 85 percent light and a life of 185 percent—quite a change in lamp life! Should you run the lamp 5 volts above rated voltage, you then get 56 percent lamp life, according to the rule.

With regard to cooling the lamp after turn off, comments to us by General Electric indicated that this cooling did not affect lamp life. However, vibration is critical to the lamp at this time and the filament can be damaged easily if the projector is moved before the lamp has cooled.

At a Bolex service session several years ago, the comment was made that due to the inherent construction, all heat filters possess a high internal stress and therefore have a fixed life. I once had one explode just lying on the bench with no one near it.

You indicate that your next article will deal with 16mm projectors. May I make two pleas:

1. Encourage projector users to keep them clean, particularly the film gate. Film is expensive and one careless user can damage and badly scratch a film the first time through the projector. A small brush, with stiff bristles, can be held to the projector with a 3AG type fuse clip that can be mounted on the projector if the original manufacturer did not provide for this. Use the brush for cleaning the film gate and other areas of the film path. Take care not to scratch the film pressure plate.

2. Equipment manufacturers specify particular lubricants in various areas for a reason! May I suggest that if you don't know the manufacturer's requirements, you may cause a malfunction or shorten the life of your equipment. PLEASE leave the 3-in-One oil in mother's sewing chest!

Keep up the good work. I will look forward to more of your articles.

Many thanks, Ken, for the information in your letter, and for your kind words. I'm familiar with the lamp slide rule, and I appreciate your mentioning it. Mine comes in a Sylvania Audio Visual Projector Lamp Pocket Guide. This is a 3-fold card containing information on Sylvania audiovisual lamps, including the rated wattage, the average life in hours, and the base type, and information on how to identify a defective lamp.

SYLVANIA GUIDE

While we're on that subject, let's quote just a bit from this informative guide.

Early failure: Lamp is clean and appears perfect in all respects except for broken filament. This lamp obviously has not been burned any length of time, if at all.

Leaker: A tiny leak in glass envelope has allowed air to enter the bulb. Milky, cloudy appearance identifies this condition."

Normal life failure: This lamp has blistered after it was used for a number of hours. Another effect that can result from normal life—a blackened bridge.

Lamp has obviously served normal rated average life. Note the blackening on top of bulb. If lamp was designed to burn horizontally, the telltale blackening is on the side of the bulb, indicating a normal life.

General Electric also made a similar rule. This one is a circular type and gives the same information. It is called *Stage/Studio Lamp Characteristics Calculator for approximate effect of voltage variation on Quartzline® and incandescent lamps.* The one I have is dated Aug. 1971.

On the reverse side, there are instructions for using the circular slide rule and some interesting information:

For voltages not shown, multiply both lamp and socket voltage by 10 or 100 to put them on the scale. For example, a 6-volt lamp operated at 5 volts is the same as a 60 volt lamp operated at 50 volts.

Note: Due to the variation between individual lamp types, the results shown are close (but not exact) approximations for any specific lamp. Indicated values are reasonably reliable between 90 percent and 110 percent "rated volts," with reliability decreasing as values depart from this range.

There is a bit more information on the reverse side which GE calls *Additional Information:*

1. The life rating of a lamp is actually the median life obtained by testing many lamps over a long period of production. At rated voltage, one-half of the lamps will burn beyond rated life.

2. Operation of a lamp on voltages higher than that for which it was designed can significantly shorten life or cause immediate failure. Quartzline lamps, in particular, should not be operated beyond 110 percent of rated volts.

3. With ordinary incandescent lamps, life at reduced voltage is predictably increased because burnout usually results from filament evaporation. With Quartzline lamps, however, increased life cannot be accurately predicted because life may be limited by factors other than filament evaporation.

4. Gradual blackening of the inside of the bulb during use is normal for incandescent lamps. Quartzline lamps do not blacken, unless operated under abnormal conditions.

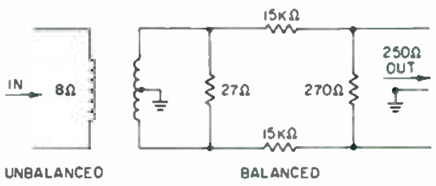
5. Bulb blistering is normal with some incandescent lamps toward the end of life. If a forced cooling system is used in the equipment, it should be checked regularly to prevent blockage of the air stream. Even partial loss of normal cooling can cause excessive blistering or premature failure.

6. Change in apparent color temperature of Daylight Dichro PAR lamps when voltage is varied will be about twice the scale indication.

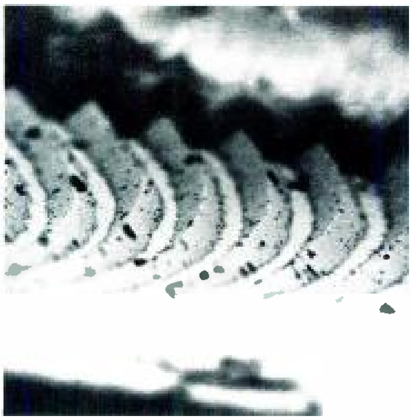
The second letter came from Jack B. Minkoff of Palo Alto, California.

What is the best circuit for an interface between a 16mm projector speaker (8 ohms) output (often furnished by means of a ¼ in. phone jack to a remote speaker) and a microphone (150 ohms) or line level 600 ohms input into a mixer or mixer amplifier?

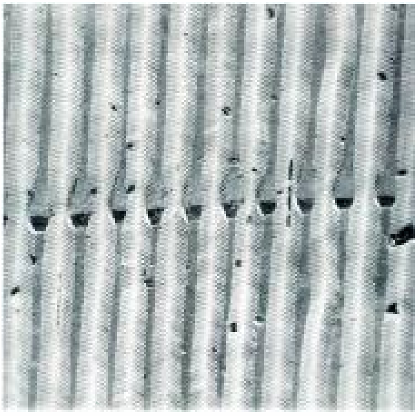
I am sure our readers have solved this problem in different ways. We would like to hear from any of you who would like to share the results. Here is one way, maybe not the best, but quite good.



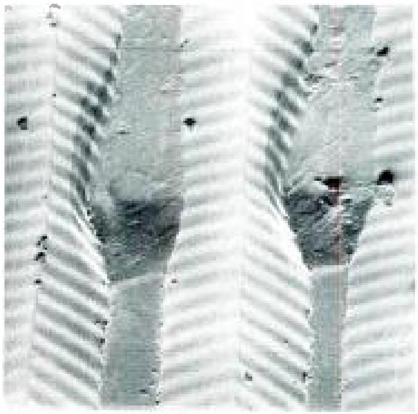
Thanks to all those who have written. We will continue to print correspondence as often as possible. ■



A pick-up's eye view of a disc, illustrating the very great depth of field and false perspective which the scanning electron microscope can be made to produce. (X160)



A small scratch made to look far worse than it probably sounds. The deformation of the groove wall covers about



10 wavelengths of the f.m. carrier, i.e., each lasts for approximately 1/3000 of a second. (X100 and X500)

A general view at approximately 45 degrees to the surface. The vertical and lateral shifts of the groove and the deviations of the f.m. signal superimposed on them can easily be seen. Although this record was new and apparently clean, dirt particles are very noticeable. (X100)

EDWARD HORN

In the CD-4 Groove

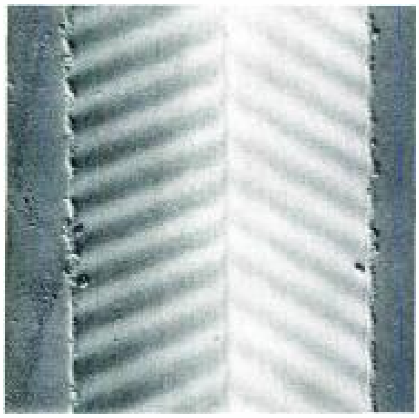
Metallurgy and microscopy reveal the tremendous detail which the CD-4 groove carries.

THE FINAL YEAR of one's degree course at Cambridge University concentrates the mind wonderfully. It is also alive with opportunities to investigate the unusual. My principal subject is the science of materials, but a major hobby is audio. This combination aroused curiosity about the demands made on the disc-recording process by CD-4 techniques.

Examination of the record groove by optical microscopy reveals only a part of the picture. The obtainable depth of field has practical limitations. So I sought the help of D.G.D. Gray, of the Metallurgy and Material Science Department of Cambridge University in preparing and observing portions of CD-4 discs in a scanning electron microscope.

A section cut from the disc is rendered conductive by electrically evaporating a small particle of gold over it in a vacuum chamber. If well judged, the film of metal which condenses onto the sample can be only a few atoms in thickness. The prepared specimen is then put into the microscope, where, after evaporation, it is scanned by a finely focused electron beam. The intensity of low-energy secondary electrons emitted from the sample varies with the surface morphology. By means of an electron detector and associated circuitry, an image of the surface is built up on a cathode ray tube, which is being scanned in synchronism with the beam inside the microscope.

Edward Horn is a third year undergraduate, majoring in Material Science at St. John's College, Cambridge University, England. His father is Geoffrey Horn, the well-known English hi-fi authority and reviewer.



