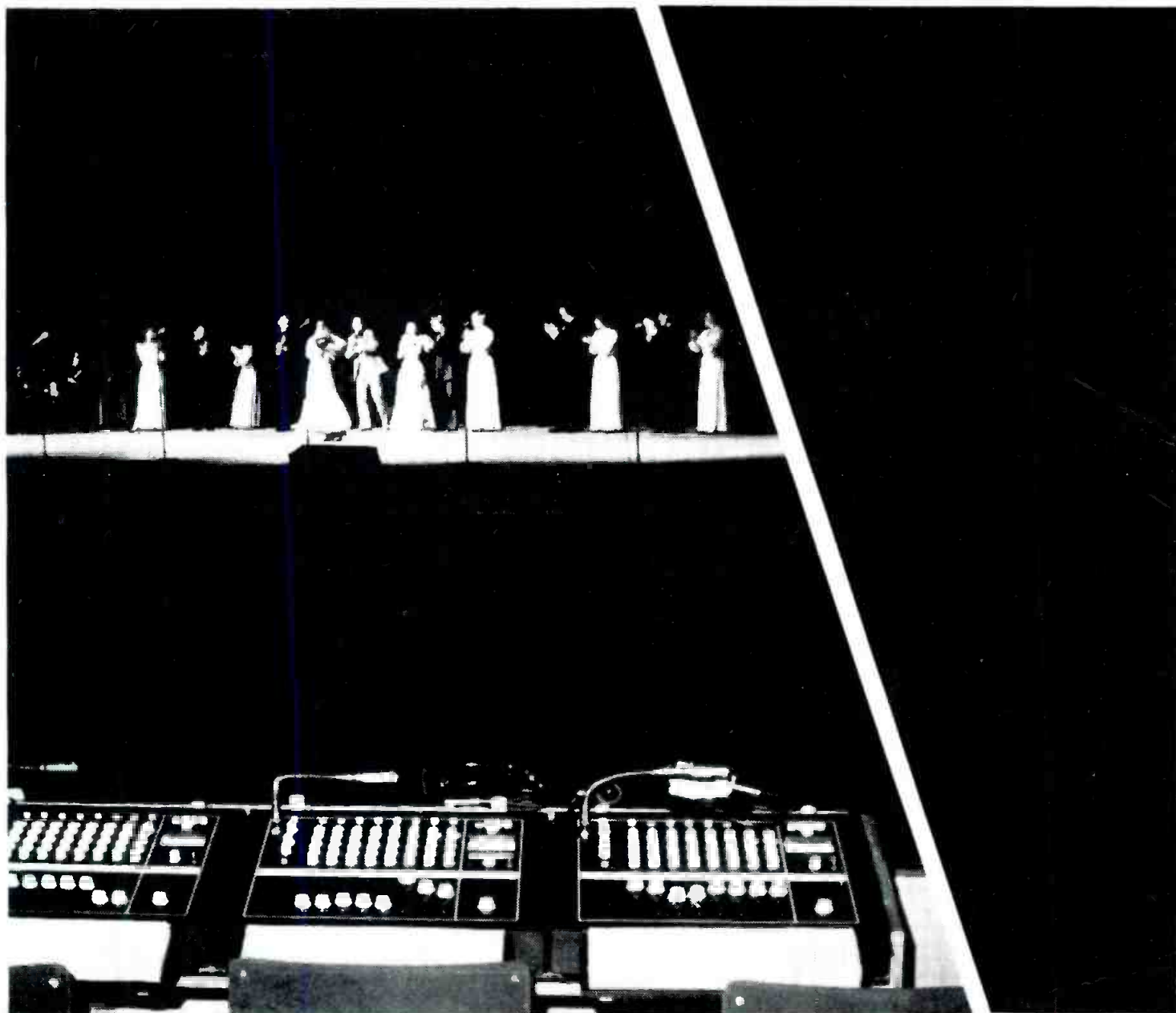


REVOLUTION

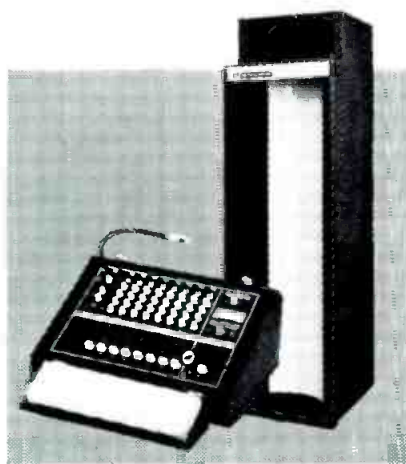


IN THIS ISSUE:

- **REVOLUTION!**
- The Signal Path — II Sine Wave Oscillators
- The 54th AES Convention And Exhibit



Standing Room Only for SR



Shure's SR auditorium-size professional sound reinforcement componentry is probably the only equipment that's been field-proved in Opryland, Las Vegas and Moscow. The SR's modular flexibility has proved its adaptability in outdoor rockfests, theaters, amusement parks, and on the road with many of the world's popular entertainers. Best of all, the SR's rugged durability and enormous power potential make it the expandable sound investment of a lifetime. SR components can be used as a system, or inserted as *individual links within a system of quality componentry in virtually unlimited combinations*. For our "SR Sound Ideas" application guide, as well as the complete new SR catalog, write:

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Manufacturers of high fidelity components, microphones, sound systems and related circuitry.

Circle 10 on Reader Service Card

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coming next month

We get down to practical matters in August to help you polish things up for a new season.

● Don Davis has one of his knowledgeable articles, **BIAMPLIFICATION—WHY AND HOW.**

● Robert R. Faulker describes a dual limiter.

● M. C. Volker has devised a **MODULAR, BUS-STRUCTURED BROADCAST CONSOLE**, in which any desired number of channels may be configured on a common bus system.

about the cover



● The sounds of *Revolution* are heard in New York City as a band plays to mark the opening of the multi-media show at the Museum of the City of New York. (Courtesy Museum of the City of New York.)

db

THE SOUND ENGINEERING MAGAZINE

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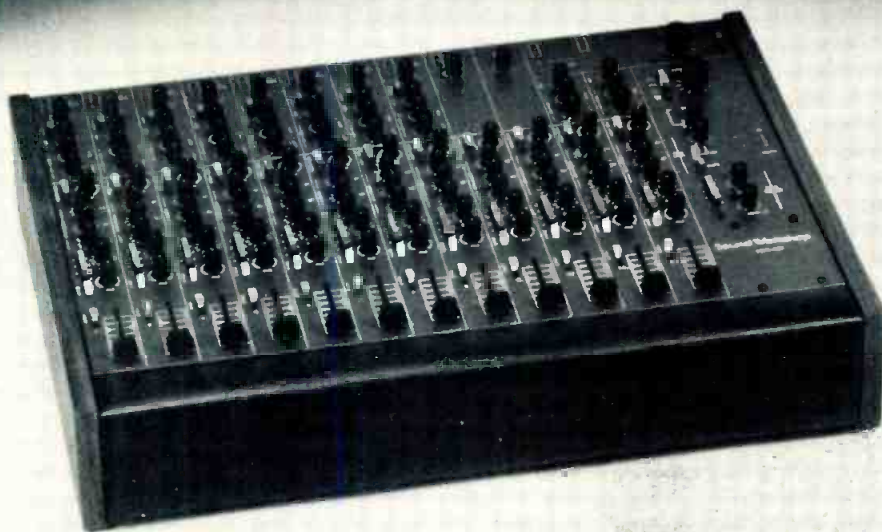
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PROFESSIONAL MIXERS FROM INTERFACE



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Inputs: Microphone: max 5v. RMS, balanced 200 ohms XLR
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 Headroom: 20 db
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Interface Electronics products will be repaired or replaced free of charge at the factory if found to be defective within one year from date of purchase provided they have not been modified or abused. Service is available after warranty at the factory at cost.

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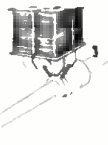
Choosing an AT15Sa can add more listening pleasure per dollar than almost anything else in your hi-fi system. First, because it is one of our UNIVERSAL phono cartridges. Ideally suited for every record of today: mono, stereo, matrix or discrete 4-channel. And look at what you get.

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*TM. U.S. Patent Nos. 3,720,796 and 3,761,647.



any good tone arm or player at reasonable settings (1-2 grams), yet sharply reduces record wear. Even compared to ellipticals tracking at a fraction of a gram. Your records will last longer, sound better.



Stress analysis photos show concentrated high pressure with elliptical stylus (left), reduced pressure, less groove distortion with Shibata stylus (right).

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FREE LITERATURE

TINY MICROPHONES

Two product bulletins describe the M-8 Micro-Mike series of sub-miniature remote microphones for use with two-way communications. Mfr: Unex Laboratories.

Circle No. 94 on R. S. Card.

PIEZOELECTRIC CERAMICS

Descriptions of piezoelectric ceramics, including various applications, composition, and explanations of terms, including a metric conversion chart and list of technical symbols. Mfr: Ferrocube Corp.

Circle No. 96 on R. S. Card.

SWITCHING POWER SUPPLIES

Standard single and triple-output switching-regulated power supplies in the 110 to 600 watt range are described in a 20-page catalogue. Mfr: Hewlett Packard.

Circle No. 97 on R. S. Card.

SOUND REINFORCEMENT

A guide to famous entertainment centers and religious buildings, along with the sound reinforcement equipment used in each is covered in a handsome 16-page booklet. Mfr: Shure Bros. Inc.

Circle No. 98 on R. S. Card.

KIT CATALOGUE

For those who like to build their own, this new catalogue contains over 400 electronic devices to keep you busy. Mfr: Heathkit.

Circle No. 99 on R. S. Card.

NOISE CONTROL MATERIAL

Data sheet 1002 lists information about Coustifilm, a limp, high-temperature-fused vinyl. Data sheet 1001 describes Coustifab, a lead-loaded fiberglass reinforced vinyl coated fabric used for the reduction of airborne and structure-borne noise. Mfr: Ferro Corp.

Circle No. 80 on R.S. Card.

VIDEO RENTAL GUIDE

A chart and brochure list an extensive array of cameras, mics, receivers, vtrs, etc. available for rent. Mfr: Technisphere Corp.

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FREE BROADCAST MUSIC

Shows featuring artists performing at the Agora Ballroom in Cleveland, Ohio are offered weekly in quad, with six available spots, three open to local announcements. Mfr: Agora Ballroom.

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If you have read our technical papers and otherwise followed our progress, you are probably familiar with the reasons for this success. Here are ten quick reminders.**

1 The Dolby system works like a constant-gain amplifier in two critical dynamic regions—low levels and high levels. Error-free signal handling is thus ensured at the dynamic range extremes. Compression and expansion occur only at easy to handle mid-levels, between -20 dB and -40 dB.

2 The system employs a simple adding and subtracting scheme which automatically results in mathematically exact complementary compression and expansion. There are no approximations, so the signal must come out the same as it went in (just check the Dolby Level now and then).

3 Compressor overshoots with high-level transient signals are suppressed without audible distortion, because of the basic system layout (dual signal paths). Since there are no overshoots to be clipped by the recorder, there is no impairment of even the most extreme transient signals.

4 The freedom from overshoot is a result of system philosophy, not an ultra-short attack time. Relatively gradual gain changes are used, yielding a compressor output which is remarkably free from modulation distortion. There is no need to depend upon cancellation of modulation products by the expander (thereby relaxing recorder performance requirements).

5 The reproduced dynamics of low-level signals are essentially immune to rumble in the input signal and head bumps and other frequency response errors in the recorder—the system has a solid low-level 'gain floor' below -40 dB.

6 The system gives a pre-determined amount of noise reduction which is realistically useful.

7 The noise that remains has a subjectively constant level. Noise modulation effects are almost non-existent.

8 The principles and parameters used in the Dolby system result in a high margin of safety. The system works well with all types of audio signals—speech, music, effects—and with practically all types of noises. High noise levels (from multi-generation copies, for example) do not impair performance.

9 The system functions reliably on a day in, day out basis, with real workaday recorders and other equipment.

10 All of the above have been proved in ten years of dependable service to the industry—25,000 professional channels in use by well over a thousand studios in more than 50 countries around the world.

* The first five A301 units were delivered to the Decca Record Company, London, on April 14, 1966.

Dolby noise reduction now looks forward to

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CALENDAR

JULY

26-30 **B&K Seminar: Industrial Noise Control.** Contact: B&K Instruments, Inc. 5111 W. 164th St., Cleveland, Ohio 44142. (216) 267-4800.

AUGUST

24-25 **B&K Seminar: Community Noise.** Contact B&K Instruments, Inc. 5111 W. 164th St., Cleveland, Ohio 44142. (216) 267-4800.

SEPTEMBER

13-19 **International Audio Festival & Fair.** London, England. Contact: British Information Services, 845 Third Ave., New York, N.Y. 10022. (212) 752-8400.

20-24 **International Broadcasting Conference.** London, England. Contact: British Information Services.

14-16 **Synergetic Audio Concepts Professional Audio Seminar.** St. Louis, Mo. Contact: Don Davis, Synergetic Audio Concepts, P.O. Box 1134, Tustin, Ca. 92680. (714) 838-2288.

28-30 **Synergetic training seminar.** New York City. (See above.)

OCTOBER

6-8 **Synergetic Training Seminar.** Boston, Mass. Contact: Don Davis, Synergetic Audio Concepts, P.O. Box 1134, Tustin, Ca. 92680. (714) 838-2288.

13-16 **B&K Seminar, Human Acoustics.** Contact: B&K Instruments, Inc. 5111 W. 164th St., Cleveland, Ohio, 44142. (216) 267-4800.

19-21 **Synergetic Training Seminar.** Washington, D.C. Contact: (See above.)

11-14 **B&K Seminar; Designing Quiet Products.** Contact: B&K Instruments, Inc., 5111 W. 164th St., Cleveland, Ohio, 44142. (215) 267-4800.

26-27 **B&K Seminar: Microphones & Accelerometers: Their Calibration and Use.** (See above.)

20-
Nov. 1 **Audio Engineering Society Show.** New York City, Waldorf-Astoria. Contact: AES, Room 929, 60 E. 42nd St., New York, N.Y. 10017. (212) 661-8528.



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26-29 **Microforum '76.** London, England. Contact: British Information Services, 845 Third Ave., New York, N.Y. 10022. (212) 752-8400.

NOVEMBER

- 2-6 **Dixie Electronics Reps. Conference,** Boca Raton, Fla. Contact: Dixie Electronics Reps., 1720 Peachtree Rd., Suite 322, Atlanta, Ga. 30309. (404) 872-5981.
- 7-8 **Convention, Society of Broadcast Engineers.** Holiday Inn, Hempstead, N.Y. Contact: Mark Schubin, Society of Broadcast Engineers, P.O. Box 607, Radio City Station, New York, N.Y. 10019. (212) 765-5100, ext. 317.
- 8-11 **B&K Seminar: Acoustical Materials & Structures: Design, Testing, and Applications.** Contact: B&K Instruments, 5111 W. 164th St., Cleveland, Ohio 44142. (216) 267-4800.
- 8-12 **National Automated Production Exhibition.** Manchester, England. Contact: British Information Services, 845 Third Ave., New York, N.Y. 10022. (212) 752-8400.
- 9-11 **Synergetic Training Seminar,** Nashville, Tenn. Contact: Don Davis, Synergetic Audio Concepts, P.O. Box 1134, Tustin, Ca. 92680. (714) 838-2288.
- 12-14 **Automatic Testing Exhibition.** London, England. Contact: British Information Services. (See above.)
- 17-19 **Synergetic Training Seminar.** Orlando, Fla. Contact: (See above.)
- 23-25 **COMPEC '76.** London, England. Contact: British Information Services. (See above.)

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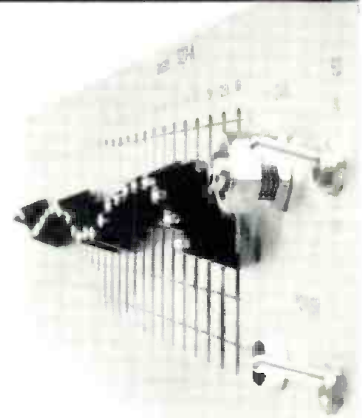
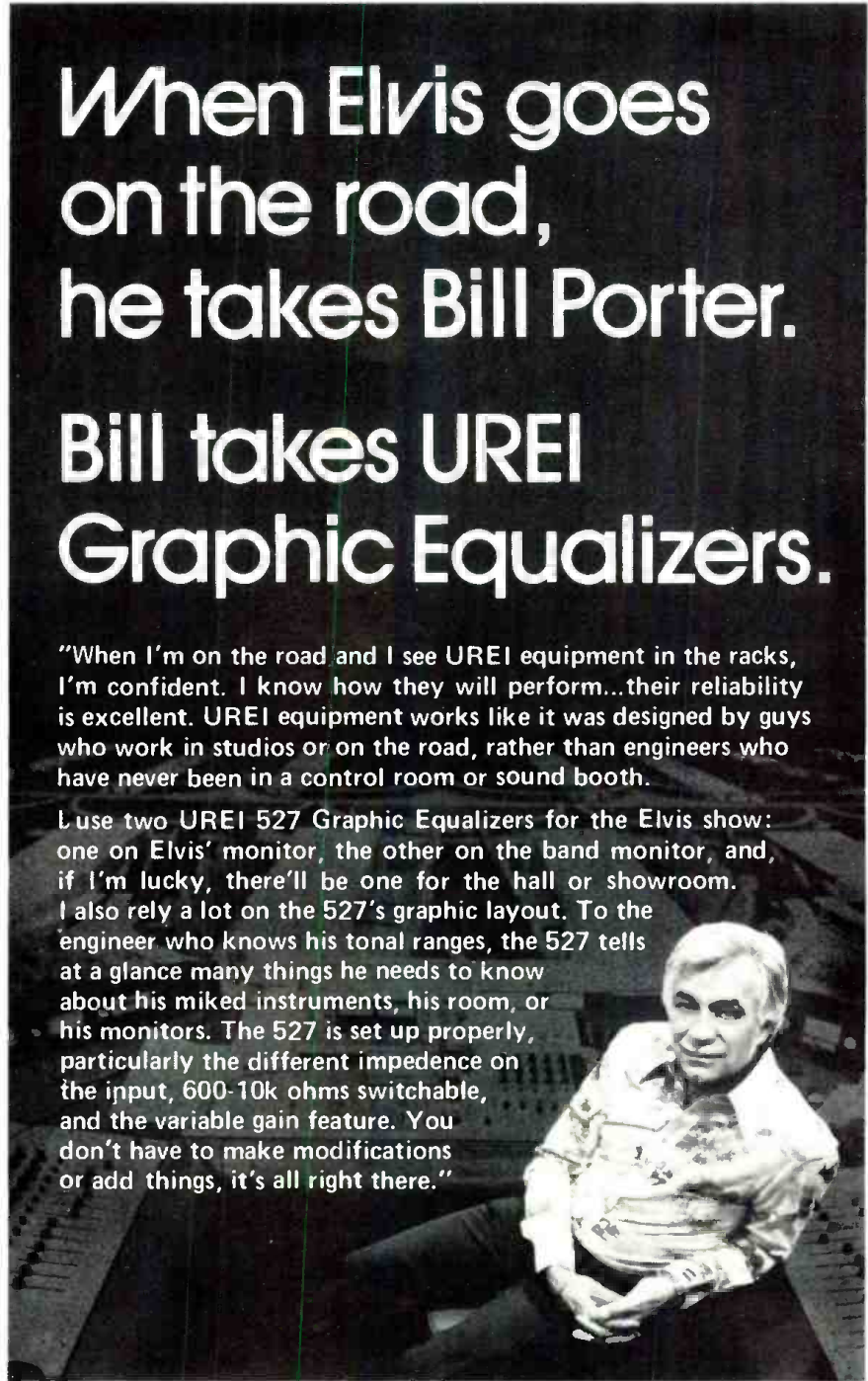
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When Elvis goes on the road, he takes Bill Porter. Bill takes UREI Graphic Equalizers.