High magnification of a single groove revealing faint parallel lines, probably resulting from imperfections of the original cutting tool. The two rows of debris visible on the "land" at the top of the groove walls are also of interest. (X1000)

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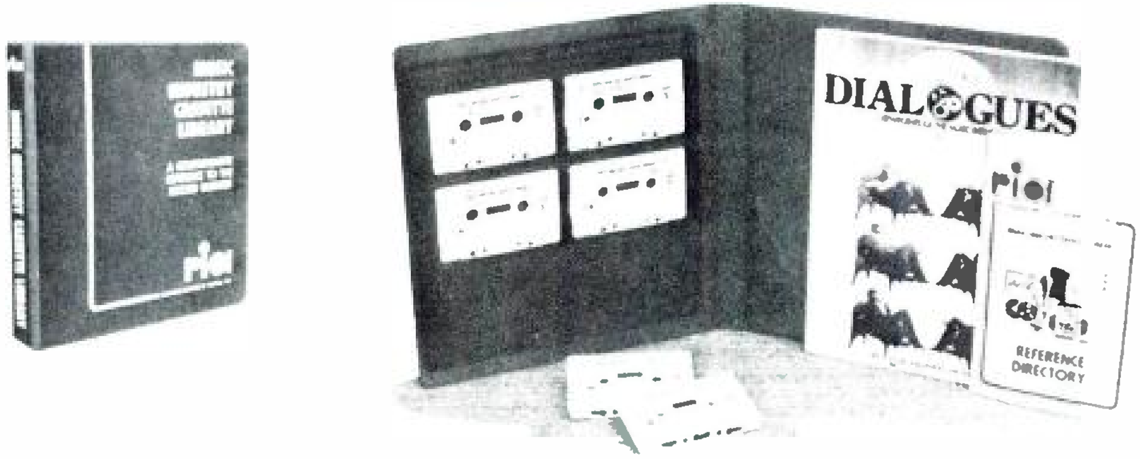

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Al Coury	V P Production. Capitol Records
Al DeMarino	V P . Music Department, CMA
Tom Draper	Dir R&B. RCA Records
Kenny Gamble	Pres & Producer. Phila Int Rec Co
David Glew	V P . Marketing. Atlantic Records
Barbara Harris	Dir . Artist Relations Atlantic Records
Emil LaViola	Prof Mgt . Chappell Publishers
Michael Martineau	Booking Agent. Premier Talent
Mark Meyerson	A&R Atlantic Records
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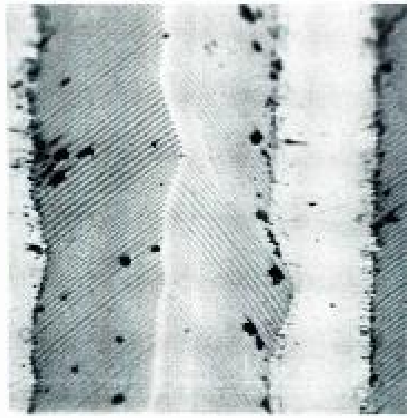

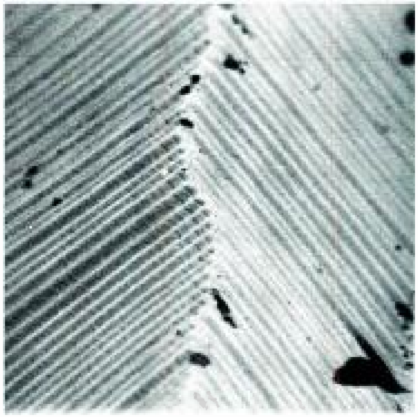

Both taken looking along a groove at a few degrees to the surface, giving the same false impression of distance as a telephoto lens. This exaggerates both the modulation of the groove and the frequency deviations of the f.m. carrier.

Controls permit movement of the sample within the evacuated chamber. One can select electrically the desired magnification to yield any number of views on the screen—to be photographed as desired. Adequate depth of field is obtained, but one has to be aware of the gross perspective distortion which can take place.

The results indicate the tremendous detail carried in the CD-4 groove and maybe clear the need for a playback cartridge capable of coping with this wealth of information.

FURTHER NOTES ON CD-4

We learn from John Eargle of JME Associates that A & M Records has made a long-term commitment to CD-4 and intends to issue their quadriphonic disc product only in the CD-4 format.

Increased software activity has been evident from RCA and the WEA group as well, and the total U.S. CD-4 catalog has grown from 194 in June of 1974 to 258 by the end of December 1974. As of the first quarter of 1975, the U.S. catalog increased by 22 items to a total of 280.

On the consumer information level, a comprehensive 28-page CD-4 *Handbook* has been developed and will be available to CD-4 dealers. Its aim is to explain to the interested consumer what quad is all about–and especially how CD-4 differs from the matrix disc formats.

Those wishing information concerning the CD-4 *Handbook* should contact Matsushita Electric Corporation of America, 1 Panasonic Way, Secaucus, New Jersey 07094, or JVC America, Inc., 50-35 56th Road, Maspeth, New York 11378.

According to Eargle, the last six months have also seen considerable interest in CD-4 cutting technology. Two significant improvements were shown to the recording world at this spring's Audio Engineering Society Convention in Los Angeles (May 13 thru 16).

That includes the new Mark III cutting system developed jointly by JVC, RCA and Matsushita in Japan. The significant features of this new cutting package are its low price (in the $30,000 range) and the ease with which it can be interfaced with a standard cutting system. The modulator design is a unique kind of modulated phase lock loop, exhibiting greater linearity and dynamic range than its predecessors.

In parallel with JVC, RCA Records has developed its own modulator unit using the same phase lock-loop principle. Both of these units underscore very clearly the fact that CD-4 cutting technology has indeed been simplified—and improved—and is well within the budget of many recording companies and studios.

Eargle also announces that the Ortofon Company of Copenhagen, Denmark, has made available its new DSS 731 cutting head, especially designed for wide range, low crosstalk cutting for CD-4. This new cutting head was demonstrated at the recent Audio Engineering Society Convention in London.

On the playback hardware side, Eargle concludes by reporting on continuing developments in cartridge design by many companies, particularly Stanton and Empire. Both are advertising new models which optimize the performance requirements of both CD-4 and stereo. ■

MARTIN DICKSTEIN

The New York Experience

Sight, sound, vibrations, combine in an exciting hour of New York sensations.

MANY TIMES, when an exhibit is billed as multi-sensory, the reference is made to indicate that several different methods are utilized to interest the visitor. The term usually means that two senses will be affected by the presentation—sight and hearing. There is one show, however, that means what it says—literally—when it is described as multi-sensory. It all results in a most exciting way for anyone to really have a most unique and memorable *New York Experience*.

New York Experience is located in a specially built theater on the lower level of the McGraw-Hill Building on the Avenue of the Americas at Rockefeller Center. It is one of only three similar presentations in the world: one in San Francisco, another in Hawaii, and the third is the relatively new show in New York. *New York Experience* is a Trans Lux/Bing Crosby enterprise produced by Electrovision Productions, Inc. The show opened in 1973, and will be a permanent exhibit; we urge you not to miss it. The presentations are hourly and take just under an hour to tell the story of New York.

As you walk in, there is a replica of old New York, with a view of a subway station and an elevated train that ran on 6th Ave., the former name of the street you are on. The corner where you will walk has the old stores, an umbrella-covered pushcart, and benches to sit on while relaxing and waiting for the theater show to begin.

SOUNDS IN THE DARK

The theater is in semi-darkness as the visitor enters. The screen is very wide and curved. As you look around, the side walls appear quietly normal, and the ceiling seems black with only a few identifiable lights. The seats swivel all around and are very comfortable. In a few moments, as the audience is being seated, there are sounds of distinguishable voices, children and adults. It sounds as though a few of the people in the theater are speaking just a mite loudly. Then the theater starts to darken. It now becomes apparent that some of the sounds are not within the theater itself, but seem to be coming from outside. You realize that this has been the beginning of the show itself which was sneaking into full presence so carefully. The presentation had begun before you were aware of it. Then the surprises begin.

A partial view of the sophisticated equipment in the projection booth.

The seven screens at the front light up, sometimes displaying stills, then dissolving quickly at different speeds to form a vast panorama of New York harbor. The result is a spectacular view that seems to curve right around the visitor. Now the side screens become active. They descend to cover the walls or rise back out of view as the history of New York unfolds from earliest days to the present, introducing a multitude of special effects.

At one moment, an extremely bright thrust of lightning is seen, almost blindingly. It starts overhead and strikes the Empire State Building. The thunder accompanying the flash is momentary, but frighteningly close and realistic. As the images change both on the front screens and on the sides, the audience can swing the seats easily to follow the action and the sounds coming from various locations throughout the theater.

In one scene, realism is enhanced as image and sound tell the story of Washington's crossing the Delaware, while real fog rolls into the theater from under the front screen. The scene envelops the audience as the people feel the fog.

SUBWAYS

In the modern city, no tale could be told without mentioning the subway systems running under the streets. It is a part of a way of life. As the presentation focuses on the underground behemoth, the noise and vibration are both heard and felt. During one sequence, a subway comes roaring in and the audience again becomes a part of the show. Not only is the deafening sound heard in all its realism, but low rumbling can actually be felt—a sensation rather unique for audio/visual displays. A similar sensation occurs during a bombardment. The rumbling sound can be heard, and the blast can also be felt.

Among the visual and environmental devices there are bubble machines, strobe lights, a car horn, realistic fire effects devices, special lights and an electronic organ controlled by sound and many more, all part of a dazzling display.

WHAT MAKES IT WORK?

Planning this complex presentation which runs almost without a hitch, 82 showings (7 days)a week, took a tremendous amount of engineering and design know-how. The entire show is automated—completely—except for the technician pushing the start button each hour, and then making sure the equipment, film, tape, slides, etc. are all back at the start point about 50 minutes later. He also knows what to do when problems arise and maintains the system and the individual components. But once the show is under way, everything happens automatically.

With the start of the show, a ¼-in.

tape cartridge (audience murmur) and a ½-in. magnetic tape begin to roll at 15 in./sec. on one of two Scully tape decks. The ½-in. tape has four audio tracks (which were made in a reduction mix from an original 16-track recording) and a cue track (between tracks 2 and 3) which is only 0.03 in. wide. It is this tiny stripe on which the rest of the show depends. It contains digital data which feed to the heart (or brains) of the system, a model 990 Command Performer computer developed by Arion Corp. of Minneapolis, Minn., specifically for this type of application. (In addition to San Francisco and Hawaii, they also have their equipment installed at Disney World and in several countries of Europe including Russia, as well as in Mexico. Canada, South America and Japan. plus some smaller projects at schools and universities.)

The 4-track sound passes through Arion preamplifiers. Crown DC 300A amplifiers, and is distributed through JBL speakers located at the front of the room. Dolby equalization was used in the recording and playback and four Sound Craftsman graphic equalizers are included in the reproduction system to help with the contouring of theater acoustics. There are also two mono-mixes of the 4-track sound. One is used for separate bass reinforcement (which deserves special mention) and the other is used to activate four 3-color organs (by Mobilcolor), located at the sides of the room. These lines are also under the control of the computer and triggered at preset times.

The ¼-in. tape cartridge (player by International Tapetronics) is fed through 12 Atlas Sound WT-15 all-metal speakers with weatherproof woofers, high efficiency drivers, and crossover networks. These units are located under the seats of the audience and are first heard at the very beginning of the show when the sound of audience chatter sneaks in to the surprise of the visitors. These outdoor units were chosen because of the real fog that comes rolling in from under the front screens during the show blown in by four fog generators). Cone speakers could never last under this assault of moisture for very long. The under-seat speakers are also used during the performance.

BASS REINFORCEMENT

The bass reinforcement does require special mention, as the speaker is unique. It is the largest in the world, and is, in fact, so large, that it had to be built on the site. In the story below the floor of the theater, a 26-ft. long unit was constructed with an opening of 14 x 16 ft. It is used during sound sequences such as cannon fire, but is basically most effective during the sound of a subway "running" directly under the theater.

The speaker has a cut-off at 20 Hz. At that frequency the ear is unable to hear, but the sound can be felt, as those in the audience know if the subway has been one of their means of transportation. The floor literally vibrates, just as a subway platform does. The bass speaker is cut in on cue from the computer almost a dozen times during the show (during the cannon shot for a period as short as about 0.1 second).

You might be wondering how a show that runs just a little short of an hour can be handled at 15 in./sec. on one tape deck. It isn't. One of the special automatic features of the system is that the second machine is cued up and ready to go on a start cue from the computer. Once it gets going, a cue on the second tape automatically stops the first machine. (This first tape can then be recued to the beginning and is ready again for the next show.) The change-over time: less than 1/10 sec.

PROJECTION

The projection system is also unique. There are thirty slide projectors set up in the projection booth, using a total of about 2,500 slides. The units are controlled by dimmers and dissolvers which can change images at five independent speeds (instant, 2, 4, 8, and 16 seconds). Every projector is controlled by its own fader, but even these are not just faders. Each is a complex unit involving a precision analog computer with eleven op amplifiers. The double-layered front screen can handle seven side-by-side images. These are so accurately adjusted that panoramic images across the entire spread can dissolve into another and look as if one dissolve action took place, but there actually are fourteen dissolve units operating at such a transition point.

The three A.V.E. 16-mm film projectors are also unique. First, they were modified to permit interlock operation. These are run by selsyn motors and are made to stop and start instantly. Since about half the time of the presentation is spent on 16mm film, the projectors use Xenon illumination sources which are ozone-free (requiring no special ventilation) and no special cooling. The films have magnetic sound tracks and the preamplifiers in the projectors were modified slightly to provide the best sound possible for the audio system. Another internal modification was the addition of new aperture plates specially cut for this show.

OTHER FEATURES

Some other modifications and provisions go into making the presentation as smooth as it is. The projectors are provided with special loop setters which operate automatically, when the pull-down claw is retracted, at just 1/50 of a second separation from the pull-down mechanism. That ensures smooth running of the film in this constant start/stop operation. Another special feature is a magnetic foil stop on the film with just 4 in. of black between film portions. No slippage can be tolerated here.

The projectors run at the normal 24 frames per second, but usually the sound drums start to rotate when the film is under way. In these units, the sound drum is specially made to get started with a unique automatic tension device so the sound head gets going instantly with the start of the projector. As another control function of the computer, the sound feed from the projectors is not cut into the system until the projectors are triggered to begin rolling, thus keeping the speakers off the line until the sound is about to begin. The functioning of the projector motion, the computer and the sound is so smooth that it is unlikely that the viewer will be aware of the 20 times the images change from slides to film and back.

In addition to starting tapes, cueing film projectors, cutting sound in and out, and setting off strobes or flashers, the computer, in its more than 3,000 cues, is called upon to lower and raise four sidewall screens, turn on rotating wheels in front of slide projectors, cue super-8 projectors around the room, start star-projectors, turn on and off lobsterscopes, turn rotating mirror reflectors above the audience, and trigger more than 50 special effects devices in total, not counting the chasing lights around the front screens, etc. It is estimated that if all the special effects were triggered to activate simultaneously, the total power drain would be more than 200 kilowatts. However, there are more than 120 relay circuits in the control system to help activate only those devices needed at any one time.

The thunder, lightning, fog, subway, cannon, and the vast special sound and visual effects make the *New York Experience* a most novel multi-sensory audio-visual experience—not to be missed by either visitor or New Yorker. Experience New York in less than one hour—comfortably, enterainingly. ■


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SUBMINIATURE MICROPHONE

● The miniaturization possibilities of electrets and transistors are combined in the Minimic to produce a device measuring only .460 x .330 x .326 inches and weighing 0.75 oz. A slightly rectangular shape keeps it from rolling around, lessening clothing noises when it is used as a lavalier. The case is constructed of smooth, slick plastic so that clothing will glide over it. The electret is housed inside a silicone rubber boot, isolating it from the case. Cable is constructed with a polyurathane outer sheath for strength and flexibility, of pure copper braid with 99 percent wrap. Inner conductors are covered with flexible rubber. Frequency response is ± 1dB 50 Hz to 3kHz. Operates on d.c. voltage or by means of a hearing aid battery.

Mfr: Transound Company
Circle 50 on Reader Service Card

3500W F.M. TRANSMITTER

● Model BF-3.5K 3,500 watt f.m. broadcast transmitter is driven in the IPA stage by 10-watt B-910 exciter, using a pair of parallel connected type 4CX250B pentodes. A type 3CX3000/A7 zero-bias triode is used in the power amplifier stage operating in grounded-grid configuration; no grid bias or screen grid power supplies are required, and no neutralization. P.A. stage efficiency occurs from 2,000 to the maximum 3,500W output power levels. Other features include automatic recycling, memory-type status indication and an output reflectometer. Start/stop functions are controlled by illuminated pushbuttons. Self-contained BF-3.5K offers full metering of all essential parameters, with remote control adjustment and metering terminations. Models for either single- or three-phase primary power operation are available.

Mfr: McMartin
Circle 51 on Reader Service Card

CASSETTE EDITING AND REPAIR KIT

● Repairs may be made without disturbing cassette components with this kit, intended to fix breaks more than six inches from the hub. As a precision editing block, one side of the block has a diagonal cutting guide at 45 degrees for normal splicing and a butt cutting guide at 90 degrees for close editing. A five-inch channel groove holds the 150-mil tape. One end of the pencil-like kit features a hexagonally shaped spindle for manually driving the cassette tape via the hubs. Six adhesive-tipped polyester picks for retrieving tape ends lost inside the cassette housing and six pieces of 150-mil splicing tape, pre-cut to proper length, are contained inside the kit.

Mfr: 3M
Price: $3.10
Circle 52 on Reader Service Card

STEREO/MONO POWER AMPLIFIER

● A pushbutton bridging switch effects the mono/stereo change on model 500D power amplifier, one of a series of new models from this manufacturer, all conforming to the FTC trade regulation rule on amplifier power-output specifications, carrying 4-ohm FTC power ratings. The unit features a thermal system using a dual speed thermostatically controlled fan in a low turbulence environment for quiet operation; thermal resistance from transistor case to ambient is 0.2 degrees C/W. Each output stage uses ten 150W single-diffused power transistors, eliminating current limiting circuits, with separate plug-in circuit modules utilized for each channel. A rocker-style circuit breaker is mounted on the front panel. The 15mHz i.c. operational amplifier, similar to those used in analog computers, is placed at the front end.

Mfr: BGW Systems
Price: $799.00.
Circle 53 on Reader Service Card

FREQUENCY COUNTER

● Six-digit portable model 5755A frequency counter capable of direct counting to beyond 512mHz. The instrument weighs five pounds and measures 3¼ x 8 x 7⅜ inches. It operates from a.c. lines, a d.c. supply or from an automobile cigarette lighter socket.

Mfr: Ballantine Laboratories, Inc.
Price: $745.00
Circle 54 on Reader Service Card

L.E.D. METER

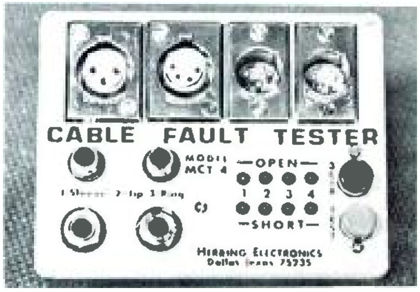
● This seven-point red l.e.d. meter features −15 to +3 vu in 3dB steps. Simplicity of construction keeps the unit rugged; there are no bearings, jewels or pivots. The meter features mechanical inertia with no oversheet, and fast response peak detection with slow decay, for accuracy. The meter is supplied in vu or S with vertical or horizontal scale. Power required is 12-15 Vdc 30 milliamp.