"When I'm on the road and I see UREI equipment in the racks, I'm confident. I know how they will perform...their reliability is excellent. UREI equipment works like it was designed by guys who work in studios or on the road, rather than engineers who have never been in a control room or sound booth.

I use two UREI 527 Graphic Equalizers for the Elvis show: one on Elvis' monitor, the other on the band monitor, and, if I'm lucky, there'll be one for the hall or showroom. I also rely a lot on the 527's graphic layout. To the engineer who knows his tonal ranges, the 527 tells at a glance many things he needs to know about his miked instruments, his room, or his monitors. The 527 is set up properly, particularly the different impedance on the input, 600-10k ohms switchable, and the variable gain feature. You don't have to make modifications or add things, it's all right there."



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● As the family car noses its way into Yellowstone National Park, Junior yells, "I wanna see Old Faithful!" Just as Mom is clearing her throat for "Settle down, Junior, we have to find out where it is," a polite voice intervenes from the car radio, welcoming Junior and family to the Park and giving directions for finding the main attractions. This system has been in use in Yellowstone for the past three years. On the approach to the Park, signs at all five entrances ask the drivers to tune their a.m. radios to 1606, where a stream of information ensues, with information relative to such things as entrance fees, parking and accommodation facilities, and where in the Park to go for further details on what to see and do.

The very first such radio directional system was instituted back in 1940 during the New York World's Fair. It was set up on the George Washington Bridge, one of the approaches to Manhattan from New Jersey, giving automobile occupants information regarding the best routes to the Long Island Fair Grounds and

other pertinent hints.

The Yellowstone system, one of a number of such installations at popular tourist attractions, is a somewhat more sophisticated descendant of the 1940 setup.

Within the Park itself, transmitters are located at strategic points, such as overlooks, campsites, and developed areas so that as motorists travel over the more than 200 miles of roads and cover some of the 3 million acres, messages tailored to the specific sight or area can keep the visitors informed and alert for don't-miss attractions.

At the entrances, it has been found that, guided by radio, almost twice the number of cars can be moved through the gates and directly to parking areas on a busy day than before the system was in use. In addition to other facts, at various locations inside the Park, safety information is given. For example, one transmission tells visitors that it is dangerous (and illegal) to feed the bears.

After the Park received the first transmitters in 1968, field tests were run for two years, and then a survey



Model 30-1-92 automatic radio station with an output rf power up to 10 watts. This model can be modified to run on 24 V d.c., operating either at 530 or 1606 kHz, feeding into an omnidirectional antenna or buried cable.

of visitors was made in 1973. It was found that over 80 per cent of the people listened to the broadcasts, and the great majority had no difficulty picking up the transmissions. There are now thirty transmitters throughout the Park and signs are widely distributed to ask visitors to listen to 1606.

TRAVELERS' INFORMATION STATION

The popularity of this new class of radio transmission in tourist areas has spurred the FCC to consider recommendations by an ad hoc group for the establishment of a new category of station, Travelers Information Station. The study by the FCC and several other federal agencies was made to determine the need to alert motorists to road hazards, and to inform them of food, gasoline, and lodging locations as well as local points of interest. There is also the possibility of informing travelers of emergency traffic controls. (Recently, in California, a section of an interstate road was rerouted due to earthquake damage, and the ability to inform hundreds of motorists of the reroute and delay time without having them stop their cars proved extremely helpful in easing the tieup.)

According to the proposed rules, transmitters would be limited to ap-

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proximately 10 watts output. They could broadcast on one frequency below the normal a.m. band (on 530 kHz) or on either 1,606 or 1,612 kHz above the a.m. band. Because these frequencies had already been allocated to other uses (530 to the federal government and the ones above the band to aeronautical, land, and maritime communications) it was decided that no harmful interference may be caused by the TIS (considered secondary) to the other (primary) services. Considering the possibility of interference, it was decided that the sharing of the frequencies would be coordinated through the Interdepartmental Radio Advisory Committee.

Another restriction was also placed on the transmissions of the Travelers Information Station. Since the sole intent of the radio station was to provide safety and convenience information to listeners, no commercial advertising could be broadcast.

According to the FCC regulations, a low power communication device which operates on the designated frequency in the approved band shall limit the radiation so that the field strength does not exceed 24,000/frequency at 100 feet. This applies to a buried cable system. Or, alternatively,

a transmitter input power to the final radio stage must not exceed 100 milliwatts (exclusive of filament or heater power). Emissions below 510 kHz and above 1,600 kHz are suppressed 20 dB or more below the unmodulated carrier, the total length of the transmission line plus antenna must not exceed ten feet, and transmitters obtaining power from public utility lines shall limit rf voltage appearing on each line to 200 microvolts or less, with measurements made with both equipment grounded and ungrounded.

By utilizing buried cable systems, it is possible to limit transmission reception areas to local spots where the information is relevant. Using transmitters, it is possible to cover a wider area with more general information.

The sources of information feeding the system, either the cable or transmitter, could be live, tape such as a repeater cassette, or any other input desired. By using the cassette, or the endless loop, the same message can be repeated endlessly. Live announcements can easily be interspersed as desired.

TECHNICAL SYSTEMS

The company that has produced the transmitters for the Yellowstone

Park system is Technical Systems, Inc., of Bozeman, Montana. (Our appreciation to Ron Campbell, president, for the information details and pictures.) T.S.I. has a simple repeater system available, or a recorder/repeater system, and a transmitter package. Frequencies covered are 530-1,620 and power is 1-10 watts variable. Systems include one indoor/outdoor a.m. radio transmitter, one gain antenna, one power supply, a timer, and an instruction manual. The recorder-repeater unit comes with a microphone.

Other parks have requested similar systems. National parks in Ottawa, Canada, will operate such systems in the near future, and the U.S. Forest Service and the Bureau of Land Management are thinking of putting systems like this along selected routes that pass historical sites. These systems will be in use during your bicentennial travels.

So, wherever you travel this season, drive carefully, and to keep your eyes peeled for signs telling you to tune to 1606. When you see one, do as it says. Your trip will be much safer and more enjoyable. You'll have this opportunity in about a hundred different places, including the California-Baja, Mexico border crossing, the Everglades, and the Grand Canyon. ■



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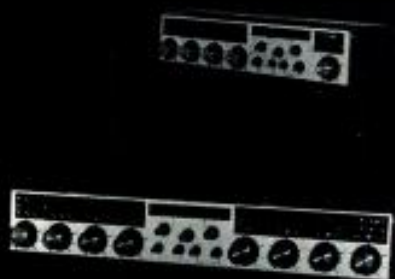
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• The other day a letter from a reader—three pages long—contained so many questions that it should last me a year for material. This reader is interested in playing guitar and being creative with the sounds he and the sound man, working together, can generate. He says he has no intention of learning the whole subject of sound reinforcement, and I don't blame him.

He complains about attitudes he meets from studio sound people, and I know what he means. They are going to do their own thing, whatever he says, and the net result is a lack of communication. He quotes me as saying that, to be creative, an engineer needs to understand all of the formulas, then apply them creatively, and adds that he hates math.

Hold it there, before I get to one of his real questions, was that what I said? It was certainly not what I meant to say. I was talking, as best I can remember, about people who rely on formulas, often blindly, expecting them to work magic for them. I referred to the experience at BYU, last year, where some of the participants wanted me to just put up the formulas, so they could "take it from there."

KNOW THE PRINCIPLES

No, it was not the formulas that I said an engineer should understand, but the principles, the basic physics, etc., embodied in those formulas. Then, as far as I'm concerned, the formulas can go hang! The thing to do is to have a grasp of the physical principles that control what we want to do, and know how to work with them.

Now, when he says he hates math—and he's certainly not alone—what does he mean? Does he mean, for example, that he will figure $3 \times 3 = 6$, mistaking multiplication for addition? If I made that kind of mistake, it would not be the first time. Or does he mean that he is apt to slip a decimal point here and there? I've done that too, in my time. I suspect more likely his problem is that, given $A = \pi r^2$ —a well-known formula—and knowing "A", he has trouble figuring what "r" will be.

In that case, the formula is arranged so that, if you know "r," you can figure "A." But *vice versa*, and you are coming in at the wrong end! Juggling the formula, so it reads r equals something that has A in it, is what he finds difficult.

Well, I've taught lots of classes in formula juggling. You can't find that in the college syllabus? They're not supposed to teach it! But I do not believe that is the best way to learn what you want to learn. The trouble is, the college profs expect you to know how to do it, so you struggle to satisfy them. And if, like the present letter-writer, you have not taken that kind of subject, then the engineer who has passes the same attitude on to you.

Before someone jumps on me for getting into education again, let me assure him that I'm going to apply it to some sound audio stuff in a minute. That formula, known to any schoolboy who has taken algebra, relates to the area and radius, or lineal dimension of a circle. And a good many of our loudspeaker diaphragms do happen to be circular, don't they?

LOUDSPEAKER DIAPHRAGMS ARE CIRCULAR

So, working one way, if you have one loudspeaker with a 4 in. cone, and another with a 7 in. cone (sorry, I'll give it in millimeters next time, if you prefer—or if the government insists), you want to compare the relative amount of air each will move. The air each moves depends on the area. To compare, you don't really need bother with the π .

You do not need much math to know that 4 squared is 16 and 7 squared is 49. And with a little more figuring, you know that 48 is 3×16 , so 7 squared is just a whisker more than 3 times 4 squared. If you have acquired a little expertise in spotting percentages, you may think that 49 is a little more than 2 per cent bigger than 48. If not, no matter; 1 in 48 or 49 is not much. In audio, twice is only 3 db.

So the 7 in. cone moves 3 times as much air as the 4 in. cone. Now hold it, one of our formula buffs will say—the formula is in radius, and the numbers you are using are diameters. So you are all wrong. Am I?

We ignored the π because we are comparing similar things. It is in the formula, both times you use it, so the ratio is unchanged by multiplying both of them by π . The formula, using diameter, is $A = \frac{\pi}{4} d^2$. You just use $\frac{\pi}{4}$ both times, instead of π both times. It still does not change the ratio.

The principle to remember is that *two areas of the same shape, in this case circular, or round, are proportional to the square of their linear measurements*—if you use the same measurement each time. You could use radius, or you could use diameter, so long as you use the same ratio for each cone. Diameter happened to be more handy, so we used it.

Now that is pretty simple stuff. The questions my correspondent got into mostly was matching and frequency response, particularly when you have multi-speaker systems. He queried whether one had to use a bi-amplifier, or multiple channels, or whether passive crossovers could be used.

Then he got into some "supposes." Suppose the units do not have the same impedance, or the same sensitivity. What happens to the frequency response, and the impedance matching, and all that stuff?

Well, a formula may very well be a help in calculating the theoretical values in an ideal crossover, where you know the impedance, and there is only one impedance, and you know the crossover frequency, and rate of change in energy at crossover. But so often what you have to work with is not quite that ideal.

My correspondent seemed to think that, if he had all the formulas packed away in his head, or in an appropriate reference book, then he'd know the answers to such questions. That is where he is wrong. The people who know all the formulas are just as much at a loss as he is, often more so. That is why I have been saying that it is important to know the *principles*, more than the math, or the formulas.

CROSSOVERS

Since the formulas give you the design for an ideal crossover, let us first look at an ideal crossover, to see what ideally happens. Then we can use a little common sense (who was it that said that it's really awfully uncommon?) to figure out how to apply it to some non-ideal situations, such as we meet every day.

What the formulas do not tie down is when and how they work. In other words, what the ideal situation really is. They give you a formula that gives values for L_s and C_s , if you know f , the crossover frequency, and Z , the working impedance. Then, assuming you put these L_s and C_s together in the proper circuit configuration, and connect the right things to them, they work their special kind of magic.

Let us see what that means. Suppose the crossover is designed for 16 ohms, and a crossover frequency of 1000 Hz. Then connecting a 16-ohm

Now relax, playfully invite your muse, and transform these tracks, adding body, stereo perspective, flanging, and a host of other time-base effects. Since Lexicon introduced digital delay over six years ago, most studios have come to depend on it at least for doubling and slap. Now, the stereo 102-S with the new VCO module* produces many other effects, including more natural double tracking, flanging, vibrato, time delay panning, extreme pitch modulation, and signal transformation for special effects. Of course, you can also use the two channels for completely independent processing.

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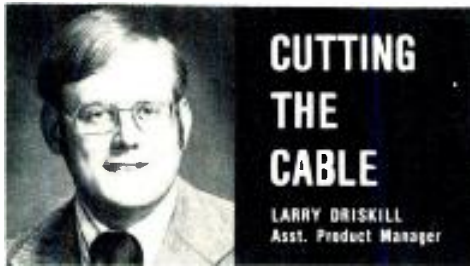
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Under a project started several years ago at Electro-Voice, we have made extensive laboratory and field studies to determine the important performance characteristics desired in wireless microphone systems, problems to be overcome, and optimum operating possibilities within the present state of the art or with improved materials and techniques. Reliability and flexibility of operation were the primary needs of most of the users we talked to.

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theory & practice (cont.)

woofer to the low frequency output, and a 16-ohm tweeter to the high frequency output, will result in the crossover providing a 16-ohm load for the amplifier at all frequencies. That is the ideal.

But now, suppose the tweeter is not 16 ohms, but 8 ohms, or even 4 ohms. Then at low frequencies, well below crossover, in the woofer's range, the amplifier is loaded with 16 ohms—the woofer. And at high frequencies, well above crossover, in the tweeter's range, it is loaded with 8 ohms, or 4 ohms, as the case may be. But what happens at crossover, and say an octave either side of it?

That depends on the circuit configuration of the crossover. For the moment we will not get into that. In our next column we will show how to deduce that. For the moment we will look at something a little simpler—how to make it come out right when you have this problem.

If the crossover is designed for 16 ohms, then it should be loaded on both (or as many as it has) outputs, with 16 ohms on *each*. In the example we picked, this means we must make the tweeter *look* like 16 ohms. Now if, in addition to having an impedance of 8 ohms instead of 16, the tweeter is 3 dB more sensitive than the woofer, the solution is simple.

You put an 8-ohm resistor in series with the tweeter, so the crossover is correctly loaded with a total of 16 ohms, and the power reaching the tweeter will be divided by 2, a loss of 3 dB in FIGURE 1.

What if their sensitivities match, but their impedances are different? One solution is to use an auto-transformer for the tweeter, to make it look like 16 ohms to the crossover. A suitable size core, with, say, a total of 28 turns tapped at 20, would serve. Connect the 8-ohm tweeter to the 20 turns, and the output from the crossover to the 28 turns, and you have it (FIGURE 2).

AMP WITH MULTIPLE TAPS

That will work with any crossover network. There is another solution, when the amplifier has multiple output taps, and the crossover networks are parallel connected. You use differently designed halves to the crossover. A 16-ohm low-pass connects from the 16-ohm output on the amplifier, to feed the woofer, and an 8-ohm high-pass connects from the 8-ohm output on the amplifier, to feed the tweeter (FIGURE 3). Or of course, 4 ohms, if that is what you have.

If the amplifier output uses a trans-

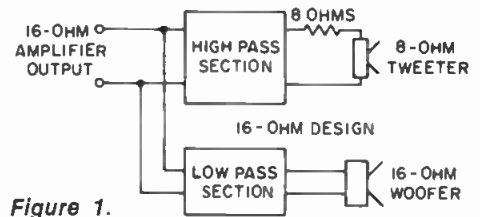


Figure 1.

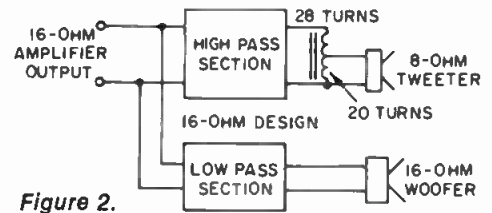


Figure 2.

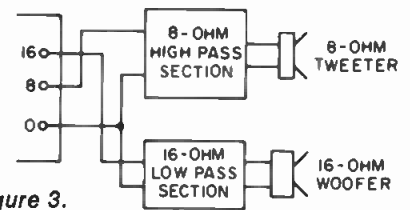


Figure 3.

former, the transformer will combine the two load impedances so the amplifier "sees" the correct impedance at all frequencies.

This will not work if the crossover is designed to combine the units in series, instead of parallel.

Here we have picked three relatively simple examples that happen to be convenient. As you may suspect, we have left a lot out. The important thing is to start your getting the idea. In our next column, we will take it from here and show how to figure what you want, from what you have.

Also, we need to take a look at the fact that loudspeaker impedances are nominal. If we actually loaded a crossover with resistors of the correct value, say, 16 ohms, then the amplifier load and the frequency response to each output resistor would be perfect. The combined energy fed to the two resistors, one representing the woofer and the other representing the tweeter, would be constant—a flat overall frequency response.

But resistors do not make good loudspeakers. Most of them emit no sound at all. Conversely, loudspeakers do not make good resistors. Their impedance is far from constant, or even resistive, over the range of frequencies they cover. This fact can change what the crossover does. Putting together a set of values obtained from a formula has no magic to it. It will not necessarily come out right, just because you used a formula.

In our next column, we will get into more details about this fascinating subject. Stay with it, and you'll master it. ■



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The Cartridge Tape System

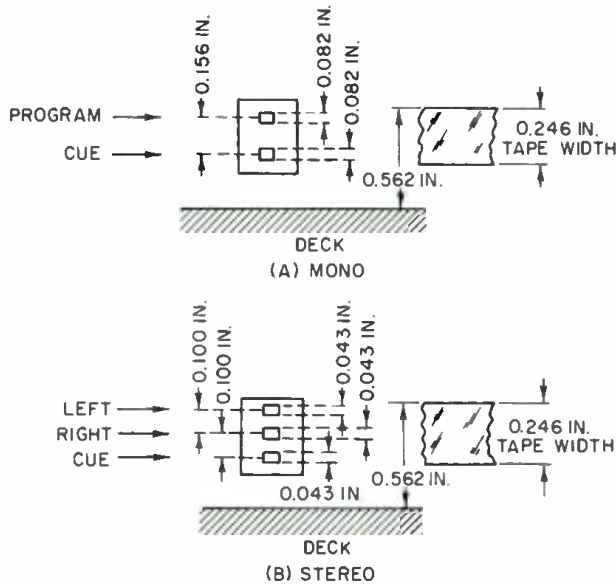


Figure 1. The NAB-standard cartridge head dimensions and track positions.

• Cartridge tape recorders used in broadcast work differ in many respects from other tape systems. These units will produce a high quality audio, but they do have their own peculiarities and temperament.

ELECTRONICS

The audio channel or channels is made up of conventional recorder amplifiers, equalizers, etc. The major difference from other tape systems is in the head assembly. All units, whether monophonic or stereo, use premium stereo heads. In the mono machine, a two-track stereo head is used, and in the stereo unit, a three-track head. The additional track is used for cueing and switching purposes.

The heads in use conform to NAB standards. These standards not only prescribe the track placement, but also its width. The two-track head produces wider tracks than the three-track head. Stereo and mono cartridges may be interchanged and played on either machine, but there are some compromises. A stereo tape played on a mono machine will lose the right channel and the output will be somewhat lower. The cue tracks will work in either case.

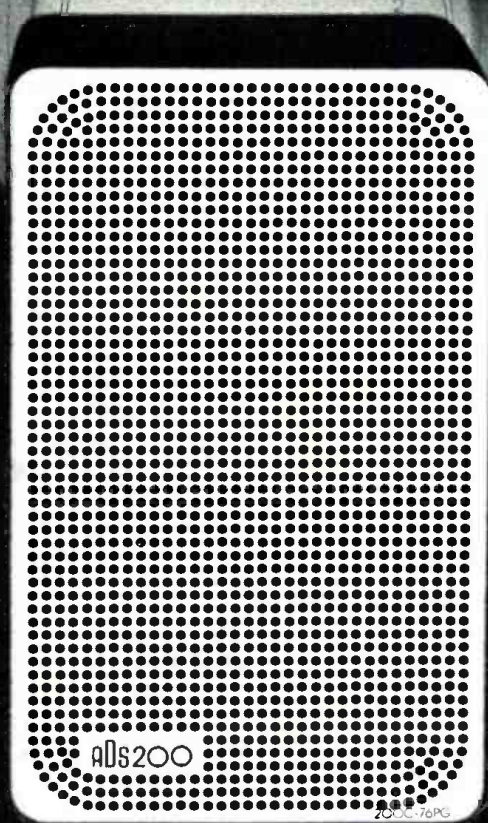
The number of heads a machine may use is dictated by its design and end purpose. Many of these machines

are intended only for playback, so they do not have a record head. In many cases, however, a dummy head will be used in the record head position so as to maintain the correct pressure against the tape. A recording unit will have both a record head and a separate playback head. None of these machines, by the way, have an erase head; erasing must be done with a bulk eraser.

The tape in the cartridge is a continuous loop, so some method of cueing is necessary. This is done automatically in the recorder, which records a burst of 1 kHz tone on the cue track at the moment the machine is started. On playback, this tone is sensed with the cue track head, amplified, processed, and then operates a relay which stops the machine and the tape movement and leaves the tape cued and ready to play again.

Besides the cueing tone, two other standard tones can be used for switching external functions or tape machines. The first of these is a 150 Hz tone, called the *auxiliary tone*, and the next is an 8 kHz tone called the *tertiary tone*. When units are equipped with this feature, the auxiliary tone is usually applied immediately at the end of an announcement on the tape so that tight switching to another machine can take place. On playback, this tone is sensed, amplified, proc-

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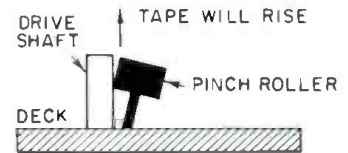
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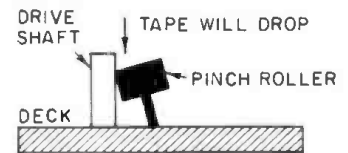
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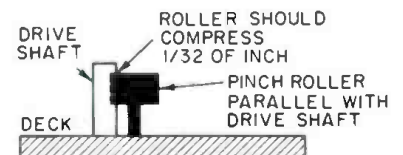
broadcast sound (cont.)



(INCORRECT)
(A)



(INCORRECT)
(B)



(CORRECT)
(C)

Figure 2. The pinch roller must meet the drive shaft properly or the tape will ride off the correct path.

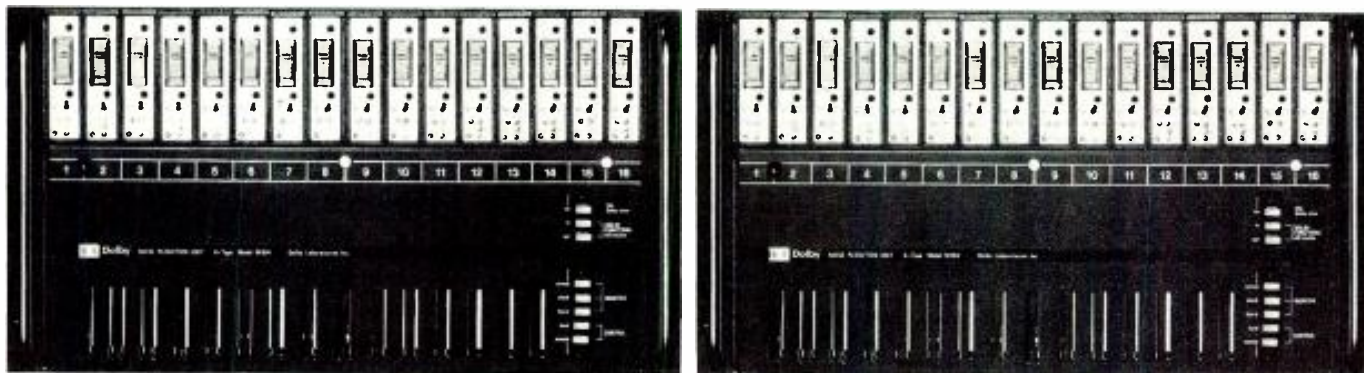
essed, and operates a relay to provide a set of dry switching contacts for external units.

These three tones—the cue, auxiliary, and tertiary, are applied on the same track of the tape, sensed by the same cue head and amplified by the same amplifier. Then they must pass through filters to separate them according to their specific functions. If this is done improperly or there is any problem with the cue channel and filtering, then there can be many problems with switching functions.

TAPE SYSTEM

This is where the major difference occurs between the cartridge and open reel systems. There is no transport with its motors, brakes, idlers etc. as in a conventional machine. All the tape handling is done within the cartridge itself. The tape is a continuous loop—regardless of its length. The actual length is very important to operation, so cartridges are filled with the correct length for the use intended—for example, a 40 second, 70 second, 2 min., etc. length. Should a cartridge that is fully loaded be used for a short announcement, there would be a considerable amount of run-out time involved. It would be

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broadcast sound (cont.)

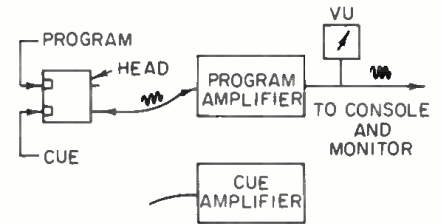


Figure 3. A quick way to check that correct levels have been recorded on the cue track (when a tape head meter is not available) is to feed the cue head output to the program channel and read it on the vu meter.

necessary for that tape to run at normal 7 1/2 in/sec. speed for the full length until it reached the beginning of the loop. There are no fast forward or reverse functions, as found on conventional recorders, so it is not possible to shuttle the tape back and forth quickly until the correct position is found on the tape.

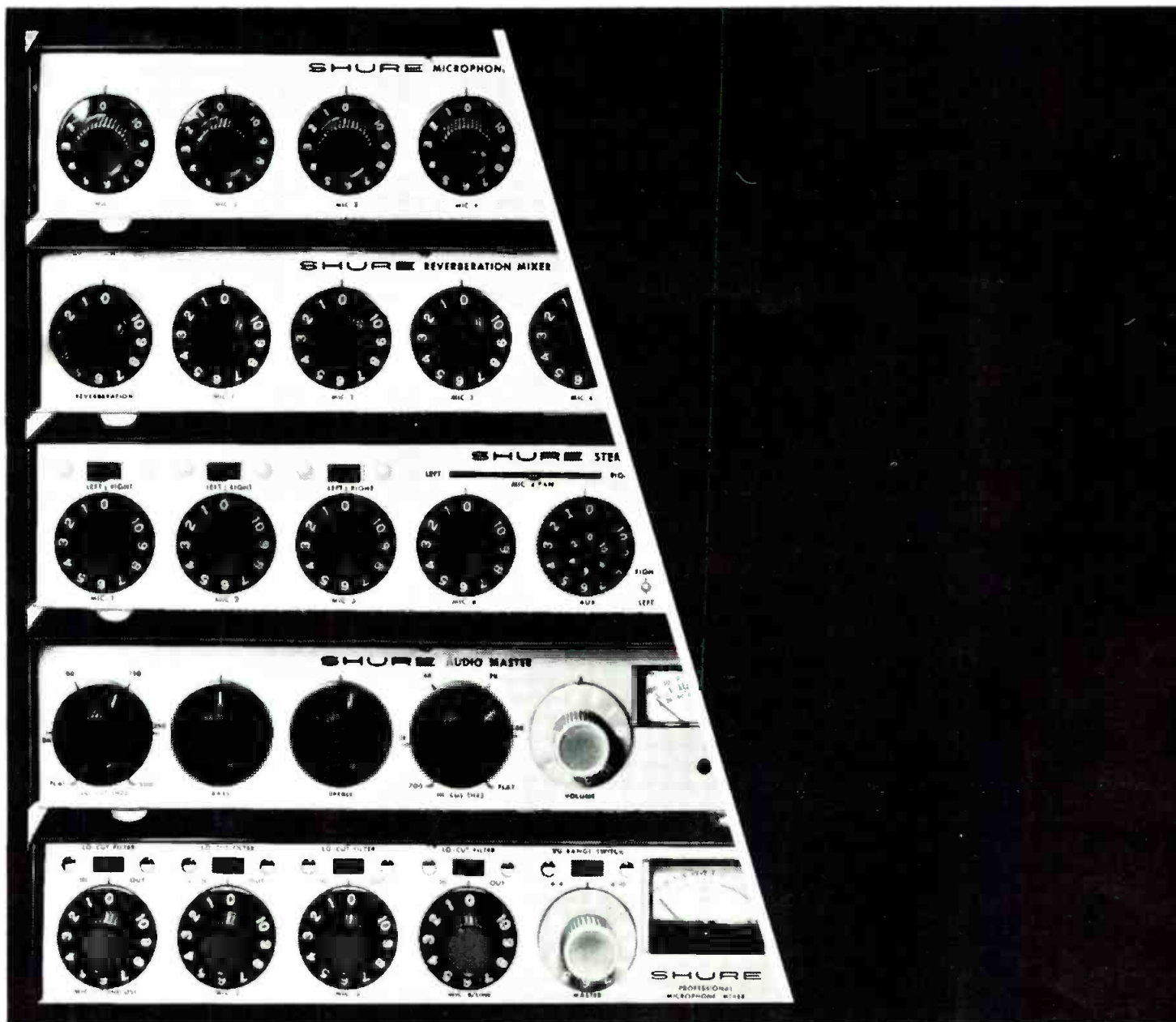
The cartridge contains the pressure pads which are used to maintain pressure of the tape against the heads. There are also a few plastic tape guides which help direct the tape travel across the heads. These are not as effective as on a standard machine, because there is nothing to maintain correct tension except the tape roll itself. Many machines also provide metal guides attached to the head assembly.

MECHANICS

The mechanics of these machines are far more simple than in conventional machines, but they are also temperamental in adjustment. On most machines, there is a single drive motor and a solenoid-operated pinch roller. (Multi-tray machines, as used in automation systems, have a somewhat different arrangement.) The pinch roller must come up inside the cartridge to press the tape against the motor drive shaft. This adjustment is rather critical, since the tape must travel a relatively long distance and pivot at an angle to the shaft. In the drive position, the roller must press against the drive shaft in the correct position or it can cause the tape to be driven upwards or downwards on the shaft and of course, out of the correct travel path across the heads. When the machine stops, the roller must drop below deck level so the cartridge may be extracted or a new one inserted.

OPERATION

When the recorder is switched into



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broadcast sound (cont.)

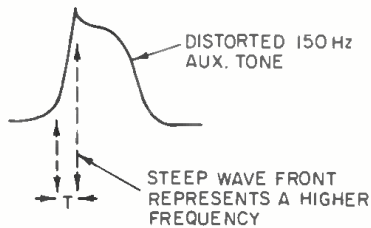


Figure 4. Check the waveforms of the cue tones with an oscilloscope. If the 150 Hz tone is distorted and has a steep wavefront, the cue circuit may sense this as 1 kHz and stop.

run mode (recording), there must be a brief delay before the announcer begins to speak. This may be about one or two seconds, depending upon the make of the unit. This delay is necessary so the solenoid can swing into position and start the tape moving; the 1 kHz cue tone burst is recorded at this time. If the announcer begins to talk as soon as he pushes the start button, the first few syllables of his words will come up cut on the playback. This is due to the fact those syllables will play as the tape is about to stop. There is a slight delay on the stop action and the sensing of the tone; therefore the tape will stop after he has spoken the few syllables. This sounds bad on the air.

Placement of the auxiliary tone at the end of the announcement must be done carefully. If this is done too soon before the announcer is finished talking, the switching action will take place and there will be two machines playing on the air at the same time. That also sounds very poor, and plain sloppy. If he delays too long after the announcement, then there will be a long pause on the air. Cartridge units used in automation systems often use this feature to provide overlaps and tight switching. The tone is placed one or two seconds ahead of the end of the announcement. This causes a music machine to switch on with the last few words of the announcement and provide a music bridge.

MAINTENANCE

The amplitude of the tones recorded on the cue track is very important. The tones should not be distorted, nor should there be noise or transients on the track. All this can cause faulty switching. The tones should be recorded at the same amplitude as are the program materials. A simple way to check this is with a

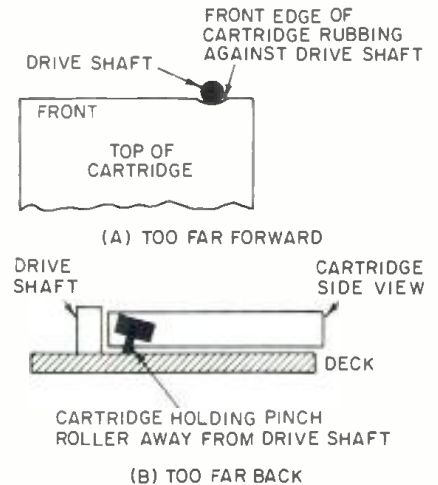


Figure 5. The cartridge must align properly with the drive shaft and pinch roller or there will be speed and tape drive problems.

tape head meter. If one isn't available, switch the cables on the playback head so as to feed the cue track to the program amplifier. Then measure the reproduced tone level with the vu meter and listen to them on the audio monitor. Let the tape play all the way through and not if there are any spurious tones, noise or transients on the track.

Another way to check is with an oscilloscope. Pick up the reproduced tones at a point in the cue amplifier where the level is adequate for scope operation. Pay particular attention to the wave shape of the tones. If the 150 Hz tone, for example, looks more like a square wave than sine wave, the 1 kHz amplifier may sense that steep leading edge as its own tone and stop the tape. This would leave the tape improperly cued.

Heads and pinch rollers must be cleaned frequently, depending upon the use of the machine. The roller will become slippery with the lubrication off the tape and will slip, causing speed variations or slow speed. The heads can become clogged with both oxide and lubrication and have a low output and faulty switching. The tape, by the way, is a particular tape for use in cartridges. It has a special lubrication. Don't use ordinary tape or it will cause all sorts of problems and wear out quickly.

Since the tape handling is in the cartridge, there are many potential problems. One is the small turntable which carries the tape. This rides on a teflon washer and must also have a drop of grease for lubrication. If this goes dry, the table will cause a drag

Rock and roll is in its third decade and there are mountains of blown diaphragms and discarded speaker systems as evidence of the difficulties loudspeaker manufacturers have had in meeting the challenge. The SP1 was designed and tooled by a new loudspeaker company dedicated to solving the basic difficulties of high level sound reinforcement in order to meet that challenge.

Our two-way is a compact, powerful, reliable, high fidelity loudspeaker with dispersion and power response so uniform that the "sound" of the system is stable in different environments. The SP1's multi-flare radial horn is the most significant advance in the control of high frequency dispersion since the invention of the radial horn half a century ago. Undoubtedly the design

will become the industry standard.