Mfr: Pulse Dynamics Mfg. Corp.
Price: $10.00
Circle 55 on Reader Service Card

AUTO FLANGER

• As an alternative to phasing, the Auto Flanger offers a precise mathematical relationship between the time delay and the resulting comb filter response, causing random program material (such as cymbals) to take on musical tonality. The manufacturer claims that the device is capable of producing true flanging repeatably and economically without the use of two tape decks or digital delay lines. Through the use of an internal regulator, it may be implemented into any system and can be incorporated into a standard console or rack.
Mfr: MXR Innovations
Price: $285.00
Circle 58 on Reader Service Card

CABLE FAULT TESTER



• Compact battery operated MCT-4 cable tester will simultaneously check all conductors in three and four pin "Cannon" type connectors, two and three circuit ¼-in. phone plugs, as well as RCA phono plugs. An l.e.d. matrix displays the i.c. operated logic circuit. The tester is designed to consider resistance greater than 500 ohms as an open, and less than 500 ohms as a short. Long low impedance microphone cables may be tested under conditions similar to their operating conditions. The unit scans for all possible open and short conditions over 400 times a second.
Mfr: Crossroads Audio
Price: $89.95
Circle 59 on Reader Service Card

ELECTRONIC MUSIC SYNTHESIZER

• With a 1 volt-per-octave control and a linear keyboard output, the model 300 synthesizer allows any number of oscillators, filters, and modules of other functions to be controlled from a keyboard while tracking together at a constant musical interval. Any external tuning control will change with oscillator pitch by the same amount, regardless of keyboard position. The keyboard spans a full 5-octave range. It has exponential or linear portamento (glide) selection and one-octave range tuning control with instant zero return. Voice outputs are linear over the whole range. Fourteen output jacks are supplied. The synthesizer also contains an envelope generator with four independent controls over the dynamics of each note; a voltage control filter with a 16Hz-16,000Hz range; a voltage control amplifier with over 100dB of accurate gain control; balanced modulator and attenuators; voltage control oscillator; sample/hold, clock, noise generator; dual mixer; dual LFO, lag, inverter; case and back plane connectors; power supply. The elements may be purchased separately.
Mfr: Aries, Inc.
Price: Kit: $895.00
Wired: $1,500.00
Circle 60 on Reader Service Card

PARAMETRIC EQUALIZER

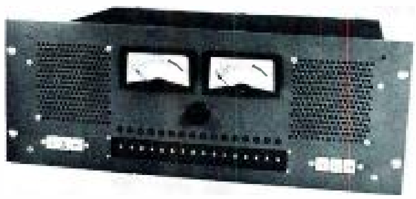
• This vari-band equalizer has five simultaneous operational sections. Each section has ± 15 dB of boost or cut, bandwidth control from 16dB/oct. to 2dB/oct., bandcenter control in/out switch and red indicator l.e.d. for fast comparison of any section or all sections simultaneously. Bandcenter frequency sweep ranges for the five sections are 20-100Hz, 100-600Hz, 600-3kHz, 3k-6kHz, and 6k-20 kHz. All circuitry is operational amplified and uses no transformers or inductors.
Mfr: Multi-Track
Price: $450.00
Circle 61 on Reader Service Card

new products & services (cont.)

POWER AMPLIFIER

● This high-power rack-mountable amplifier is available in two models. Model SR105A provides both direct-coupled speaker output, 200 watt continuous rms and transformer-coupled 150 watt rms constant voltage 70-volt output. Similar model SR105B permits direct speaker coupling only. The amplifiers are capable of delivering 200 watts rms to a four-ohm load and may be interconnected with additional units to provide the greater sound power required by especially large coverage requirements. Direct-coupled frequency response is flat, 20 to 20,000 Hz, ± 1.5 dB. The amplifiers are protected against short or open circuit loads and can operate at full power at ambient temperatures up to 42 degrees C. without derating.
Mfr: Shure Bros, Inc.
Price: SR105A: $348.00
SR105B: $321.00
Circle 56 on Reader Service Card

DIGITAL AUTOMATION SYSTEM



● Digimation series 2000, a complete digital automation system for a.m., f.m., catv, sca, and other audio applications, features state-of-the-art solid state audio switching and built-in 25 Hz tone sensing, eliminating the need for external sensing equipment. Up to eight sources of reel-to-reel or cart machines may be connected in any configuration. The 16 event memory is impervious to power failures. The system also contains adjustable silence sensing, a priority interrupt function, vu meters, internal monitor amp and speakers (switchable to PGM, CUE, and AUX), and bridging unbalanced inputs with 600 ohm balanced outputs.
Mfr: Audio/Video Products
Price: Stereo: $1,950
Mono: $1,550
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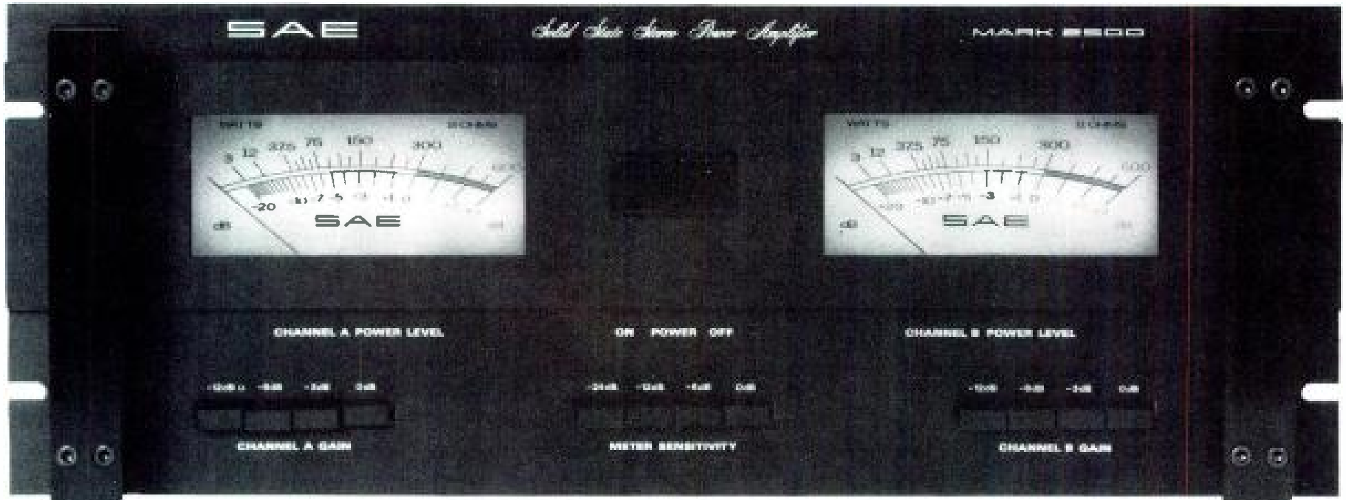
Powerful alternative.

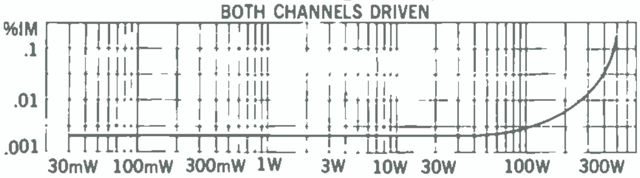


SAE 2500 Professional Dual-Channel Power Amplifier

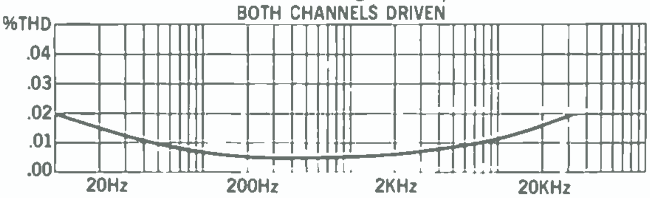
When you compare power amplifiers, you have to look at the hard facts. The SAE 2500 Professional Dual-Channel Power Amplifier has them—top power, specifications, reliability and features that make it the most "powerful alternative."

Power. 450 Watts RMS per channel, both channels driven into 4 Ohms from 20Hz to 20 kHz at no more than 0.1% total harmonic distortion. Or, 300 Watts RMS per channel, both channels driven into 8 Ohms from 20Hz to 20 kHz at no more than 0.05% total harmonic distortion.* Plus, a new, smaller wide-channel power transformer coupled to 4 computer-grade capacitors for a power supply that varies no more than 10% from no load to full load. (For extra protection, there are relay and thermal cut-out devices.)

2500 INTERMODULATION DISTORTION @ 8 OHMS, FULL POWER 49V RMS BOTH CHANNELS DRIVEN



2500 TOTAL HARMONIC DISTORTION @ 8 OHMS, FULL POWER 49V RMS BOTH CHANNELS DRIVEN



Reliability. The SAE 2500 gives you high current capability with Parallel-Series-Output Circuitry (PSO)—without loss of wide power bandwidth, low leakage current or super-high slew rate. Sixteen triple-diffused output transistors have an electrical and thermal SOA 50% higher than maximum design requirements for reliable high demand capability. This configuration can handle anything from continuous full signals to highly reactive surge loads—all day long without failure or overheating. Dual relay disconnect circuits and plug-in board design further assure reliable performance.

Features. Feedback level controls assure a constant input impedance of 50k Ohms and reduce the noise figure to more than 100dB below rated output in all positions. Loudspeaker protection relay-activated circuit automatically disconnects speakers in case of ±DC outputs. Plus, direct power reading VU meters and forced air cooling.

The SAE 2500 Professional Power Amplifier weighs only 58 lbs. making it practical for portable sound reinforcement, public address, communications and recording applications.

Specifications.

IM Distortion from 250mW to rated power at 4 or 8 Ohms with any 2 mixed frequencies between 20Hz and 20kHz at 4/1 voltage ratio	0.05 Max
Frequency Response at rated power	±0.25dB 20Hz to 20kHz
Noise	Greater than 100dB below rated power
Transient Response of any Square Wave	2.5μ sec rise and fall time
Slew Rate	40 V/μ sec
Dimensions	Front panel 19"W x 7"H Chassis 15"D (excluding handles, controls and connections)

*These specifications comply with FTC requirements for power amplifiers

The professional alternative.

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DB/8/5

Please send me the reasons (including available literature) why the SAE 2500 Professional Dual-Channel Power Amplifier is the "Powerful Alternative."