The real marvel of the SP1 system, however, is the Model 22 Compression Driver. We have been producing it since August 1975 demonstrating that it is possible to combine adequate high end response (13 KHz), efficiency (30% midband), high power handling (40 watts pink noise 8 hours continuous), reliability (6 forms of on-line analysis plus listening) and good sound in a compression driver. Until "22" a high performance 2-way like the SP1 was not possible.

The low-end of the system is provided by a 15" horn loaded cone speaker covering the range of 60 - 500 Hz.

The extensive Q.C. system devised for the driver has been expanded to allow the same scrutiny of the SP1.

Some strong statements have been made here, but we know we can deliver. The demand is so great for a system with the SP1's performance that our dealers have ordered over 1,200 units (as of Dec. 1, '75) based on word of mouth from the few people who have heard samples from pilot production.

The SP1.

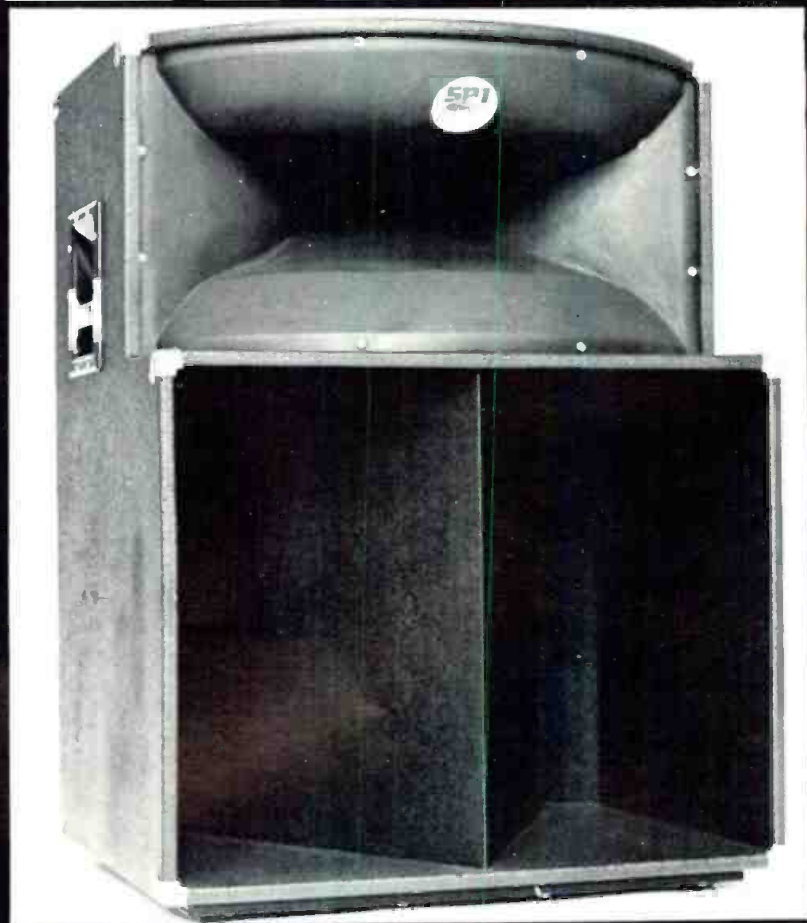
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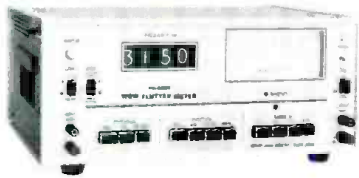
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W/F range is 0.003% to 10% at inputs above 30mVrms and 0.01% to 10% with inputs from 0.5mV to 30mVrms.

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Sabor corporation

Circle 31 on Reader Service Card

broadcast sound (cont.)

on the tape and there will be speed variations in the reproduced audio. However, do not use oil and never allow grease or oil on the tape itself.

For the tape to play properly, it must be in the correct relationship to the heads. There are cartridge guides for this purpose and these must be adjusted properly. There is also a leaf spring that holds the cartridge down against the deck. If this is weak or absent, the cart will lift up during play and the high-frequency response will fall off. If the guides are not correct, the tape won't position properly, and there can be a variety of improper results. Set the guides, head assembly, and drive shaft and pinch roller so the tape cartridge goes directly into the heads. The cart should not be too far forward or the edge will drag against the drive shaft. If it is too far back, the pinchroller shaft will be held back, reducing pressure of the roller against the drive shaft. The roller shaft must clear the keyhole in the cart.

The solenoid is a very important part of the assembly. This should be disassembled occasionally and the plunger and inside of the solenoid cleaned

out. Lubricate with Teflon dust or powdered graphite. Never use oil or grease as the heat of the solenoid will cause it to become sticky and gummy, causing the plunger to fail to operate.

Many problems occur in the cartridge, so these should be inspected regularly. A good time is prior to recording. Inspect the tape for wear. If the oxide is streaked or gone, replace the tape. Check the pressure pads. Press the sponge tape pads; they should spring right back when released. If not, they have lost their strength and should be replaced. The peg in the end of the cart should be down in its socket and firm. If loose, re-cement in place. This peg is what feeds the tape across the front of the cart. Visually inspect the insides through the clear top for tape that is too tight or too loose in wind—both are faults. And make sure the wire guide is in place. The case itself should not be damaged or broken.

SUMMARY

The cartridge tape system is in many ways different from other tape systems. It can produce a high quality audio recording when proper attention is paid to pampering its fickle temperament, and constant maintenance with attention to its peculiarities, is observed. ■

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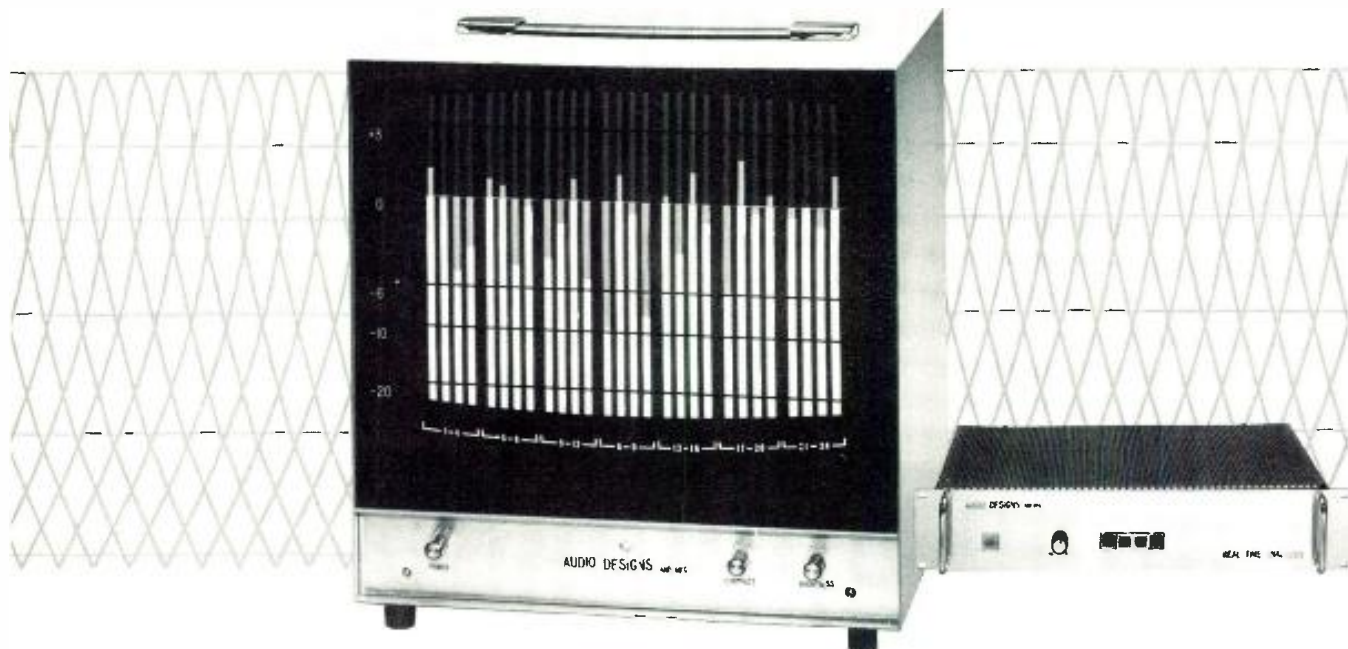


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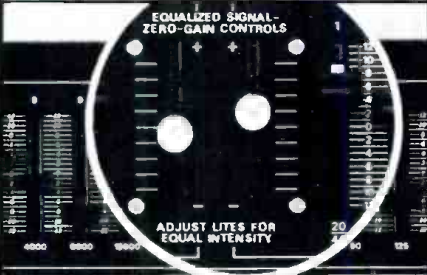
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● Shallow-depted Eh 800 horn is designed to be used in two-way situations where space is limited. The device is made so the horizontal beam remains constant throughout the middle and high frequency range. The full sound spectrum may be directed exactly where it is needed without horizontal or vertical diffraction. Coupled to the EA 175 high frequency driver, it is claimed that the two linked devices deliver less than 0.5 per cent total harmonic distortion. EA 175 operates well in high power applications and has a conveniently replaceable voice coil/diaphragm assembly, which centers precisely in the voice coil air gap.
Mfr: Emilar Corp.
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R.A.M. DIGITAL DELAY



● Combination variable digital delay line and pitch changer Harmonizer™ has an output variable in 7.5 msec. steps from zero to 112.5 msec. in the delay mode. An optional second output variable offers 7.5 msec. steps from zero to 82.5 msec. In the pitch change mode, the output, variable in pitch from -1 octave to +1 octave, may also be delayed by zero, 30, or 60 msec. It is claimed that because of its digital configuration, musical relations can be preserved with no degradation of signal/noise ratio of frequency response even while increasing the delay up to maximum. An optional keyboard, varying the pitch of the input signal by musical intervals as keys are depressed, permits a performer to control up to three Harmonizers. Signals of any complexity can be processed. Other control modes allow the device to be controlled by the top

octave output of any synthesizer or a variable control voltage. A feedback control generates odd "spacey" effects. Room resonance is eliminated through an anti-feedback mode triggering a controlled vibrate. An optional readout allows precise pitch ratio setting without the keyboard.
Mfr: Eventide Clockworks, Inc.
 Circle 51 on Reader Service Card

QUARTER-INCH RECORDER



● Full track mono and half-track head configurations in portable, rack mount, and console mountings are available with A-67 quarter-inch tape recorder/reproducer. The unit offers 3-speed crystal-controlled servo capstan drive; servo tape tension control on both take-up and supply motors; and tape timer reading in minutes and seconds. The transport and audio electronics plug in with access from the front panel.
Mfr: Willi Studer America, Inc.
 Price: \$2,400.
 Circle 52 on Reader Service Card

EDITOR DUPLICATOR



● Designed especially for fast editing of on-the-street interviews, Tri-master editor duplicator allows rapid conversion from cassette to open reel for editing without the need for additional slaves. The unit may also be used for reel-to-cassette or cassette-to-cassette duplication. It is available in either two-track or four-track versions.
Mfr: Pentagon
 Circle 53 on Reader Service Card

SOUND ANALYZER



● Designed to be used primarily as a monitor for program material, model 142 sound analyzer incorporates a 28 by 11 led matrix for the display of 27 one-third octave channels from 40 Hz to 16 kHz plus one broadband channel for overall indication of level. Decay time can be varied, in steps, from 0.1 seconds to 2.0 seconds. The unit has a built-in pink noise digital generator, available at both the front and rear, presented at a level of zero dBm. Two cmos memory registers store information as long as the unit is turned on. In a SAMPLE mode, parts of program or pink noise test signals can be stored for later viewing. The ACCUMULATE mode registers the highest peak readings during any segment of program material for later viewing. Of particular usefulness are the dual memories, convenient for comparison readings.

Mfr: White Instruments, Inc.

Price: \$3,200.

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DIGITAL MULTIMETER

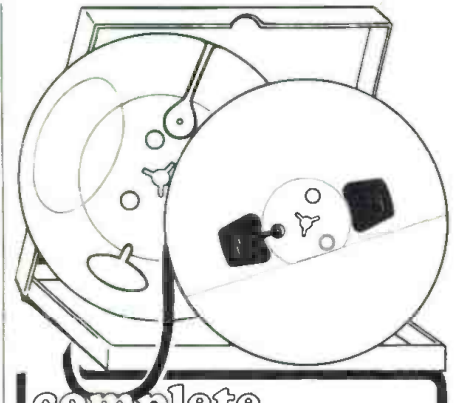


● Measurement of current, voltage, and resistance is simplified with convenient little Model 3476A digital multimeter. Voltages are measured from ± 100 microvolts to $\pm 1,000$ volts d.c. and from 300 microvolts to 700 volts r.m.s. a.c. Resistance is measured from 1 ohm to 11 megohms. Current can be measured from 100 microamperes to 1.1 ampere d.c. and 300 microamperes to 1.1 ampere a.c. Auto-zero, autopolarity, and autoranging are built in. The unit, which uses fine-line, tantalum nitride resistor technology, has a range hold feature that allows the instrument to be locked to any desired range. The l.e.d. readout gives all voltage readings in volts, resistance readings in kilohms and current readings in amperes. Battery or line powered.

Mfr: Hewlett Packard

Price: \$225-\$275.

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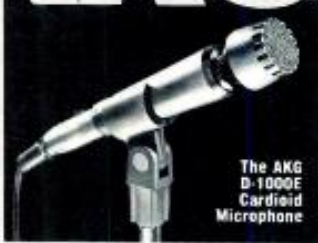
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Many professional people prefer AKG microphones... and for many reasons. Take our D-1000E cardioid, for instance. Its built-in flexibility allows a variety of options for a more "personal" sound in recording and live performance situations. The D-1000E's Bass-Medium-Sharp equalization switch says that the sound you get is the sound you want... even in acoustically poor environments.

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products & services (cont.)

POCKET PAGING RECEIVERS



• Three new Pagemaster f.m. selective pocket paging receivers have been designated SS35VT, SS150VT, and SS450VT. The solid-state superheterodyne units operate in the 35 MHz, 150 MHz, and 450 MHz frequency bands. The hands-free units have built-in memory which stores a page signal until the wearer is ready to receive it. Weighing 5.5 ounces including battery, the units use completely solid-state integrated and hybrid microelectronic circuitry that plug in. They also have tone signaling as well as voice message. Other features include active filter decoding, including the ability to change codes in the field, and compatibility with existing standard EIA two-tone sequential f.m. systems at 35, 150 and 450 MHz.

Mfr: Bogen Division,
Lear Siegler, Inc.

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MIXER POWER AMPLIFIER



• Up to 12 fully controllable inputs are offered on portable model M-251A mixer amplifier, with 11 types of plug-in modules and six-channel reverb. option. Power amplifier output delivers 100 watts rms continuous duty. A 7 point led vu meter is optional. A "slave amp" on the back panel provides an output from the mixer driver for monitoring or for use as an input to a booster amplifier. The unit is equipped with reset circuit breakers on the output and power lines and low load impedance output current limiting circuits to protect the output transistors. Heat sinks cool the output transistors for continuous operation.

Mfr: Pulse Dynamics Mfg. Corp.

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MOVING COIL PHONO CARTRIDGE



• A beryllium crystal cantilever, directly coupled to a coil assembly, holds the stylus on MC 1000 reference pickup. The unit also features a double-layered damping system. Optionally available are accessories MCB 100, moving coil pickup booster transformer and FG 100 stylus force gauge. The stylus gauge can be used with other phono systems.

Mfr: Nakamichi Research, Inc.

Price: MC-1000, \$250;

MCB-100; \$100;

FG-100, \$20.

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SOUND REINFORCEMENT



• Two 15 in. speakers in a front loading exponential horn for uniform bass projection, a high frequency compression driver coupled to a wooden radial horn for midrange reinforcement, and a pair of high frequency piezoelectric tweeters for treble response are included in model 15 sound reinforcement enclosure. The unit is especially suitable for keyboard reinforcement. High power handling is a continuous 200 watts.

Mfr: Sunn Musical Equipment Co.

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VOCAL STRESSER



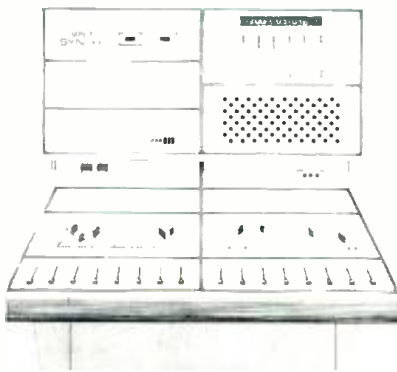
• Vocal stresser model OCA769XR combines the functions of a four-band parametric equalizer and those of an integrated multi-slope compressor, expander, and limiter. It is completely capable of performing the functions necessary to studio microphone enhancement or complete a.m. or t.v. audio chain processing.

Mfr: Orange County Electronics

Price: \$1,256

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COMPUTER MUSIC SYSTEM



● Computer Synthi is made up of a PDP-8/A minicomputer, two cassette tape drives, analog-to-digital and digital-to-analog converters, pushbutton and slider controls, input-output plugs, sockets, patch panels, and 16-position led display. The tape drives make it possible to use the equipment for different projects by changing cassettes. It can be used with any voltage-controlled equipment, particularly in composing electronic music, creating sound effects, audio signal experiments and sound research. Twenty independent streams of control voltages can be used with synthesizer oscillators and filters to build a voice model.

Mfr: Electronic Music Studios
Price: \$28,000.

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PARAMETRIC EQUALIZER/ PREAMP



● Three separate frequencies can be controlled simultaneously by means of PQ-3 parametric equalizer/pre-amp, designed for use as a patchable outboard equalizer, as a musical instrument preamp, as an adjunct to a conventional instrument amplifier, or in a p.a. system for feedback suppression. The controls are continuously variable, creating special effects when desired. Once a frequency has been selected, the exact amount of boost or cut may be set with the corresponding equalization control, varied up to +20 dB boost, to over -40 dB cut. Adjustment of the matching bandwidth control permits the user to determine the extent to which the frequencies surrounding the selected frequency are affected by the equalization control.

Mfr: Furman Sound Service
Price: \$250.

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WIND PICKUP TRANSDUCER



● Purity of pickup is claimed for W-200 and W-250 transducers elimi-

nating all extraneous mechanical vibrations from wind instruments, brass, or drums. Feedback is also kept to a minimum. Two styles in the three-dimensional pickup adapt to flutes or to other wind or brass instruments, and drums. The instrumentation grade preamps, housed in 14-gauge stainless steel, are transformer-coupled to be compatible with studio and p.a. equipment; they can also be used with instrument amplifiers. Pickup is flat from 20 to 20,000 Hz.

Mfr: Frap

Price: W-200, \$500; W-250, \$600

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products & services (cont.)

8-CHANNEL STEREO MIXER



- Variable negative feedback circuitry is featured in 800-S mixer. Each of the eight channels has separate high and low equalization, as well as a slide level control for maximum tone control and output level. There is also pre- and post-capability for monitor, reverb, and effects send controls, individual channel attenuation and stereo pan. A master section features slide level controls for left and right main and monitor, as well as low, mid, and high equalization for both left and right mains. Also included is master level, return, and pan controls for the effects and reverb busses. Two lighted vu meters with screw adjustments are located above the master section.

Mfr: Peavey Electronics Corp.

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HAND WIRE STRIPPER



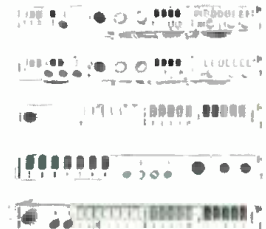
- Cutting edges harder than insulation but softer than copper are claimed for the Alpha Plastic-Blade Stripper, using Stilan[®] plastic blades. The stripper can remove the insulation from twisted pairs, multi-conductor cable, ribbon cable, twin-lead antenna wire, electrical cable, etc., without separating the conductors. Requiring no adjustment for wire size, the device strips any size wire from AWG 12 through AWG 28 with most types of insulation. Blades are replaceable through injector action.

Mfr: Alpha Wire Corp.

Price: \$39.95.

Circle 65 on Reader Service Card

RECORDING CONSOLE MODULES



- Comprehensive switching and control facilities for multi-track recording, quad-stereo-mono mixdown, and monitoring are possible with series MAP 8422 console control modules. Included are selectable mic/high level inputs with programmable led peak level indication; an internal power network for condenser mics; switchable 70 Hz Hi Pass filters; channel mute and solo on all inputs; quad panning and quad/4-track/stereo mode selection; direct track feed; two independent echo channels with pre-post fader selection, delay, echo, and monitor send and return functions; two independent cue channels; self-contained multi-track mixing amplifiers with full range rotary Submaster level controls. Complete control facilities for monitoring, talkback, and slate are also provided. The series plugs directly into printed circuit motherboards. Faders, equalizers and/or compressors are omitted from the input modules to allow the assembler to choose these items to suit his convenience.

Mfr: Modular Audio Products, Inc.

Circle 66 on Reader Service Card

Listen to wow and flutter.



If you service record/playback equipment, you need to measure wow and flutter. And with the BPI Model 1000A, you can listen to wow and flutter as well. Because right between those needle meters is a speaker to help you diagnose the problem. The Model 1000A is an easy-to-use, all-solid-state pushbutton instrument that measures wow and flutter to 0.02%. And it's priced at under \$650.



BPI, 7853 Balboa Ave., San Diego, Ca. 92111, Phone (714) 279-3344

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HEAD-WORN BROADCAST MICROPHONES



● Designed for occasions where the user wishes to transmit as well as pick up, models SM10 and SM12 feature unidirectional pickup patterns that reject unwanted background noise, and miniature windscreens. Low impedance permits long microphone cables; snap-on connectors keep wires out of the way. The mics, which weigh less than three ounces, pivot and extend to fit the individual. SM10 comes with headband and microphone, SM12 with microphone, headband and earphone.

Mfr: Shure Bros.

Price: SM12, \$96.00; SM10, \$72.00.

Circle 67 on Reader Service Card

LIVE AUDIO CONTROL CONSOLE



● As an aid to live performance treatment, Grandson III, model 110-T, offers quadriphonic mixing, pre-setting, and full theatrical communications. Up to 16 input positions may be combined to 8 mixing busses. Presets distribute the quad busses to each of 8 outputs. Theatrical communications interface into headset intercom, backstage, cue/page, etc. The modular unit contains a phantom condenser microphone, 8 vu meters, quad positioners, 4 eight-output presets, separate stage and audience mixing, 2 effects send/receive channels, and stereo control room monitoring with solo function combination. 20 dB headroom is provided over +4 dBm output. Each input position provides a stepped input sensitivity control handling level from -70 dBm to +20 dBm at input. Also provided are a linear motion attenuator at each input position and a six-frequency equalizer.

Mfr: Auditronics, Inc.

Circle 68 on Reader Service Card

INTERCOM SYSTEM



● "TW" two-wire intercom system, operating through a closed circuit headset, is designed for field use. Up to 50 user stations can be connected on line to two independent channels. The stations feature built-in mic limiters, carbon or dynamic mic input, flashing call light with variable frequency adjustment for selective paging, two-watt headphone power amp, and individual auxiliary audio input. With #22 gauge cable, the TW will operate on 2,000 feet of line. Supplies and the user stations are available in rack mounting packages for permanent installation. The rack mount models feature standard three-channel operation. Included are also phase locked loop, cmos and fet devices.

Mfr: RTS Systems

Price: Beltpack, \$150;

PS-10, \$350; PS-50, \$500.

Circle 69 on Reader Service Card



WORAM AUDIO ASSOCIATES

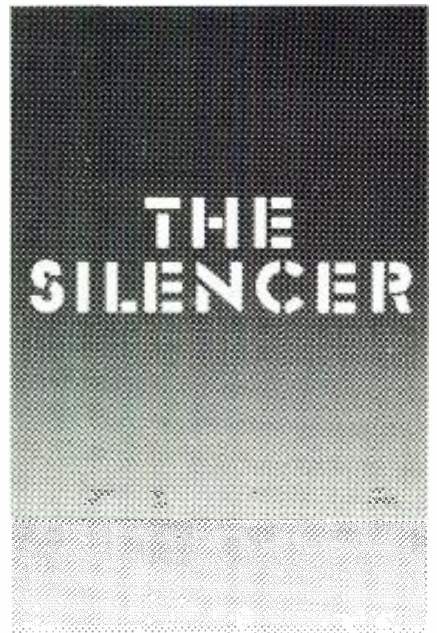
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Your ears are burning with amplified noise. Even though your system is delivering sound accurately, it's also doing an efficient job of pumping out noise . . . accurately. Ideally, music should be recreated against a dead silent background. The Phase Linear 1000 accomplishes just that with two unique systems: The Auto Correlator Noise Reduction and the Dynamic Range Recovery Systems.

★ It improves the overall effective dynamic range and signal/noise ratio 17.5 dB in any stereo system with any stereo source.

★ The Auto Correlator reduces hiss and noise 10 dB without the loss of high frequencies and without pre-encoding.

★ The Dynamic Range Recovery System restores 7.5 dB of dynamic range without pumping and swishing.

★ Plus, it removes hum, rumble and low frequency noises, without the loss of low frequency music.

★ WARRANTY: 3 years, parts and labor

Even the finest stereo systems are limited in performance by the quality and nature of the recording. With the Phase Linear 1000, these limitations are overcome. Added to any receiver or preamplifier, it gives you the most significant improvement in sound reproduction for the money . . . more than any other single piece of equipment you could add to your system. Ask your dealer for an audition. The silence is deafening.



*Phase
Linear
1000*

Phase Linear Corporation,
20121 48th Avenue W.
Lynnwood, Washington 98036

Circle 23 on Reader Service Card

Revolution!

New York celebrates its part in America's history with a technologically improved, dynamic multi-media show.



The Museum of the City of New York.

“WHEN IN THE COURSE of human events it becomes necessary for one people to dissolve the political bands that have connected them with another and to assume among the powers of the earth the separate and equal station. . . .”

So begins the official declaration by the thirteen colonies that they would no longer tolerate the rule of England, and that henceforth they would be free and independent states. This Declaration of Independence was drawn up and approved on July 4, 1776, by 12 colonies—the thirteenth, New York, approved on July 9, retroactively.

The City of New York played an important part in the early days of the revolution, and to help commemorate the Bicentennial, the Museum of The City of New York opened a specially designed multi-media display late last year which will run to the end of 1976. The entire project was made possible by a grant from the Bowery Savings Bank as its celebration contribution.

The rear projection display takes place in a large darkened room surrounded by exhibits of real historical objects of the times of the revolution. The audience enters and is seated in the center of the room, while the lights are up. The surrounding exhibits are illuminated for viewing. Specially scored music with a revolutionary period flavor, written for the show, is heard. After a few minutes, the lights dim, and the program begins with the sound of hammering. Notice is being posted that the tariffs have been raised again! The notices go up across the screens. Voices talk about their feelings, some angry, some expecting things to improve in the future.

A PERSONAL TOUCH

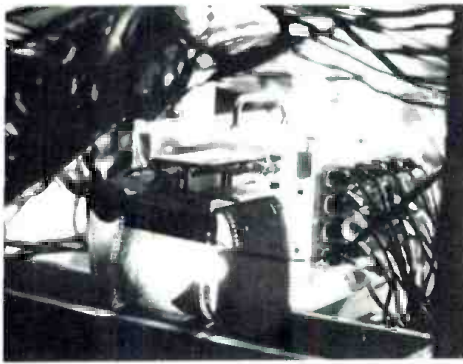
In order to give the program a personal touch, the nar-

ration is given by a fictional woman. When she starts, she says it is 1750 and she is eleven years old. She sounds like an eleven year old girl as she talks to her mother. As the story unfolds, and the years go up on the screens, the narration and the dramatic acting tell of the events from 1750, through the death of King George II and the belief that now things will improve, (King George III is worse) through the Stamp Act of 1765, taxes on various things including tea, the New York Tea Party in 1774, and the revolution—centering specifically on events occurring near New York.

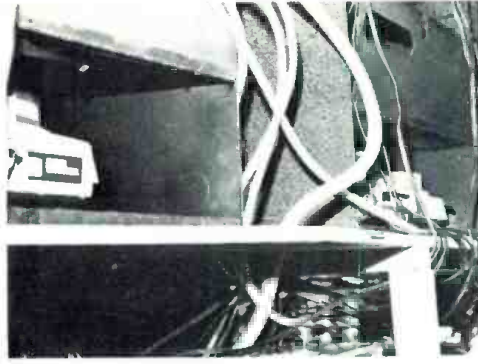
As the years go on, the girl grows older, her voice becomes more mature, and she tells the story through her eyes—describing events in her family life, her surroundings, and how political and military events affected her, including Washington's coming to New York to take over the command of the soldiers, his retreat, the final victory of the Continental Army, and the beginning of a new nation with its first president, and its first capital, New York. The drama of the British surrounding New York with more than 500 ships and about 10,000 men, the marches through the city, the British habit of stopping for tea rather than continuing to capture the colonists—are based on some well known, some little known, facts, all authenticated and accurate. The images on screens are taken from the real items in the museum itself.

AUTHENTICITY TO START WITH

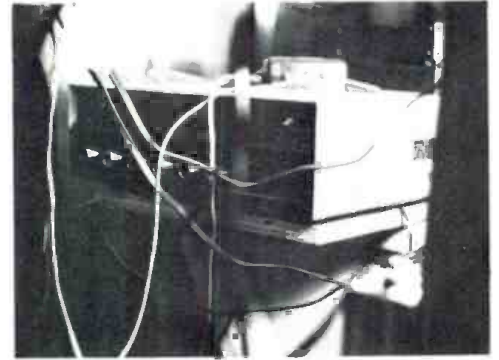
Revolution is by no means just another multi-screen display. When the decision was made to develop this display, Motiva Ltd. of New York was called in to execute the actual creation of the exhibit. Beginning with the facts provided by the museum and the authentic historical displays already in existence, Motiva set about



The programmer and control unit with paper tape and cords to advance desired slide projector units. The paper tape is activated by the cues on the audio tape and the optical signals trigger the slides.



Scene behind the screen, showing wiring and a typical single-projector module, with a double-unit cubicle at the right. Lightweight aluminum compartments disperse heat rapidly.



The Commander power amplifier used for sound distribution. A cassette player plays the audio track and feeds cue signals from the second track to activate the programmer tape.

getting the script, music, talent, sound effects, and visuals coordinated.

Research by the museum staff produced the facts, and all the provided materials were then utilized as necessary. The original musical score, written by Michael Valenti, uses 18th century musical instruments. The script was by Roy London, the soundtrack coordination by Chuck London, acting by the Circle Repertory Company, and programming by Frank Vince. Supervision was by Robert Schwartz, President of Motiva, Ltd.

The uniqueness of this exhibit's audio visual display comes from the singularity of the original concept. According to Mr. Schwartz, multi-screen exhibits develop their visuals first, then program them to change according to the script, which is produced to follow the images on the screens. Also, most exhibits are front projection, and to develop large enough images for the whole audience to see them clearly, the projectors must use high power light sources, the overall action is slow moving, and the results can lose some of its potential impact.

MULTIVISUAL MATRIX SYSTEM

The new concept by Motiva is called the Multivisual Matrix System. The underlying idea is to provide large, bright images even when used in well-lit areas. For size, previous exhibits used single large screens and wide angle lenses. For brightness, light sources, including xenon lamps, were made more powerful. Motiva uses rear projection, which, in itself, can provide brighter images even in lit rooms. However, for normal rear projection, throw distances behind the screen become very long with large images. The projection distance is reduced by folding the throw, and using front-surface mirrors.

For extra brightness, and to create fast-moving effects, the concept incorporates individual cells, in which there can be single or double carousel slide projectors. At the audience side, the cell has an acrylic rear screen approximately 3 x 2 ft. in size. If there is only one projector, the standard 2 in. lens is used with two mirrors. If there are two, one projector has the straight lens; the other is fitted with a standard 2 in. RP lens. This way, the optical axes are separated by only 1°47' of arc, allowing perfect superimposition of lap and dissolve images, or two images on the same screen at the same time. Since individual cells can be placed in any configuration desired, the "screen" can be made as large as desired in either a vertical or horizontal direction, or curved concave or convex. The depth of the cell, only 34 in., provides a hold-down system to lock the projectors in place once the registration on the individual screen has been set. The space between

cells has been set at 3/4 in. so that separation between screens is more visible and the impression of image movement is heightened and more effective.

To enhance the effect of individual *modules*, as they are called, a method had to be developed to create separate images from a single source so that the total could duplicate the original on a large scale. The devised system is an optical matrix slide registration method which permits up to 49 images to be developed from a single 35mm slide. Thus, a single slide can be enlarged to any size without loss of light, since each section is projected with the full power of the projector within the cell. Each unit uses standard carousel lamps, without modification. However, the ENH lamp version is employed for longer life

STRAMP





THE MPS-24

featuring 9-band EQ ± 15 dB per channel, LED peakreading meters, up to 24-track recording.

Professional portable studio board.

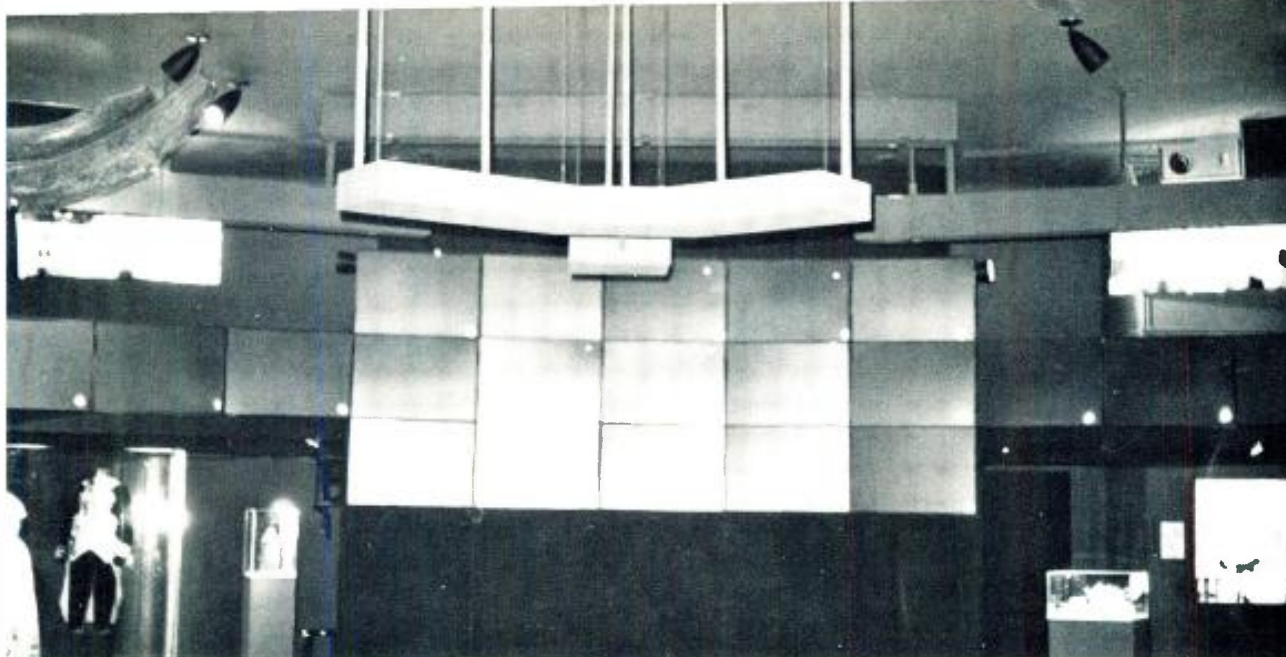
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White dots on the screens indicate that slide projectors are at zero positions.

and reduced relamping necessity. (No relamping process has been standardized, since the lamps are rated at 100 hours and usually run longer due to efficient cooling while in use through adequate venting of the module. This capacity also permits replacement at the time of a blowout.)

At the heart of the system is the unique concept that the sound track should come first, and the images on the screens should follow the sound, the reverse of the more usual multi-screen exhibit. With this idea in mind, a new programming method had to be developed, done off the line, and in non-real time. This also was the opposite of the method used with other types of slide presentation. A multi-channel optical programmer made it possible to trigger changes of effects in any fashion desired. Using a corresponding manual punch, a 3 in. Mylar and rope-paper tape is punched at leisure according to the effects desired.