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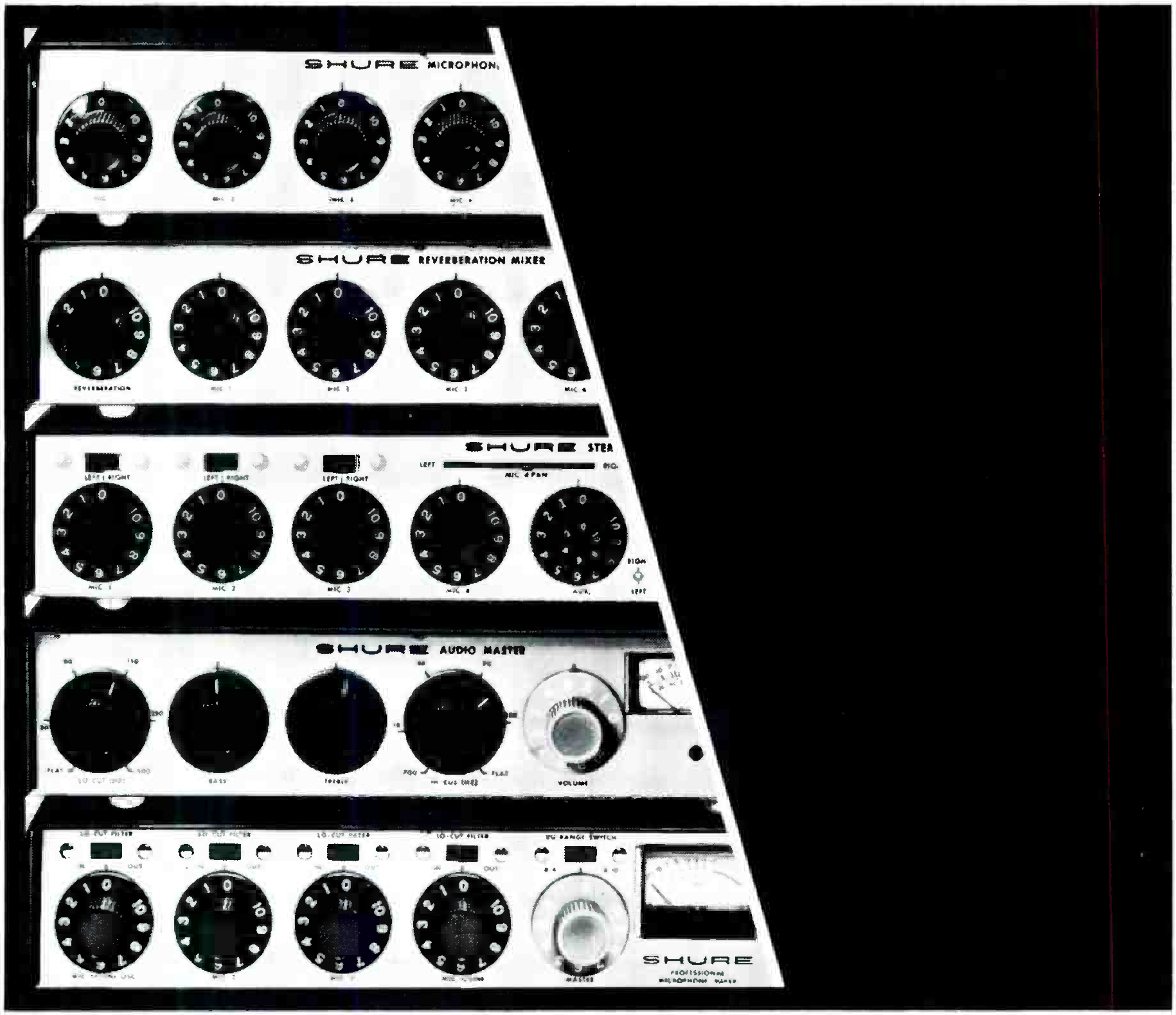
SHURE MICROPHONE
SHURE REVERBERATION MIXER
SHURE AUDIO MASTER
SHURE

ROBERT C. EHLE

Operations of Moog Synthesizer Modules And Components

Familiarity with the functions of synthesizer modules enables the user to select a custom-planned instrument.

IN TEACHING the operation of synthesizers in several schools, I have found that a desirable first step is to take each module in the synthesizer and describe its operation. Thereafter, the different interconnections can be studied after the student has a working knowledge of each module.

Here we describe the typical modules found in a medium-sized synthesizer, in this case, one manufactured by the R. A. Moog company, although other brands are very similar. The modules are as follows: oscillators, mixers, keyboard, voltage-controlled amplifier, envelope generator, filters, ring modulator, envelope follower, and sequencer. The last three modules are extras in the Moog synthesizer. The ring modulator and the sequencer are usually mounted in separate cases. They are included in other manufacturer's synthesizer models, however, and are basic components in electronic music procedure. For that reason they are included here.

A purchaser of a modular synthesizer may select any set of modules he prefers and thus have a custom synthesizer from "off-the-shelf" components. Most customers prefer to take the advice of experts and accept a standard complement of modules in a specially built cabinet. Such a standard complement may be purchased by number from most manufacturers

THE MOOG OSCILLATORS

The Moog model 901-A oscillator controller is, in effect, an amplifier with the special capability of taking the algebraic sum of all of the inputs presented to it. There are five such inputs: the three jacks marked control *voltage* and the two controls marked *fixed control voltage*. The two controls are a range switch and a vernier, both of which are marked off in volts. The summing amplifier takes the algebraic sum (accounting for the sign and the magnitude of each component) and then generates a current proportionate to the sum. The current is a voltage-controlled current.

It is this voltage-controlled current that is actually fed to the model 901-B oscillator. The oscillator contains a capacitor which stores this current as it is fed in. As the capacitor fills or charges, the level of electrons or charge increases in the capacitor. A level detector senses when the capacitor is full and rapidly discharges the capacitor. This slow charge and rapid discharge produces the sawtooth wave, the basic waveform in the Moog oscillator. The switch on the panel of the 901-B selects one of six different capacitors, thus selecting one of six different charge rates. The knob beneath the switch is a vernier for that control.

The other three waveforms (sin, triangular and pulse waves) are generated by waveform modifying circuitry from the basic sawtooth waveform. Thus all waves have exactly the same frequency and are in phase. They may be used simultaneously for performing synchronized control functions.

Different models of synthesizers have slightly different oscillators. The difference is more in appearance than operation.

In the Synthesizer 2, the oscillator is a one-piece unit. In the Synthesizer 1, however, the oscillator appears to be constructed from three modules. That is not actually the

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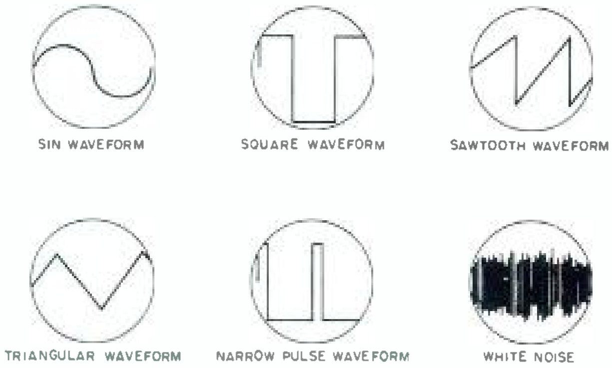

Figure 1. Examples of various waveforms as displayed on an oscilloscope.

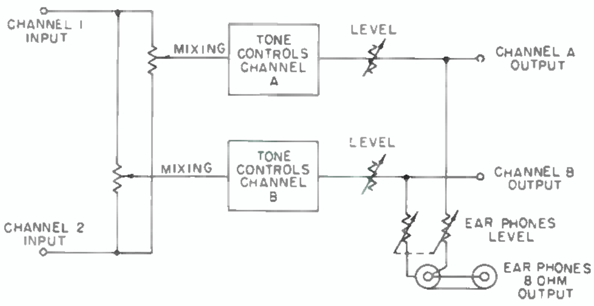

Figure 2. Block diagram of two-channel mixer in Moog synthesizer.

case, as the modules are internally wired together and are inseparable. Thus, the 901-A oscillator controller, the 901-B oscillator and the 901-C output stage are all parts of one oscillator and may not be separated. Note that only the left oscillator has an output stage; the right oscillator has none.

The function of the oscillator controller is to provide a voltage-controlled characteristic to a semiconductor oscillator which would normally be sensitive to changes in current rather than voltage. Signal connections between the oscillator controller and the oscillator are internally made. The function of the output stage is to provide an amplitude control, a switch selectable set of waveforms, and a pair of complementary outputs. Thus the output signals from the 901-C are identical to those from the 901-B with these exceptions.

The four waveforms made available are the sin wave, the square wave, the triangular wave, and the sawtooth wave. The square wave may be converted into a variable width pulse wave with the pulse-width control on the 901-A. FIGURE 1 shows various waveforms found in the synthesizer, as displayed on an oscilloscope. An oscilloscope is an ideal tool for presenting a visual picture of the characteristics of electronic music. The drawings illustrate various waveforms and illustrate the concepts of variable-width pulses.

OSCILLATOR TERMINOLOGY

Various names are often used for the component part of the different waveforms. When the complex but repetitive wave is analyzed by means of Fourier techniques, the results are a series of harmonically related frequencies called *harmonics*. The fundamental frequency (the lowest frequency) is the first harmonic. The sin wave contains only the fundamental, while the square wave and the triangular waves contain only odd-numbered harmonics (1, 3, 5, 7, 9, etc.) and the sawtooth wave contains both odd- and even-numbered harmonics.

The components of a wave that are present are called *partials*; thus, the second harmonic is the second partial of a triangular wave, but the third harmonic is the second partial of a square wave (because the second harmonic is absent). But partials do not have to be harmonic (in which case the wave is not periodic and cannot be analyzed by Fourier analysis). For example, the piano tone contains frequencies which are not harmonic; these are called partials but not harmonics. They are overtones, however, because they are generated by subdivisions of the same string. They are non-harmonic, due to string stiffness and the end effect, which makes the overtones higher than true harmonics. For that reason, the piano cannot be synthesized by subtractive synthesis, but only by additive synthesis.

The three terms—partial, overtone, and harmonic—have different but related meanings, and their differences are worth noting. To sum up, any component of a complex sound is a partial. Partials having small whole number ratios are overtones, and partials generated by the same string or pipe are overtones (a generic term).

THE MIXERS

The Moog model 982 mixer is necessary for nearly all work done with the synthesizer. FIGURE 2 illustrates a block diagram of model 982. Note that the two input controls act as panners between the two inputs. The tone controls and level controls apply only to their particular channel marked A or B. Also, the earphone jacks are stereo and have inputs from both channels. That permits the synthesizer to be used as a self-contained instrument with a pair of earphones. The center of the tone controls (twelve o'clock) is the flat position.

Other types of mixers will be useful in electronic music. One of the most useful is the *panner*. The panner has special controls allowing one output to be reduced while another is increased. That may be used to produce the effect of moving sounds when the two outputs feed the two channels of a stereo sound system.

Simple mixers may be either "wet" or "dry," meaning powered or unpowered. Powered mixers may provide amplification and absolute independence of control of one channel from the others. They have no cross-coupling. Unpowered mixers may only provide a limited amount of isolation, and turning a control on one input will have some effect on the others. Unpowered mixers may provide only loss and no amplification. They are, however, inexpensive. The less expensive powered mixers may, in fact, be less desirable because they introduce noise or hum.

THE KEYBOARD-PITCH CONTROL

The Moog keyboard contains two types of control outputs, one operated by the keyboard and the other by the internally triggered envelope generators. Here we discuss the keyboard-controlled pitch voltage outputs.

This voltage output (actually two outputs in parallel, having exactly the same output signal) has a range of zero to 6 volts. Normally it is used to control the voltage-controlled oscillator but may control any voltage-controlled device with this voltage range.

The controls affecting this device are the *scale*, *range*, *hold* and *portamento*. These labels apply to the effect achieved when controlling the voltage-controlled oscillator and indicate the specific parameter of the sound thus controlled. Thus, scale determines the scale produced; range, its tessitura; portamento, the connection between pitches; hold, the effect when all keys are released (with the switch on. The internal circuitry remembers the last key depressed and continues to produce that control voltage).

Of course, these controls have related effects when the pitch-control voltage is used to control, for example, the voltage-controlled amplifier. That is possible since all Moog modules have exactly the same control voltage range and are interchangeable in this respect.

By inserting a resistor, used as a voltage divider, between the output of the pitch-control section and the voltage-controlled module, the range may be reduced farther than the internal range control allows. When controlling the voltage-controlled oscillator, this permits "micro-tonal" scales and other unusual effects.

THE VOLTAGE-CONTROLLED AMPLIFIER

The Moog voltage-controlled amplifier is a singly balanced (control input only) modulator with a resemblance to the ring modulator to be described later. The difference is in the specific circuitry used to balance both inputs in the ring modulator.

Normal operation involves connecting the voltage-controlled amplifier to the envelope-control voltage output from the keyboard, thus using the voltage-controlled amplifier for envelope generation triggered by the keys on the keyboard. For this type of operation, the fixed-control voltage control on the amplifier is set to zero. The *exponential/linear* switch may be set either way, although an exponential curve duplicates the type of envelope produced by an acoustical instrument such as a piano. (Such an instrument seems to have a linear decay due to the compensation by the ear which has a logarithmic characteristic.) A *linear decay* is one of those sounds which may be synthesized, but is never heard in nature. Thus it makes an interesting resource for original music.

The voltage-controlled amplier may also be used as an amplitude modulator. In this type of arrangement, one signal feeds the signal input while the other feeds the control input. The amount of intermodulation can be controlled by the setting of the fixed-control voltage which sets the operating point on the amplifier's characteristic curve. The voltage-controlled amplifier, when used as an amplitude modulator, produces more harmonic distortion than a well-adjusted ring modulator and is, therefore, less desirable for live-concert modulation of voices and instruments than that of instruments alone.

THE KEYBOARD-ENVELOPE GENERATION

The basic Moog keyboard contains two envelope generators which are internally connected to the keys of the keyboard. Thus, every key triggers both envelope generators in an identical fashion.

Interconnections from the envelope generators is by means of two patch cords, one for each envelope generator. The output control voltages again have a range of zero to 6 volts. They may be used to control any of the Moog voltage-controlled units. Normal use is to connect them to the two voltage-controlled amplifiers for generation of actual envelope control. Thus the controls are labeled for this application. The four controls on either envelope generator are labeled *attack speed*, *attack height*, *decay time* and *sustain level*. When the generator is used to control an envelope with a voltage-controlled amplifier these are the actual parameters controlled.

Of course, as with other Moog voltage-controlling modules, the generator may be used to control the oscillator or the voltage-controlled filter as well. In these cases an analogous effect is produced by the controls, which may

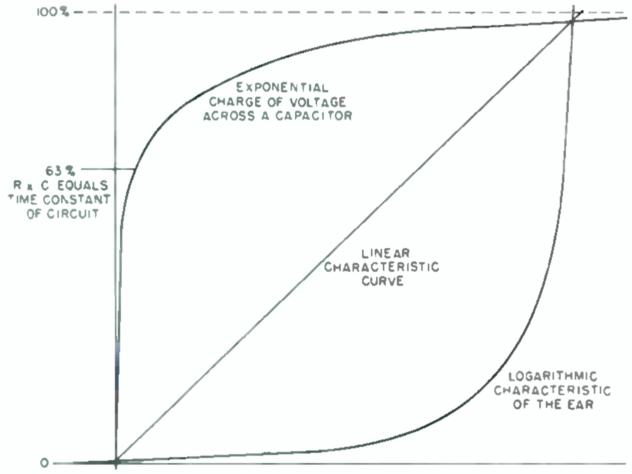

Figure 3. Graphic representation of exponential versus linear characteristic curve.

not be the exact effect described by the label of the control.

The larger Moog synthesizers also contain independent envelope generators with a somewhat wider variety of control. They have a continuously variable attack time rather than the two-position switch and they have a trigger input.

An interesting variation in envelope control is to drive one signal input of the vca with one envelope generator and the control input with another. The resulting envelope will be the difference between the two envelopes. This technique may be used to produce very slow attack times on the simple envelope generator synthesizers.

THE FILTERS

Two types of filters are employed in the Moog synthesizers. These are fixed band-pass filters and variable voltage-controlled filters. The voltage-controlled filters are of two types, low-pass and high-pass. When used with an auxiliary coupler, the combination of a low-pass and a high-pass filter results in a voltage-controlled band-pass filter or a voltage-controlled notch filter, depending on how they are connected.

Fixed filters are usually supplied in banks which may be specified as quarter-octave, third-octave or half-octave, depending on the sharpness of the filter band characteristic. Narrower band filters require more units to cover the same total range. Third-octave filters require three per octave, half-octave filters two per octave, and so on.

Voltage-controlled filters are usually provided with a regeneration control which is used to regulate feedback around the filter. When turned up, the regeneration converts the filter into a resonant filter, similar to the acoustical formant filter. That is useful for musical coloration. Note that the resonance occurs at the point of maximum amplification or minimum filtering.

The Moog voltage-controlled filters have the same control voltage range as all the other Moog modules and may be controlled from all the common control devices. They may also be modulated, producing spectrum modulation.

THE BODE-MOOG RING MODULATOR

An instrument designed by Harald Bode and manufactured by the R. A. Moog Co. is the multiplier-type ring modulator with squelch. Producing a much lower distortion output than equivalent circuits set up on the Moog synthesizer, this unit is ideal for live performance and produces a particularly attractive and musical output. The inputs may be any combination of audio signals. If one of the two is a "live" acoustical instrument, and one an electronic sound source, attractive variants on the acoustical signal result. The technique is desirable for use in real-time electronic music performances.

The multiplier-type ring modulator generates very small amounts of harmonic and intermodulation distortion (other than the desired sum and difference). Thus, when two sin waveforms are presented to the two inputs, the output is also a pair of sin waves, the sum and the difference of the two inputs. Other ring modulators may generate harmonics of the modulation products as well as products of the harmonics of the input signals. These roughen the sound quality of the output and make it much less attractive to the listener.

The reader is referred to the *Electronic Music Review*, vol. 1, no. 1, for detailed discussion of techniques that may be performed with the ring modulator. Some of these techniques will be repeated here for convenience.

If the two signal inputs are complex waves, such as square or sawtooth waves, having an infinite series of partials, the resultants will be two infinite series of partials, one the sum series and the other formed by the difference.

If one input is a band of white noise, and the other a sin wave, the band of white noise will appear in the output but twice as wide, or in two segments formed by the sums and the differences, respectively. If the sin wave is made to sweep, the white noise in the output will also sweep, producing the effect of "howling wind."

Sounds picked up by a microphone may be ring-modulated with themselves if the overtones are filtered from one input and the entire spectrum is presented to the other input.

A NOTE ON THE BODE RING MODULATOR

Due to the advances of technology and more recent developments a new instrument has evolved from the Bode Ring Modulator, manufactured by Moog, referred to in this article. It is the Bode Frequency Shifter, which comes in a Bode version and as a Moog module. In contrast to the ring modulator, which changes two sine waves with the frequencies f_1 and f_2 into the combination of $f_1 + f_2$ and $f_1 - f_2$ at the output, the frequency shifter is capable of separately producing the sidebands $f_1 + f_2$ and $f_1 - f_2$ on two individual outputs. A mixer combines both sidebands for a third output. In the center position of the mixer control the signal of this output equals that of a ring modulator.

The ring modulator produces a particularly attractive tremolo effect when connected in the same manner as standard tremolo or vibrato on an amplitude modulator. If the unmodulated signal is reproduced through one loudspeaker and the modulated signal through another, the result is a sort of amplitude-phase modulation in space which is very attractive.