The tape is then "played" in a Photo Transistor Array Optical Sensing Reader. The "tape" is started by a single 1 kHz pulse tone from the second track of a standard 1/4 in. audio tape. The high-torque synchronous motor with electronically controlled dynamic braking pulls the tape through and effects take place as punched. When the tape reads a *stop* punch, the tape is stopped instantly, and waits for the next pulse. In this way, less punched tape is used during the program.

REAL-TIME AND SPURT

It is this combination of real-time and spurt system that allows separation of "what" from "when," and permits activation as rapid as 1/15 of a second, almost the equivalent of the speed of a movie film. (Programming is also possible in multiples of 1/16 on the tape, although normal positioning is 1/15.) The programmer has a built-in sensitivity meter controlled by a lockable potentiometer. Each projector control is individually adjustable. The programming unit, a plastic box only 7 in. high, 9 in. wide, and 17 in. deep, contains six integrated circuits: three computer logic chips (two digital and one memory) and three linear, and operates at 115 volts.

By prepunching programs to activate projectors, lights, or other devices in sequences of 1/15 of a sec., precise timing with music beats far superior to other methods is possible. Effects can be achieved in rapid succession to sound effects, voices, or even fast drum beats. Patterns

can be swept on and off the screens, or spirals of movement created, pictures can be created as single images over the whole screen, in individual blocks, or in any pattern desired, and can be brought on or wiped off in precise coordination with the sound.

Revolution utilizes a center screen made up of fifteen cells (three high and five across) with the center row extended horizontally to three more screens on each side for a total of 21. Each module contains one projector, with the center nine (three wide by three high) containing two slide units each, for a total of 30. The programmer unit has 42 channel capability. Over 1,500 slides are used to provide the images for the show. Once the show is over, the last pulse on the audio tape allows the punched tape to run itself to its last stop cue. In this space, cues have been put on the paper tape to get each of the projectors back to zero for the beginning of another showing. Each show is eighteen minutes long with about three minutes between.

For sound, a single track is used with the speakers located above the side screen array. A special "Cannon" speaker is also used. A unique indication is even employed to show whether the projectors have all "homed." Each of the slides in the zero slot has a dot or hole cut through it. With every projector in the right slot, each screen shows a dot in one corner; the screens with two projectors show two dots, one larger (primary unit) and one smaller (secondary projector).

Motiva Ltd. has developed many such shows with two presently running simultaneously at New York's Museum of Natural History. One is *Winter in Central Park* with eighteen projectors and three screens, the other called *Options* for the Hall of Gems with 24 projectors and 15 screens. Should you come to New York, you will find the Museum of the City of New York and the Museum of Natural History on almost directly opposite sides of Central Park.

Through the use of the unique techniques developed by Motiva, the Bicentennial exhibit of *Revolution* takes on a completely novel effect of drama and history combined with new technology. The price at the City Museum is the standard fee—free! You'll never get your history entertainment at a better price. Shows are continuous from 10 a.m. to 5 p.m. and will continue through December, 1976. The museum also offers four floors of exhibits to help you spend the day. But don't miss *Revolution*. ■

The 54th AES Convention and Exhibit

A recorder which practically slaps your hand if you make a mistake and a computerized fantasy mixer are just part of the news unveiled in L.A.

THE AUDIO ENGINEERING SOCIETY held its 54th convention and equipment exhibit at the Los Angeles Hilton, on May 4-7. If you've been reading *db* for awhile, you'll know that each year there are three conventions; one in New York, one in Europe, and one in Los Angeles. Some critics wonder why the audio industry needs so many conventions. After all, what could be so new in audio to require a show every few months?

So what's new? Plenty! No doubt it was just a coincidence, but it seems that just about every manufacturer had something new to show off at this convention.

AMPEX ATR-100

A month or two ago, Ampex introduced the MM-1200, an updated version of their well-known MM-1100 multi-track recorder. So when the Ampex crew announced a press party to show "something new," a lot of the audio correspondents didn't get too excited, figuring they had already seen the MM-1200.

Surprise! The "something new" is the ATR-100, a quarter-or half-inch recorder that is a complete departure from Ampex's AG-440 series machine. A complete description would take an article all by itself, but here are some of the details. (See FIGURES 1, 2, and 3.)

On the head assembly there is a four position speed selector ($3\frac{3}{4}$, $7\frac{1}{2}$, 15, 30 in/sec.) The electronics may be equalized for any two speeds. If you've equalized the machine for, say, $3\frac{3}{4}$ and 30 in/sec., and then try to pay a tape at 15 in/sec. the machine won't start. A red warning light comes on to tell you to either change speeds or fix the equalization.

You don't have to worry about the pinch roller getting dirty, because the machine doesn't have one. The tape loops around an oversized capstan, and constant tension



Figure 1. Checking out the new Ampex ATR-100.



Figure 2. The four channel, half-inch Ampex ATR-100.

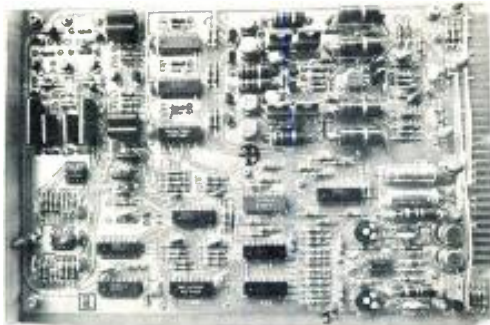


Figure 3. This is just the servo card from the new ATR-100.



Figure 4. 3M's new Selectake II with an M79—24-track in the background.



Figure 5. The dbx K9-22 ready to slip into a Dolby 361 unit.



Figure 6. The Telefunken Telcom will also be available as a Dolby mainframe retrofit.



Figure 7. The Neve-Necam system pictured at a quiet moment.

is maintained by the supply and take up motors, which are servo driven. In fact, the Ampex engineers demonstrated the machine's stability by mounting the reels off-center and then playing a tape. It sounded fine, with no detectable speed fluctuations at all.

From the Ampex press kit, here are some preliminary specifications. The figures in parentheses are the equivalent AG-440 specs, for comparison.

Signal-to-noise ratio @ 15 i.p.s.	60 dB (63) unweighted
Third harmonic distortion at 1 kHz	less than 0.3% @ 370 nWb/m
Even order harmonic dist. at 1 kHz	less than 0.1% @ 370 nWb/m
Flutter and wow at 15 i.p.s.	± 0.03% (0.06%)
Start time	250 milliseconds (300)

The signal-to-noise comparison is even better than it looks, since Ampex has changed its reference points. The AG-440 figure is measured with respect to a record level of 520 nWb/m, while the ATR-100 spec is referred to a level of 1040 nWb/m. Since these reference levels represent a difference of 6 dB, there is actually an improvement of 12 dB in the signal-to-noise specification.

As to the "bottom line," here are some dollar comparisons for a two-track machine from various manufacturers.

Ampex	AG-440C	\$4,800
Scully	284B	5,205
3M	M79	5,400
Ampex	ATR-100-2	5,550
Studer	A80	7,105

3M COMPANY

The 3M company didn't have a new machine to show, but they do at last have a tape time locator—the Selectake II—that reads in minutes and hundredths (FIGURE 4.) The earlier Selectake displayed revolutions of the supply reel, which was not nearly as convenient as a real time indication. The Selectake II has all the features found on the typical state-of-the-art auto locator, plus nine memory points, so you can enter various tape locations and then recall them simply by depressing a one digit number on the keyboard. The Selectake II goes for \$1,700 when bought with a new machine, or at \$1,900, has a retrofit for the machine you already own. I imagine 3M will be deluged with orders for the Selectake II, because once you've done a session with such a device, it's awfully hard to go back to the hunt and peck method.

NOISE REDUCTION

All sorts of things are happening in the noise reduction department. A few years ago, Dolby packaged its noise reduction electronics on a plug-in card, which they call the cat-22 (i.e., catalog #22). Sixteen of the cards fit in a Dolby M16 mainframe, and each Dolby 361 system uses one cat-22 card. Then along came dbx with its rival system that was neither physically nor electronically compatible with Dolby.

Well, now dbx opened a few eyes at the exhibit with a plug-in card that fits directly into any Dolby mainframe. It's still not electronically compatible, but you can quickly switch from Dolby to dbx noise reduction just by changing cards. In either case, the alignment controls are mounted on the cards, so you don't have to re-calibrate every time you change over. This seems to put Dolby in



Figure 8. The Quad-Eight console, as equipped with the Compumix III automation system.

the enviable position of supplying the audio industry with mainframes for both systems, as well as producing the cat-22. The dbx pug-in card is known as the K9-22 (!!!), and sells for \$250 per card. (See FIGURE 5.)

Just to keep things interesting, Telefunken says it plans to market its own noise reduction system (FIGURE 6), and Gotham Audio Corp. demonstrated a prototype at their booth. By an odd coincidence, it too will plug directly into a Dolby mainframe, but is electronically compatible with neither the Dolby nor the dbx system. However, it incorporates some of the operational features of both systems. That is, it divides the audio spectrum into four bands (as does Dolby) but the companding action is spread across the entire dynamic range (as in the dbx).

CONSOLE AUTOMATION

Neve ran continuous performances daily in their large demonstration room, to show off the NECAM—Neve Computer Assisted Mixer (FIGURE 7). NECAM uses servo-driven faders that actually move up and down when the computer is doing its thing. It sounds a bit like Rube Goldberg until you think about it. The moving faders give a graphic indication of what's going on at all times, and they are touch-sensitive. So, to update a mix-down, you just lightly touch the fader that needs changing. This disables the fader servo, and level changes may now be made manually; these are stored in the computer as update information. When the fader is released, its computer-driven servo resumes control.

Faders may be arranged in sub-groups by depressing the "group" button on the computer keyboard. An alphanumeric display reads "Please touch required faders." The faders to be put in a sub-group are then touched one at a time, and the group button is once again depressed. Now, the faders that were touched all move together when you move any one of them.

The computer also runs your tape recorder for you. When you go searching for a particular section or take, the computer notes the position of the tape and then goes off into fast forward or rewind. After a very short interval, the tape lifter closes for a fraction of a second—just long enough for the computer to find out where the tape is. IT compares the new location with the old one and computes the additional time that will be required to get to the desired location. And all this happens faster than I described it! NECAM also thoughtfully drops the faders so you don't blow out your tweeters along the way.

Quad Eight had its automated console set up, too (FIGURES 8 and 9). Like the Neve, it uses a keyboard to enter instructions. However, the visual read-out is in the form of a large color video screen, as seen in our photo. Both the Neve and the Quad Eight systems re-



Figure 9. A closeup of the Compumix II keyboard.



Figure 10. The Sound Workshop's 12-in, 4-out console.



Figure 11. Electro-Voice's wireless microphone system's transmitter and receiver.

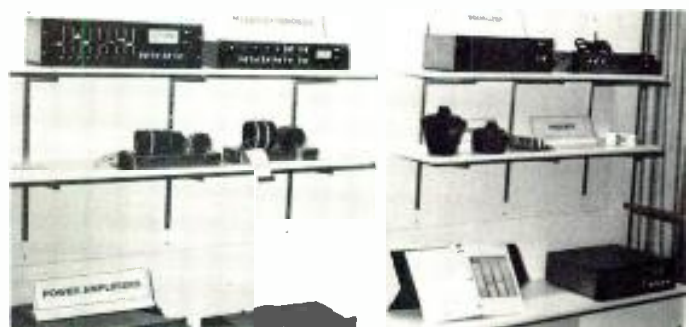


Figure 12. The Bogen lineup of equipment uses Techcraft as a new trade name.

Figure 13. The Yamaha PM-1000 being put through its paces.





Figure 14. The complete array of Pioneer equipment as it was shown.



Figure 15. Technics' graphic equalizer on the right, a new stereo preamp control center at left.



A Dolby Cinema system is flanked by Dagmar Dolby and the newest Dolby, Thomas.



Tom Hay demonstrates MCI's latest, now at Sound 80 in Minneapolis.

quire one track on the multi-track tape recorder for an SMPTE time code, with all mixing instructions stored on a floppy disc in the computed package. Both systems allow electronic editing. For example, you can get on the keyboard and tell the computer to play back the first part of Take 3, the middle of Take 7, and the end of Take 1. The computer then plays back a composite mix, and if you like it, you just tell the keyboard to store it. This gives a whole new dimension to "We'll fix it in the mix."

Since these little toys are not exactly off-the-shelf items, prices vary considerably, depending on your requirements. Typical NECAM price tags range between \$50,000 and \$60,000. Of course, you'll want a console too, and that's extra.

New automated consoles or equipment also come from API and Allison (now marketing separate and independent systems). While both companies had booths, neither showed their systems. We'll have details on them in a future issue.

If that's not all quite what you had in mind, Sound Workshop had a 12-in/ 4-out console at their booth for less than \$3,000 (FIGURE 10.) Last convention, they introduced a very nice spring reverberation system for \$375, and this time they showed up with a \$500 vocal doubler, in addition to the console. They specialize in setting up complete budget studios for the semi-pro with more enthusiasm than cash.

J. W.

* * * *

No question about it, the Ampex ATR-100 attracted a lot of attention at the show, and John Woram has just skimmed the highlights of this unit. Let's just say that its introduction portends a lot of change for the tape recording industry. At the least, it sets new standards for performance—subjects we'll cover in a future issue.

This particular convention was characterized by more new equipment than I've seen introduced at previous shows. It's my purpose to cover the highlights of some of these features.

The exhibitions were displayed in three main areas. The principal section had conventional booths arranged in the ballrooms of the L. A. Hilton, the host hotel.

Several rooms off to the side of the main exhibition halls were given over to individual exhibits by manufacturers who wanted to demonstrate as well as show.

Electro-Voice occupied a large room in which it presented its traditional medicine show with Bill Raventos talking about mics and speakers most ably. At center stage among their product exhibits, we picture in FIGURE 11 the new wireless mic systems they are introducing.

Tascam occupied another of the rooms and filled it with their now large line of TEAC-Tascam tape decks, small and large mixers, and the latest version of the basic console they pioneered. A highlight was the first tape deck with built-in dbx noise reduction. (See FIGURE 18.)

Do you remember the name Bogen? They've come back into pro audio with a strong line of professional sound reinforcement equipment, mixers, equalizers, pre-amps, and power amplifiers, as shown in FIGURE 12.

Yamaha's division which makes sound reinforcement console mixers occupied a demo room in which most of their new units were operating (FIGURE 13). In addition, they showed and demonstrated advanced power amplifiers and speaker systems.

Two companies well known in the consumer audio field are expanding into pro audio, and both had demo rooms. Pioneer showed its tape decks, a speaker system for disco use. (Does that mean that it can be played very loudly?) and assorted other (basically hi-fi) equipment, pictured in FIGURE 14.

Panasonic has some new equipment in their high-end

consumer audio Technics line. Model SP-10B is a definitely professional broadcast station turntable, and a new graphic equalizer also got a lot of attention from visitors (FIGURE 15). Panasonic did not actually have a demo room, but was one of the main hall exhibitors.

I don't need to go into the attention the Neve-Necam automated console system received. John Woram has already touched on it. I just wanted to comment that their demo room was always filled with people eager to get their hands on the system. The same can also be said of the Quad Eight system, where a pretty (and informative) color art display told what the Compumix system is doing.

I don't want to slight other demo room occupants, but in the rush of the show I didn't get more than cursory glances into their rooms. I did manage to see some new equipment in the Bozak room, including a time display unit and a new disco loudspeaker system.

JBL also had a demo room in which their large line of amplifiers and speakers were in constant (and loud) demonstration. They too, drew crowds of listeners.

UPSTAIRS

On the fourth floor, a number of exhibitors also held forth with demo rooms. Ampex had one in which several ATR-100's were shown. One was connected to an array of sophisticated test gear, which proved its performance claims.

dbx showed its usual wares; the topic of interest was definitely the K9-22 card. The unit shown was a prototype, with production models promised shortly, at average prices of \$250 per card. As John has already explained, this card is a conversion retrofit to a Dolby A mainframe.

One room that was very interesting was manned by Bob Berkovitz of Acoustic Research. An AR-developed multi-channel digital delay system was used to feed sixteen channels of speakers around the room. The re-creation of a true hall ambience was quite impressive—better than I've heard it from four-channel records, in fact. AR insisted that this was strictly a research project being demonstrated and that no commercial product was coming from it, at least not imminently.

There was a clear implication given to me that there will be a simplified (perhaps requiring only four channels) system that will nearly duplicate the uncanny realism created by the sixteen channels on demo.

Another room on the fourth floor was occupied by AKG with mics and reverb units on display. Emilar, with heavy duty sound reinforcement systems was at the other end of the hall from Spider-Peavey with its line of super sound reinforcement equipment. Infonics held forth with its extensive line of tape duplication systems; Audio Dynamics Corp. showed a new turntable system that can be programmed to play any band on a disc and in any order. Rauland-Borg was another company with sophisticated sound reinforcement equipment. Sennheiser had their mics, as well as an infra-red headphone transmission system with stereo capability. Finally, Sansui was demonstrating (as expected) the latest QS capabilities, and also had their new broadcast a.m. stereo system on demonstration. It sounded very good.

It was quite a show. Incomplete attendance figures seem to put the number well over 4,000 attendees; it was also noted that there were a large number of students. Students do grow up into workers, after all, so I'd call this convention easily the best attended, best exhibited, and perhaps even best organized that AES has put together. Can New York top it in October? We'll see. ■



Mike Colchimar of Sound Workshop demonstrates their line of budget gear. That's TEAC'S 8018 with dbx at his right.



Otari has come up with the MX-5050-8, an 8-track deck using half-inch tape.



The new generation from Lexicon is the model 102 stereo Delta-T digital delay.



Amber is now producing this combined multi-purpose generator and analyzer, model 4400 audio test set.

The Signal Path: II

Sine Wave Oscillators

Sinusoidal oscillators come in various forms, producing a variety of configurations, according to need.

IN A PREVIOUS Signal Path article I examined some techniques for signal sources using waveform generators which produce triangle, square, sawtooth, pulse, and sine waves. This time we take a look at methods for generating higher purity sine waves, both rudimentary and state-of-the-art in quality.