Any sound may be transposed (up and down simultaneously) by modulation by a sin wave. Up transposition is produced by the sum tones and down transposition by the difference tones.

The Bode-Moog ring modulator is also available in dual units for stereo operation and other techniques.

VOLTAGE-CONTROLLED SEQUENCER

The Moog sequencer is voltage-controlled and voltage-controlling. This means that it is useful only with voltage-controlled modules of the type normally supplied with the Moog synthesizers. The range of output voltages is 0-2, 0-4, or 0-8, selectable by a switch which provides a degree of control but also a slight incompatibility with the 0-6 volt range of the Moog modules.

The Moog sequencer is built from digital computer components and is based on a binary counter. For this reason it has eight stages (2^3). A three-level binary counter counts to eight and then resets and begins counting over again. This is the procedure used. The pulses actually counted come from a standard voltage-controlled oscillator. The repetition rate of these pulses may be controlled by varying the control voltage. Thus, the counting speed may be controlled.

The three-level counter is decoded using computer logic to produce one line out of eight with a signal on it. This signal line corresponds to the count on the counter (and the light on the panel). The signal line activates one of eight switches which applies the control voltage to the output. There are actually three switches per count, one for each of three outputs. Each output has a separate control for each of the eight counts. Other features include skip and stop switches, a switch to apply the third row of control voltages to the oscillator, and a series of input and output jacks for each count position. These allow any position to control or to be controlled by an external signal. ■

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DAVID COPE

A Realistic View Of Electronic Music

Development of fully realized electronic music depends on mutual understanding between composers and technicians. A composer tells how to dissolve existing confusions.

IN A SENSE, all sounds emanating from a loudspeaker represent electronic music because they are the realization of electric currents projected through (or with) air by way of paper cone vibrations. More specifically, however, electronic music has come to mean those sounds which originate from audio oscillators or generators and are altered by processes of filtering, envelope construction, etc. This not-so-new art, dating back to Delaborde's *Electronic Harpsichord* in 1761, has suddenly (since about 1951) become a serious art form, a popular rock device, a profound contributor to the commercial music scene. Over 30 percent of TV commercials employ either complete or partial electronic sources, according to a study done by the author two years ago. It's also a guaranteed Pavlov scare technique in the motion picture industry (current example being *The Exorcist*).

We are not concerned here with the history, aesthetics or current uses of electronic music, but rather, the distinctly unique problems of the interdisciplinary synthesis of music and science. In a recent interview with Pierre Boulez, conductor of the New York Philharmonic Orchestra, I became more acutely aware of these problems. Boulez offered the following observations:

"I think that you cannot do good work in this area until you have teams working together. You must have composers and technicians alike. Four things, really: composer, technician, good equipment and a company or factory with money to back the operation as well as performers in some cases, and as long as these elements cannot work together you will have small laboratories without any outstanding results."

The many problems become magnified when trying to teach *electronic* music to musicians and/or electronic *music* to scientists. Synthesizers such as that shown in FIG. 1 are typical of manufacturers' attempts at making sound synthesis a possibility for one "Renaissance" man to create a great work of art. Piano-type keyboards abound (and with them the ten-finger limitations of piano music which electronic music is, or should be, able to avoid). Frequency switches containing reference points in organ stop lengths (8 ft., 4 ft., etc. rather than Hz) are at every oscillator; numerous other musical reference points no more than hint at the ultimate use of the equipment.

On the other hand, a host of oscilloscope functions, digital sequencers, sample hold techniques and waveform indicators contrast the musical terminology with often highly technical and strangely abbreviated scientific jargon. To say the least, teaching the synthesizer and its manifold functions to any group of specialists requires a remarkable blend of vocabularies, leaving most students with the impression that only a madman would attempt an honest association with this combination of gear and gadgetry.

To date, most of the writing about this subject has been in music journals or textbooks edging around electronics, acoustics, and engineering with variable amounts of success. The composers, teachers and serious practitioners of

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David Cope is a distinguished composer whose works have been performed by major orchestras. He is at present resident composer and director of the Electronic Music Laboratory of Miami University, in Oxford, Ohio.

electronic music have had to be content to subscribe to music journals as well as journals such as **db** and others in the scientific fields of acoustics, electronics and physics. The intent here is to acquaint the sound engineer with the incredible problems the serious composer of electronic music faces. By doing so, we hope that more literature will appear offering solutions to some of these problems.

UNFAMILIAR GROUND

Through necessity, the composer must search an initially unknown subject, electronics, to gain even a bare insight into his raw material (the instrument). And the electronics engineer must grope through the more personal, yet still highly technical skills of unfamiliar musical material. For the most part, as Boulez has pointed out, neither combination has yet produced outstanding results.

Going ahead in one's own speciality without anything but a bare knowledge of the other fields involved has sometimes proved fatal in the end result. We find the creative process so ego-demanding that, as Stockhausen has remarked, "It is necessary to constantly switch personnel so as not to invoke daily fistfights." Half the time, the specialist is attempting solutions without knowing the problems encountered in the other discipline. (A complete studio was once destroyed by a composer turning all pots on full to hear his sound, unaware that his product was sub-audio).

One can easily uncover a problem and call for an answer. Proposing a concrete solution is another matter. After having worked in electronic studios for over seven years and taught college courses for a number of years, I've come up with a set of priorities possibly of value to the sound engineer, most certainly of value to the electronic music composer. My priorities are not complete, they are merely my own viewpoint. Hopefully, they will create a possible bridge between one art, music—and a series of sciences.

POINTS OF INTEREST AND/OR CONFUSION

- Relationships between audible non-linear sideband production and combinational tones (cochlea produced).
- Construction and possible standardization of waveform identities other than sine, rectangular, sawtooth, staircase, and triangle.
- Standardization substitutes for the now confused plug and connector systems (phone, phono, cannon, etc.).
- Details of acoustical placement of speakers (angle toward ceiling, etc.).
- True "balanced line" properties and priority when connecting one unit to another.
- Importance of speaker enclosures and possible reconstruction of available units for better responses in variable circumstances.
- A third possibility of pot control besides vernier and slide, that presents viable clean operation during recording or playback.

These represent but a few current problems. A sound engineer's glance through Allen Strange's *Electronic Music* (Wm. C. Brown Co., 1972), Gilbert Trythall's *Principles and Practices of Electronic Music* (Grosset & Dunlap, 1974) and others—including my own *New Directions in Music* (Wm. C. Brown 1971)—will give him an insight into many other existing problems. Although these books might not have solutions to some of the engineer's questions, one must keep in mind that electronic music, taken seriously only since 1951, is still a baby art. No books nearing the above quality were available within 25 years of the development of the violin!

DEMANDS OF EVER-NEW TECHNOLOGY

Possibly the most significant challenge facing the electronic music composer, as well as the sound engineer, is

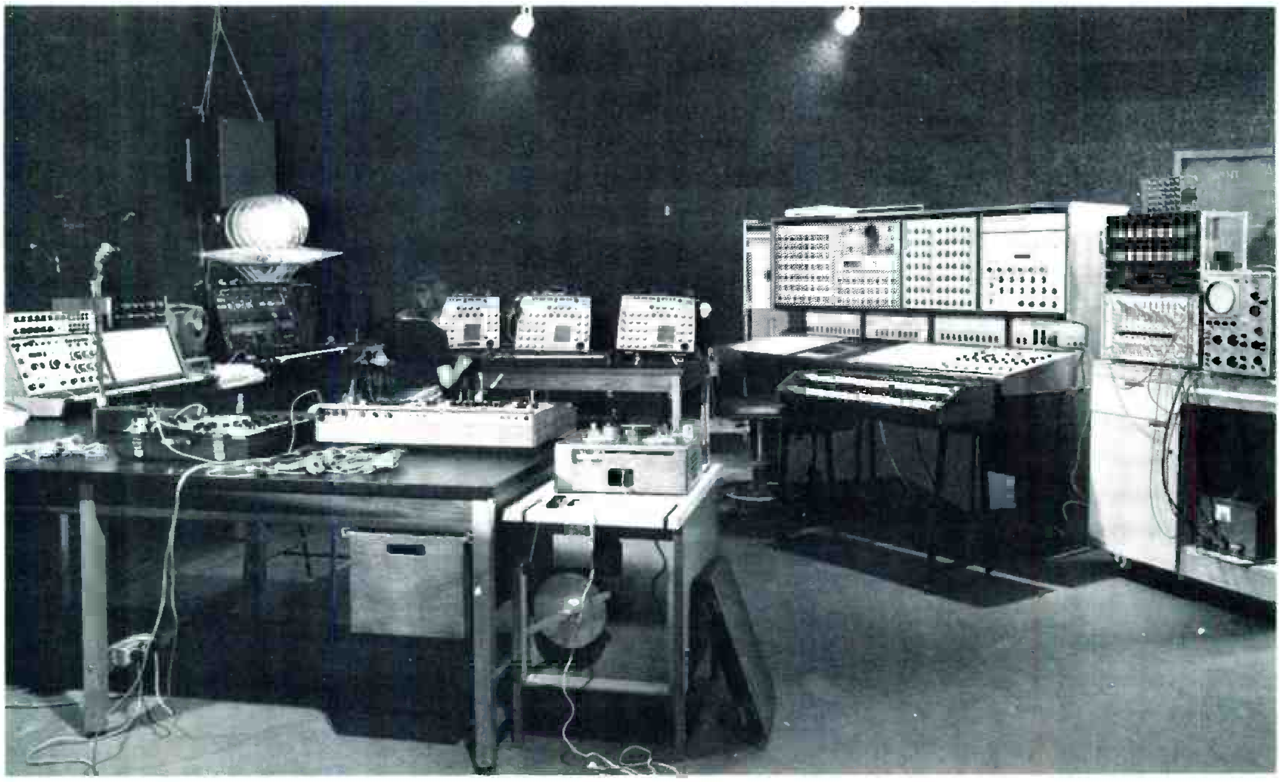

Figure 1. A sophisticated setup for the interpretation of electronic music.

that of progress. No sooner has one spent his entire budget on what was the best available equipment than another, more advanced, synthesizer or module appears. The composer can treat that in one of two ways. He can forget it—music is music—and opt out of the expense of valuable time learning to use the equipment as well as the money spent. Or, he can buy the equipment, learn to use it, and usually find that something else yet more advanced is now being produced.

A good friend who is currently a director of a computer music studio recently wrote to me: "David, after five years I have finally arrived at a complete D/A interface for our IBM 7090, only to discover that I have forgotten what it was I was going to do with it." To compound the problem, it was recently learned that the computer time was taken away due to business and science priorities.

Problems and confusions continue. With the advent of light pen writing on CRT inputs for computers, as well as the possibility of computers actually reading music for direct analog playback (and voice activation of quick alterations), the endless study of voltage controlled synthesizers may have been a wasted one—at least for the composer.

COOPERATION A NECESSITY

There is, however, a light at the end of the tunnel when the composer finally realizes that he has worked with "performers" for years, whether technical or musical, equally respected for their craft in their own rights. Their relationships may not have been smooth. But it may become apparent that the sound engineer, who takes delight in discovering and purchasing new equipment, and the composer, concerned with artistry, can more than coexist. As a flexible unit, they can produce works of music far beyond our current vocabularies.

These two-three man groups would need three vital properties: a common vocabulary for communication, constant role identification in the creative act, and patience.

Another matter is becoming more and more clear. Instead of the keeping-up-with-the-Jones's attitude of our colleges (major creators of electronic labs around the country), we need to funnel these monies into two or three large, centrally located laboratories. These labs then will become the centers for research in sound engineering and for composer creativity.

INSTITUTE OF SONOLOGY

Such a center exists at the Institute of Sonology, Utrecht State University, the Netherlands. This lab is equipped with four complete studios (including computers, synthesizers of all types, and ten professional tape recorders). It employs six scientific staff members, four technical staff members, and two secretaries. The results are represented on every major record label in the world and speak for themselves. More than once, an American university has lost a gifted student to this incredible environment.

My electronic music is listed on two record labels, Discant and Orion, and represents what I hope are crafted and inspiring compositions. They are, however, far less than highly sophisticated in terms of sound engineering, and future works will necessarily remain so. It takes years for sound engineers to fully comprehend, in terms of their own craft, the nuances of interpretation necessary for a true partnership of the technical and musical possibilities. If sound centers became a reality, the opportunity would be present for the closer sharing of the creative processes.

When the disciplines of music and technology finally erode their differences, we will come, as Varèse says, . . . "to the liberation of sound." ■

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db people/places/happenings

• Of interest to those in or servicing the music industry, **International Musexpo '75** will take place on September 21-24 at the Las Vegas Convention Center. The exhibition will feature firms from the United States and Europe, including the communist countries. Russia will be represented by Mezhkniga, the official agency that imports and exports recordings, sheet music, and books. The exhibit will display wares from recording companies, studios, and audio accessory manufacturers. **Roddy S. Shashoua** is focalizing the exhibit. The address of MUSEXPO is 1350 Avenue of the Americas, N.Y.C. 10019. Telephone number is (212) 489-9245.

• **Thee Studio,** of Claremont, Ca. now boass a new 16-track recording-mixdown facility, built by **Everything Audio.** The studio is equipped with the Spectra-Sonics 1024 console, 24-in/24-out, an MCI 16-track machine, and Dolby noise reduction. The monitors are JBL 4341s powered by Crown amplifiers. The studio is located at 224 N. Indian Hill Blvd.

• **John Pritchett** has been appointed to the post of president of **Quantum Audio Labs, Inc.** of Glendale, Ca. Mr. Pritchett, a public address technician, recording engineer, and designer, comes to Quantum from the James E. Lansing Company. He has also been associated with Altec.

• Recording, mixing, and editing from 16 tracks down to mono will be offered by **Studio 21,** new recording facility located at 635 Madison Avenue, New York City. The studio has high speed duplication facilities, sound effects libraries, spectator seating, office facilities, and shipping service. Musical instruments are available free of charge. **George Agoglia** is director of operations.

LEON A. WORTMAN

• **L.A.W. Associates,** providing specialized marketing and sales consultant services to audio and closed circuit television firms, has been formed by **Leon A. Wortman.** The new firm's office is located at 743 Holly Oak Drive, Palo Alto, California. Mr. Wortman, who was formerly with the **Ampex Corporation,** is the author of the **CCTV Handbook.**

• **University of Wisconsin,** Madison, Wisc., will host a three-day Sound Engineering seminar September 3-5. The seminar, conducted by **Don Davis,** will cover the following: Design of a biamped system; use of digital time delay; where to place loudspeakers; filter sets; altering loudspeaker coverage patterns; acoustic levels and electrical power; design and placement. To enroll, contact: **Lowell B. Jackson,** Dept. of Engineering, University of Wisconsin-Extension, 432 N. Lake St., Madison, Wisc. 53706.

• A radical saving of power, to the tune of 400 million watts, through the use of switching power supplies in place of linear regulators, is possible, according to findings published by **Darling & Alsobrook** as part of a four volume International Electronic Packaging series. According to **Dr. John Salzer,** vice president of the Los Angeles management consulting firm, "The cost of a switching power supply can be ten to as much as fifty percent higher than that of a linear regulator type, but the overall cost of the system incorporating a switching power supply is less because the supply dissipates less heat and thus requires less cooling." Dr. Salzer also pointed out that at higher ratings, switching power supplies will still dissipate an acceptable level of heat, in contrast to linear regulators, which are seldom used at the 300-watt level or above. Other advantages are compactness and simplicity of support and mounting. Although there has been resistance to power switching because of the expense and natural suspicion of new techniques, the study indicated continued growth in this area, projecting from two percent in 1973 to thirty percent by 1978.

• Pioneer **General Electric Company** engineer, **Dr. Ernst F. W. Alexanderson,** died on May 14 at the age of 97. Dr. Alexanderson, an associate of **Steinmetz** and **Marconi,** received a total of 322 patents during his 46-year career with GE. His most significant contribution was a high-frequency alternator, one of the seed inventions that led to the development of modern radio. Previous to the invention of the alternator, only dots and dashes could be transmitted by wireless. Wireless operators on ships on historic Christmas Eve, 1906 were astounded to hear voices coming over the wires. They were hearing Dr. Alexanderson's alternator in action, and the birth of radio. In addition to the alternator, Dr. Alexanderson developed the magnetic amplifier, the electronic amplifier, the multiple tuned antenna, the anti-static receiving antenna, and the directional transmitting antenna. He also devised radio altimeters, and his studies in the polarization of radio waves made possible effective radio direction finders. He was instrumental in the development of shortwave uses and television.

• **Jack Valenti,** president of the **Motion Picture Association of America** and Special Assistant to the President of the United States during the period 1963-66, will be the guest speaker at the get-together luncheon of the **SMPTE** conference scheduled for September 28-October 3, at the Century Plaza Hotel in Los Angeles.

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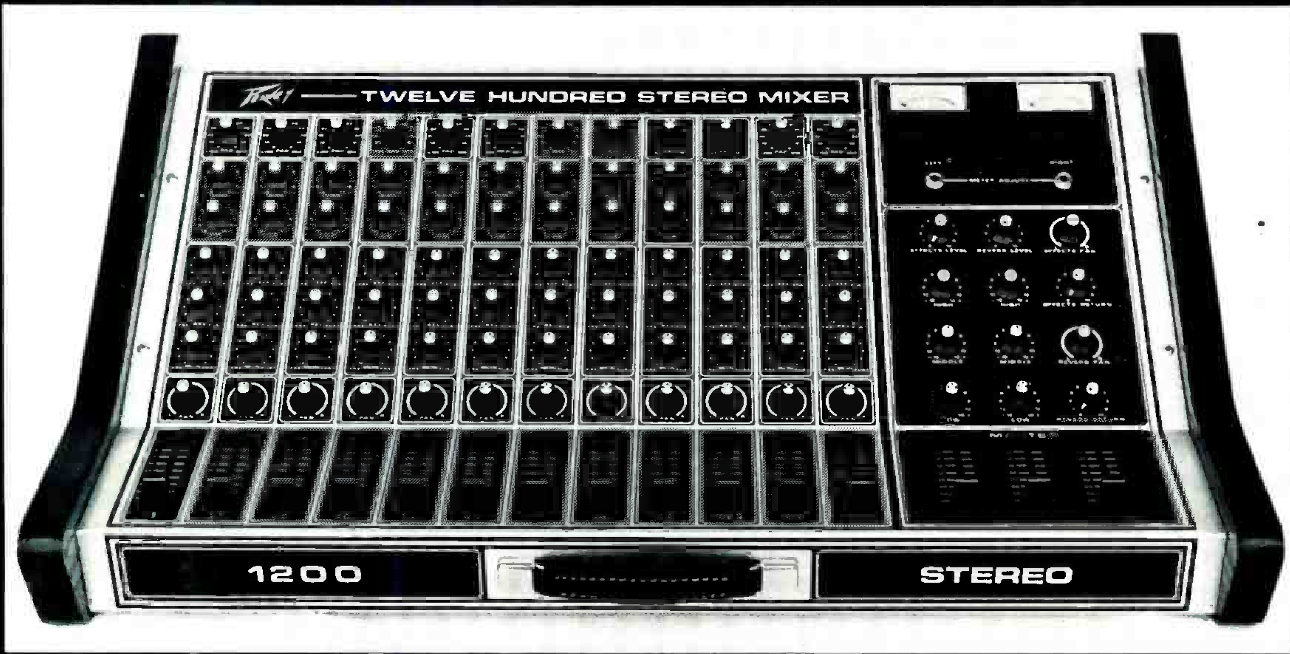

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