There are a seemingly endless variety of ways one can configure circuits to produce sine waves.¹ Seen from afar, one can easily wonder why are there so many of them—that is, what distinguishes them in terms of performance. The best general answer to that question would depend on what is expected out of the circuit, what you want it to do for you, how well you want it to perform, how complicated, how easy to reproduce or manufacture, how stable, how expensive, and so on. As performance levels increase, so do parts count and cost, although, it is not always true that cost increases linearly with performance. Good design techniques which take advantage of modern high performance devices can really hold cost down while wringing a lot of performance from an i.c. or two. So, this article will attempt to discuss a bag of tricks useful in oscillators of various complexities and quality.

WIEN BRIDGE OSCILLATORS

One of the first types of sine wave oscillators to pop up is the family (and there are many members, believe me) based on a Wien network. Or, as it is more popularly known in oscillator form, the *Wien bridge oscillator*. For starters, a single example is shown in FIGURE 1.

In operation, the Wien network, consisting of R1-C1 and R2-C2 provides positive feedback from the amplifier

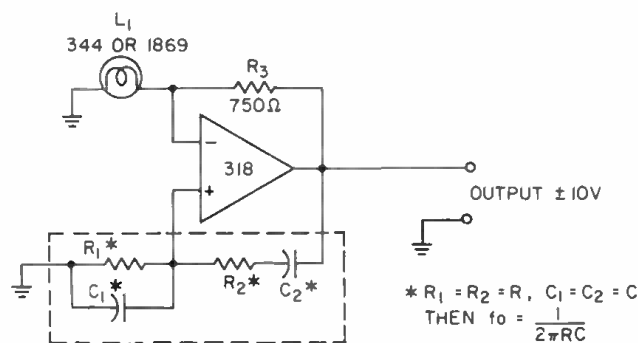


Figure 1. Lamp stabilized Wien-bridge oscillator.

output back to the plus input terminal. This feedback will occur with zero phase shift at a frequency where the time constant R1-C1 is equal to that of R2-C2. This is the basis of the Wien network used as a filter. Note that the values of R1-R2 and C1-C2 need not be equal, if their time constants are equal. For simplicity's sake however, R1 is normally set equal to R2, and C1-C2. With this arrangement, resonance occurs at a frequency f_o which is simply

$$f_o = \frac{1}{2\pi RC}$$

where R and C are the values of R1 (R2) and C1 (C2).

As this frequency, the attenuation of the network will be 3/1; that is, one-third of the output is fed back to the plus input. Therefore, oscillations will be sustained if the amplifier gain is 3 to 1 or more (the value required to

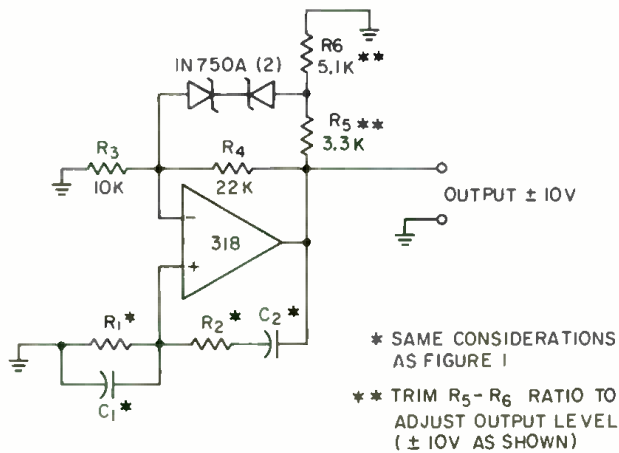


Figure 2. Zener stabilized Wien-bridge oscillator.

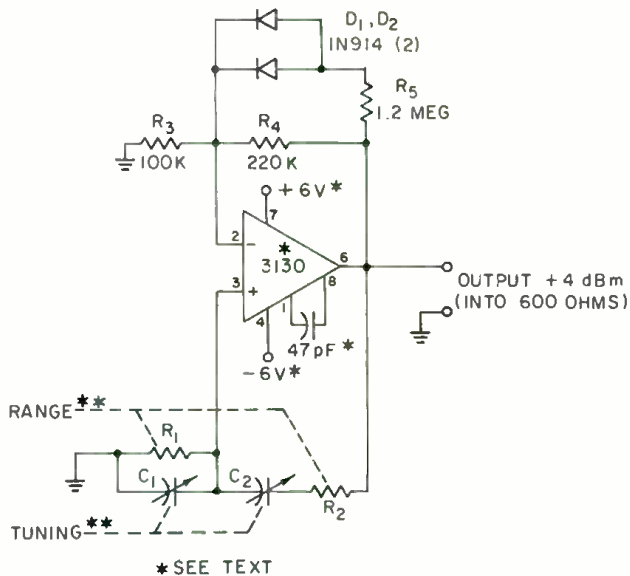
make up for the network's loss). Here lies the key to a successful and undistorted sine wave oscillator—getting the gain of the amplifier just right.

Gain must be precisely held equal to the Wien network's loss, for if it is too low the oscillator will never start, if too high it will build up until clipping occurs. Any practical oscillator of this type must incorporate some means of stabilizing the output by dynamically changing the amplifier's gain. Many means exist of doing this (for various reasons, as we'll see) but the example shown here uses the non-linear resistance of lamp L1. Since incandescent lamps have the property of increasing resistance with applied voltage, an increase in output voltage will be counteracted by a rise in L1's resistance, which lowers gain. Conversely, output which tends to decrease will be stabilized by a decrease in L1's resistance (an increase in gain). The net result is an output sine wave which is stable at a level where L1's resistance is half R3's nominal value.

What are the keys to making the circuit work up to its capability? The lamps specified are 10V, 14mA models, but will typically exhibit variance in impedance. So, you will probably find it desirable to trim R3 to adjust the output to $\pm 10V$. You cannot make it work properly below the natural thermal time constant of the lamp. This allows use down through the audio range, but not at 1 Hz, for instance. Also, since stabilization is inherently acquired by thermal means, the lamp is sensitive to temperature (and also shock). The main virtue of this circuit is its simplicity; it will work just as shown without tweaking or coddling, with a thd content of 0.25 per cent or less.

Considerations should also be given to the op amp used and the Wien components (these comments will apply to many of the circuits which follow, also). The 318 shown is an excellent audio range choice and has no limitations, except for its input currents which will place an upper range on R1 (and R2) values of about 100 k or so. 741s, including 741 dual and quad derivation, will function up to a few kHz, but are best used below 1 kHz. The 356 is also a good choice, and since it is an f.e.t. input unit, allows use of resistances up to hundreds of megohms if desired. Supply voltages for the op amp are $\pm 15V$ and should be rf-bypassed at the socket, especially with wider bandwidth units like the 318.

Don't skimp on the quality of the Wien network and you will be rewarded by trouble-free service. Stick to poly-styrene and/or poly-carbonate caps if possible, and stable low t.c. resistors. Both should match as well as



* SEE TEXT

** TABLE I

RANGE	R ₁ , R ₂
20 - 200 Hz	20 MEG
200 Hz - 2 kHz	2 MEG
2 - 20 kHz	200 K
20 - 200 kHz	20 K

C₁, C₂ = 40 - 400 pF

Figure 3. Battery operated Wien-Bridge oscillator.

practical, 1 per cent or better preferred. If R1-R2 are used for tuning, the dual pot sections should track well. And, if high impedance components are used, shield the network to reduce noise pickup. Tuning may be via R1-R2 or C1-C2 with the other component pair switch selected for range in decade steps.

ZENER STABILIZED WIEN BRIDGE

A version of the Wien bridge which is quite similar, differing only in its form of amplitude control, is shown in FIGURE 2. This one uses zener diodes to control output amplitude. As the Wien network and amplifier considerations here are similar to that of FIGURE 2, the discussion will be limited to the stabilization method.

In this circuit, a pair of 4.7V diodes are connected back-to-back as a symmetrical clipper. The advantage of zeners is that they do not have a limiting time constant and there is no theoretical lower limit on frequency of operation. Also, they are smaller, lighter, and easier to get your hands on than miniature lamps. The R4-R3 ratio is set at 3.2, a value greater than 3, which ensures starting of the oscillator by regeneration.

Once oscillations build up to a level where the zener thresholds are exceeded, stabilization occurs by reduction of the net gain to 3. For a $\pm 10V$ output, R5 and R6 reduce the level fed back to the zeners to scale their clipping level upward. Although the clipping process is inherently more non-linear than a lamp, thd is still reasonable, at 0.8 per cent. Best operation will be realized with matched diodes, such as i.c. transistor E-B junctions.² If a pair of diodes can be selected for low thermal conductivity, the stage will be temperature-compensated also.

Quite often, a portable, battery-operated signal source is a handy device to have around a studio or workbench. Battery operation for low output levels is entirely feasible, as illustrated in FIGURE 3.

This circuit is a modification of FIGURE 2, using gen-

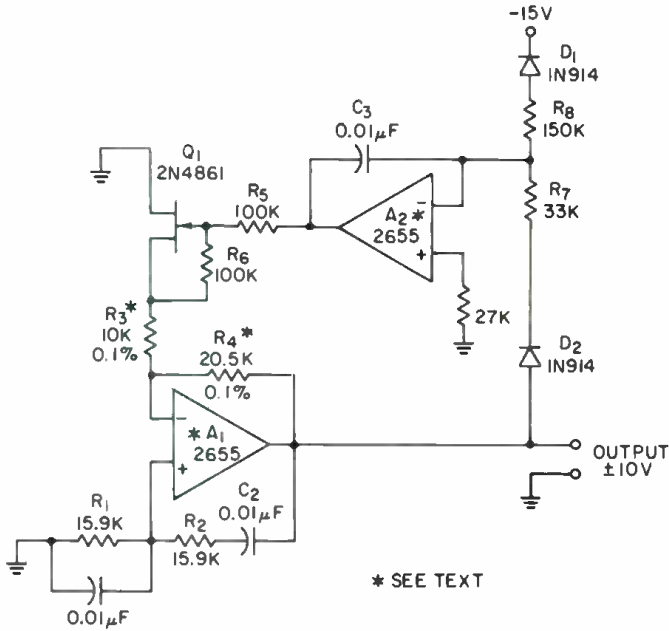


Figure 4. Low distortion f.e.t. stabilized Wien-bridge oscillator.

eral purpose diodes for amplitude control. In general impedances are scaled upward to minimize power waste, and a low voltage fet input op amp is used. This allows operation from 6V batteries, and the low op amp input current allows R1-R2 values up to 20 megs (or more), a factor which allows a dual 400 pF miniature tuning capacitor to be used for C1-C2. If C1-C2 are padded for a 40-400 pF tuning range, R1-R2 can be switched, selected to cover a 3 or more decade range (see TABLE I for details).

Output is set at approximately +4 dBm by R5 (which may be trimmed if desired). Distortion is slightly higher than the zener version, measuring 0.9 per cent. The circuit may be used at higher supply voltages also, such as ±9V or ±15V, if higher voltage op amps are used, such as the 356 or 8007, both fet types.

A circuit which improves considerably on the performance of the previously described "passively stabilized" Wien bridge oscillators is shown in FIGURE 4. This is a Wien bridge circuit with active automatic gain control, which is provided by Q1, an fet. Here the variable channel resistance of the fet is used to control the gain of the amplifier about its nominal value of 3.

There are several keys to making the circuit work well in this form. You may note that feedback resistors R3 and R4 are specified as close tolerance types with a ratio only slightly more than 2/1. The actual gain will be determined by the R3 resistance, plus that of Q1 in relation to that of R4. It is desired that this ratio be very close to (but in excess), of 2/1. The actual gain will be determined by the R3 resistance, plus that of Q1 in relation to that of R4. It is desired that this ratio be very close to (but in excess) of 2/1. It must be in excess to ensure starting, but the closer it is to 2/1, the less the channel resistance of Q1 need be varied. You may also note that Q1's nominal resistance of 100 ohms is a very small percentage of R3, so it provides only minimal correction. This ensures a low p-p voltage across Q1, a factor necessary for lowest distortion. The close tolerances specified for R3-R4 may be dispensed with if a 2 k or so rheostat is inserted in series with R4, and adjusted for positive startup with lowest distortion. Alternately, R3-

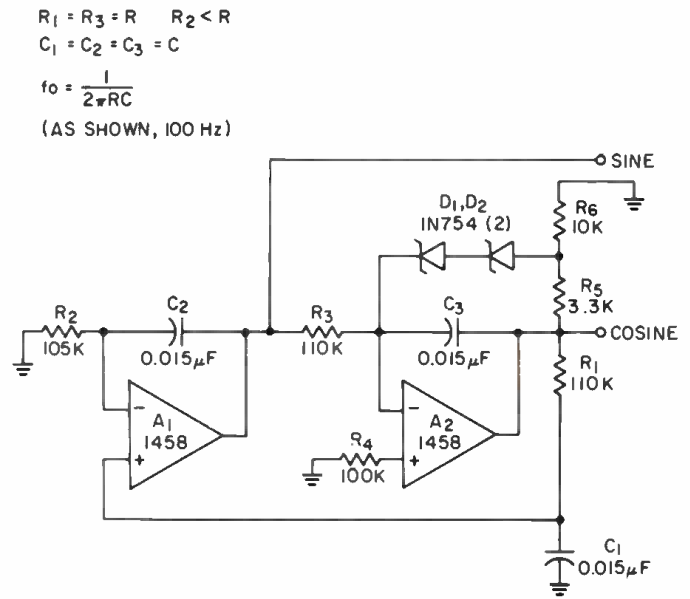


Figure 5. Quadrature (sine/cosine) oscillator.

R4 may be a 10k/22k pair, at the expense of higher distortion.

Local feedback around Q1, provided by R5-R6, lowers its contribution to distortion even further. Output distortion is considerably below a figure of 0.1 per cent due to these measures. At lower frequencies, integrator capacitor C3 should be increased in proportion, to maintain lowest distortion.

D.c. bias for Q1 is provided by from the integrator, A2. The high d.c. gain of this stage automatically compensates for unit-to-unit bias variations of Q1. The output is rectified by D2, and compared against the -15 V supply as a reference. R7 may be adjusted to scale the output, if desired.

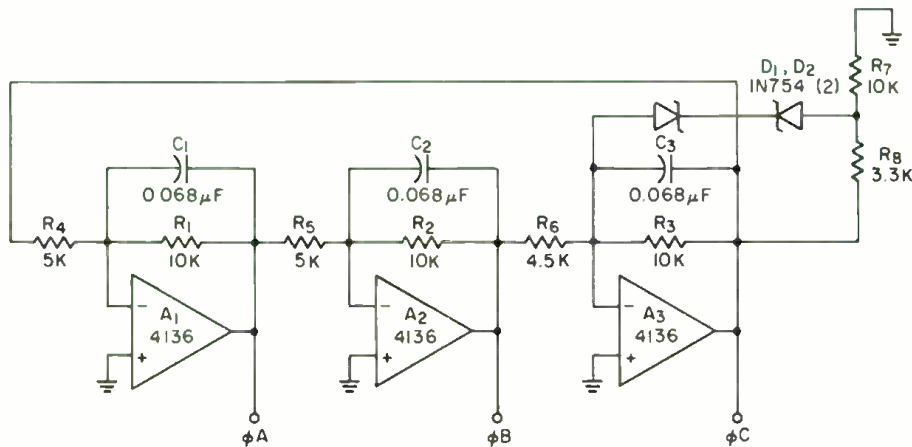
The op amp used is a new Harris unit, the 2655, a dual, 8 MHz bandwidth device with a 5V/µs slew rate. This is the best current choice in a single package dual. Lower performance alternates are the Raytheon 4558, and the standard 1458, a dual 741 type. All are pin-compatible.

Having discussed four different variations on Wien bridge oscillators and their ramifications, we've hardly begun to scratch the surface of Wien bridge variations. The Wien bridge is the most widely used and versatile type—a good combination of simplicity and performance. Other types, as we'll now see, sometimes sacrifice a feature to achieve another objective.

QUADRATURE OSCILLATOR (SINE/COSINE)

FIGURE 5 illustrates an oscillator featuring two outputs which differ in phase by 90 degrees. Thus, it is called a quadrature, or sine/cosine oscillator. The main reason for using this oscillator is the fixed phase difference; it is quite cumbersome to tune because of the three time constants involved. Because of these three time constants, it requires closer tolerances for best performance.

The circuit consists of a regenerative loop consisting of a conventional integrator A2, and a non-inverting double integrator, A1. The three time constants are R1-C1, R2-C2 and R3-C3. R1-C1 provide 45 degrees of phase shift, as do R2-C2 and A1. An additional 270 degrees of phase shift through A2 (and R3-C3) provide



DESIGN PROCESS:

- 1) SELECT R_1 (R_2 & R_3)
- 2) CALCULATE C_1 (C_2 & C_3)

$$C_1 = \frac{\sqrt{3}}{2\pi f_0 R_1}$$

- 3) CALCULATE R_4 (R_5 & R_6)

$$R_4 = \frac{R_1}{2}, \text{ AND } R_5 = R_4$$

THEN LET $R_6 \ll R_4$

$$R_1 = R_2 = R_3 = R$$

$$C_1 = C_2 = C_3 = C$$

$$f_0 = \frac{\sqrt{3}}{2\pi RC}$$

Figure 6. Three-phase oscillator.

the 360 degrees (or in-phase) condition around the loop necessary to sustain oscillation.

As illustrated previously, a zener clamping network is used to stabilize the output level at A2. R5 and R6 adjust output, and the values shown yield ± 10 V. Limiting such as this does introduce some distortion at the *cosine* output, but because of the further filtering at the *sine* output, distortion here is lowered. With close tolerance components, thd of considerably less than 1 per cent is possible.

In the example shown, which operates at 100 Hz, a 1458, as indicated, is adequate for good performance.

THREE-PHASE OSCILLATOR

As may be already obvious from above, multi-phase oscillators of virtually any arbitrary phase angle may be implemented, using op amps in phase shift stages with defined gain(s). The necessary condition for oscillation is net feedback in phase, and a gain of one or more at the frequency where the phase shift is zero. Exactly how you partition the phase shift(s) is really not limited to any great extent, at least not in theory.

An example is the three-phase oscillator showing FIGURE 6, which divides the total 360 degree phase shift requirement equally between three similar stages. In a sense, this one is reminiscent of the familiar phase shift oscillator, one main difference being that it delivers three buffered outputs in a wye configuration (balanced to ground).

This particular example splits the phase shift equally between stages A1, A2 and A3, or a phase shift per stage of -240 degrees. The total phase accumulation is then 720 degrees (or equivalent to an in-phase condition). Each stage is also designed for an input/output transfer gain of unity, making all three outputs equal in amplitude.

To ensure startup, the input resistor to one stage (A3) is lowered 10 per cent to give it initial gain > 1 . Then, after oscillatory buildup, the zener network reduces gain and stabilizes the output at the desired level.

A big virtue of this type of oscillator is the large reduction in distortion due to filtering of two stages. For example, although distortion at the ϕC output is about 0.5 per cent due to limiting, this is reduced to well below 0.1 per cent at the ϕB output. This can be improved even further if desired by using an active AGC network in series with R6 for amplitude control (similar to FIGURE 4).

Frequency of operation is set by three r-c networks, R1-C1, R2-C2, and R3-C3. To retain the 120 degree phase difference, all time constants must be modified simultaneously when scaling, frequency wise. Hence this is not an easily tunable oscillator, unless a 3-gang capacitor is used (with good tracking). Resistors R4, R5, and R6 set the gain and should remain fixed. Stability and accuracy of components is even more important in this oscillator, since all those mentioned have a bearing on performance. Given proper ingredients, this oscillator is capable of precision performance with output thd of 0.01 per cent or better.

A quad device is an excellent choice for the op amp here, a 4136 as shown, or the Raytheon 4137, the Harris 4741, or the Exar 4212, all wideband quad units which will perform well at audio frequencies.

STATE-VARIABLE-FILTER OSCILLATORS

At this point, your appetite may be whetted for a more highly developed form of multi-phase oscillator which takes advantage of multiple stage filtering and high Q operation. The next two circuits discussed refer to just such an oscillator, in two different forms.

FIGURE 7 shows an oscillator circuit based on the state variable filter, an active filter configuration which is capable of extremely high Q with excellent stability. It also happens to be one which is easily tuned and programmed; therefore circuits of this type are readily adapted to automated control. In this circuit, the state variable filter itself consists of A1, A2, A3 and their associated elements. A4, Q1-Q2 and R8-R9 are added to provide a positive feedback path with amplitude stabilization.

This oscillator is different from the above previous types in that the zener amplitude control is *not* a soft limiter; it actually truncates the sine wave at A2's output, through the use of A4 and zener diodes Q1-Q2. The resulting *squared* waveform is well limited in amplitude, as applied to R7. A constant amplitude square wave fed into a bandpass filter will result in a very stable output sine wave amplitude. With sufficiently high Q in the filter, the square wave harmonics can be removed, with low resulting thd. This circuit is capable of thd well below 0.1 per cent, with short term amplitude stability of 0.05 per cent or less.

Of course, as with the previous circuits, performance actually realized will be dependent upon the quality of the components used. Tuning components are obviously

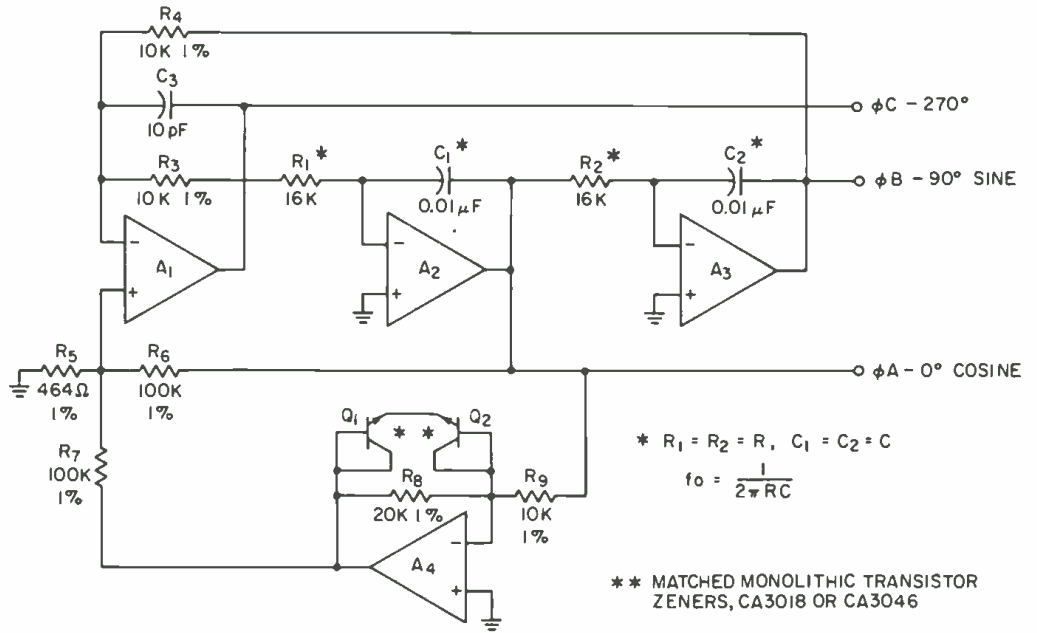


Figure 7. Zener-stabilized state-variable-filter oscillator.

important, namely R1-C1 and R2-C2. If the excellent amplitude stability mentioned is desired, the remaining resistors should be close tolerance, low t.c. units. The op amps used should be wide bandwidth for this kind of performance at frequencies above a few hundred hertz. Quad units should be a 4136 or one of the others mentioned, but even better performance can be realized with 318s or 301As operated feedforward.

Three outputs are provided, phased as shown—two in quadrature with the complement of the sine output as a bonus. The sine output will be the lowest of the three in terms of distortion, for previously mentioned reasons. All are equal in amplitude.

Tuning, as in the Wien bridge oscillator, is accomplished by simultaneous (and tracked) variation. You can add an additional control as in FIGURE 8, namely RA and RB. Here this linearly varied dual pot reduces the per cent of signal applied to R1 and R2, thus changing the frequency downward as RA (and RB) are reduced. The shift can be calibrated linearly in terms of frequency if care is taken that R1 and R2 do not load the output of RA-RB, excessively. C1-C2 are then assigned as decade range switches. The arrangement of RA and RB may well suggest an even further variation to many readers.

FET STABILIZED STATE-VARIABLE-FILTER OSCILLATOR

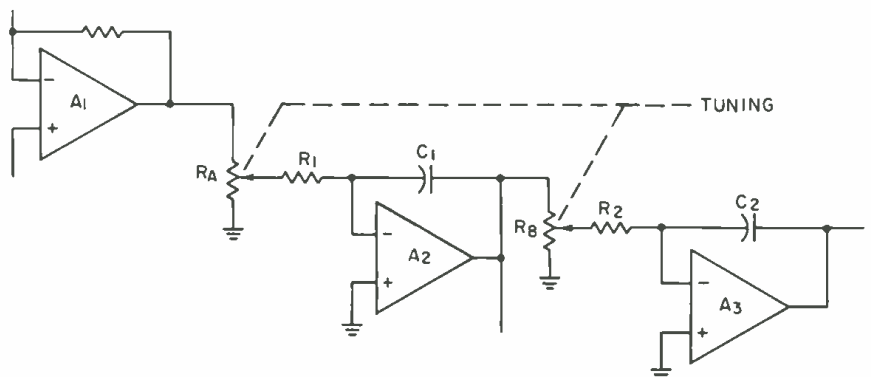
As a final touch, FIGURE 9 illustrates an oscillator circuit which is capable of state-of-the-art performance in terms of distortion. It is similar to the device shown in FIGURE 7 in that it is based on the state variable filter, but has a lower distortion form of automatic gain control.

The oscillator circuit itself is quite similar to the one in FIGURE 7 except that a positive feedback path is added, via R5. The positive feedback is greater than the negative at switch on, which ensures startup. After oscillations start, automatic gain control voltage is developed to drive Q1 off and balance the loop at a stable low distortion operating point. When operating properly, thd at the φC output is on the order of 0.02 per cent, while the φA and φB outputs are even cleaner.

No selection of fets is necessary, due to the gain of A4, which automatically adjusts to the required bias. If desired, R7 can be trimmed to optimize distortion performance, but there is a tradeoff between lowest distortion and fastest settling.

A 4136 op amp is indicated as an inexpensive single chip which will work as well as described above. Even

Figure 8. Tuning method for state-variable-filter.



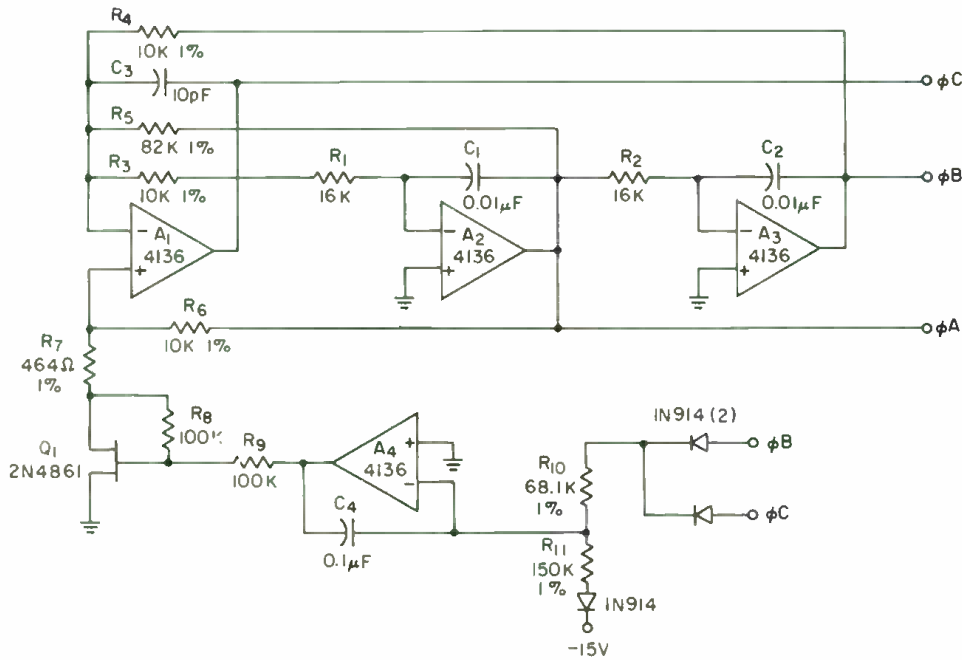


Figure 9. F.e.t. stabilized state-variable-filter oscillator.

better performance may be realized by using the wide bandwidth units mentioned for the FIGURE 7 circuit.

OUTPUT BUFFER STAGE

For the absolute highest performance from any of the oscillators described, particularly the state variable versions, a buffer stage is desirable. A suitable circuit is shown in FIGURE 10.

This circuit will drive a level of +26 dBm into 150 ohms with diminishing small distortion across the band, because of its wide bandwidth. This is due to the 301A in its feedforward mode, one which features a 30 MHz

gain-bandwidth. Wideband buffer transistors are also used, and biasing to minimize parasitics. Bypass capacitors should be tantalum or other rf types. Short circuit protection is provided by the 27 ohm emitter resistors.

PRODUCT SOURCES

Resistors: Allen Bradley type CC metal film resistors (1%)
Allen Bradley
Milwaukee, Wisconsin 53204

Capacitors: KEMET F300 series film capacitors (to 0.5%)
Kemet-Union Carbide
P.O. Box 5928
Greenville, S.C. 29606

Op Amps:

Exar Integrated Systems 4212
750 Palomar Avenue
Sunnyvale, Ca. 94086

Intersil 8007
10900 N. Tantau Avenue
Cupertino, Ca. 95014

Harris Semiconductor 4741
P.O. Box 883
Melbourne, Fl. 32901

National Semiconductor 318, 356, 301A
2900 Semiconductor Drive
Santa Clara, Ca. 95051

Raytheon Semiconductor 4136, 4137, 4558
350 Ellis Street
Santa Clara, Ca. 95051

RCA 3130
Solid State Division
Route 202
Somerville, N.J. 08876

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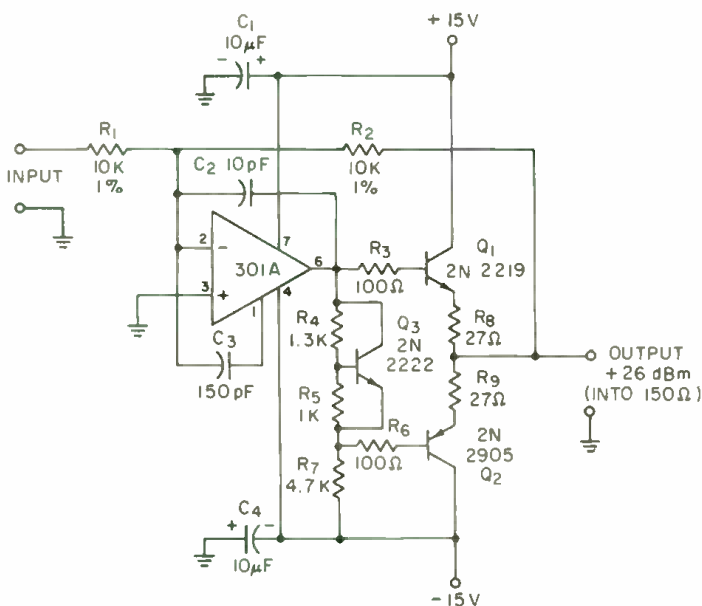


Figure 10. High performance buffer/line driver.

Budget Sound or What About the Garage?



Baron von Hautman, trademark of Baron Records and official announcer of all visitors.

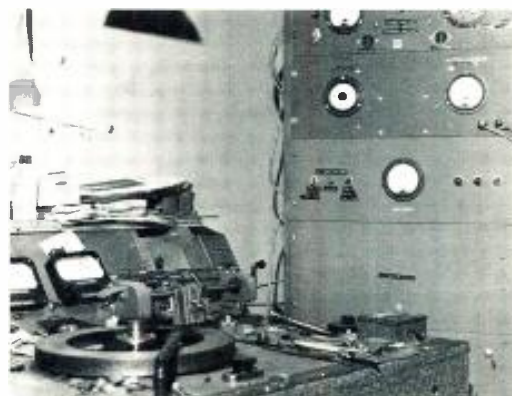
Architectural improvisation, good basic equipment, and a lot of skill keep quality up and prices down in the offbeat garage studio.

GARAGE STUDIO? Budget studio? Marginal quality studio? It doesn't necessarily have to be *all* true.

Garage studio. Why not? Looks need not be a criterion for good sound. My garage studio would not be classed as a beautiful studio, though I don't consider it the ugliest one either!

The Altec A-7, 500 playback speakers are covered by draperies, the walls and ceilings are lined with egg crates, and I have black light mood lighting when required, making all the egg crates glow in different colors, as do the black light paintings. Near the ceiling, at the opposite end of the studio from the Altecs, are mounted four 12 in. electro-magnetic speakers, also covered by draperies. This is a spare bank of speakers used for multi-purposes. Sometimes they fill the "hole in the middle" of stereo. Other times they are the rear of quad. Still other times, for those who cannot handle headphones for vocal overlays, they are used to "boom" the music tracks over their heads.

The Hammond X-77 organ, and Deagan four octave marimba add a touch of class. An old upright piano serves my needs, and I have an Arp Odyssey music synthesizer, and an Atkins musical saw. I'll bet the biggies don't supply that latter instrument!



A closeup of the main equipment rack and the disc lathe.

CONSTRUCTION

Construction? The two-car garage is of heavy stucco and wood construction, with the two garage doors still remaining. The inside of the door area was studded in, and three inch fiber glass insulation was installed on all walls and ceiling. Then three-quarter inch sheet-rock was applied to the inside walls. The egg crates were painted with fluorescent paint, then glued to the surfaces of the sheet-rock.

Each egg crate was positioned at a 90 degree orientation to the adjacent one, so that, sighting down the row, the valleys in one egg crate would line up with the humps

William Newcomb is the proprietor of Newcomb Recording Studio in Richmond, California.

in the next egg crate. Thus, any travelling waves taking a trip along the walls or ceiling would be broken up, and their trip would be a difficult one. A small item, 'tis true, but it proved to be a very dead studio in the end. But then again, a garage studio is what it is, because of lack of funds. Therefore, every small detail becomes important if good sound is to be realized. The concrete floor is covered with indoor-outdoor-type carpet squares that have a one-quarter inch rubber padding. The studio measurements are 18 x 20 ft.

I am fortunate that there exists a seven foot breezeway between the studio and the control room. The breezeway is closed in on one end, and a sloping corrugated plastic roof has been installed from the house to the garage. The other end is fenced, but open. I hope one day to close in that end also. Then the breezeway could become vocal quarters, or any other usage that would require more separation from the happenings in the studio.

The exterior of the house is also stucco, but unlike present day stucco, this is practically pure concrete. Therefore, the two stucco walls, plus the seven foot separation, gives excellent sound separation between the studio and the control room, with very little bass leak-through from a wailing rock band.

The ten mic lines, two hi-level lines, recording indicating lights, and playback speaker lines all run across the breezeway, over the entrance door, and through the wall into the control room.

The control room measures 13 x 35 ft. and was the old "rumpus room," in the house proper.

THE BUDGET ANGLE

Budget studio? Of course. We have to be. We don't have all the name brands like Ampex, 3M, Telefunken, UREI, Neve, Spectra-Sonics, etc.



Far left, disc lathe; in the equipment rack top, four meters with hot stylus control; center meter, a.c. control; bottom panels, four power amps. Above the rack, a monitor speaker; below the patchbay, the home-brew compressor. Also, 'scope for positioning, Sony two-track, G.E. am/fm tuner, Newcomb tape deck.

To the customer who feels that unless you have these name items, the sound cannot possibly be good—well, he goes elsewhere. I am glad that he does, for no matter how good a job you do, he's going to be dissatisfied. I had

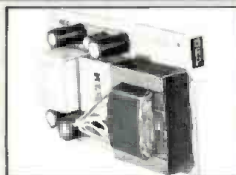
IMPAC* from MAP

*INTEGRATED MODULAR PROFESSIONAL AUDIO COMPONENTS

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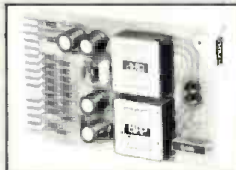
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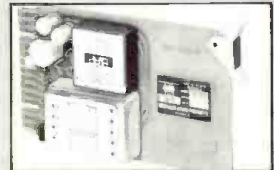
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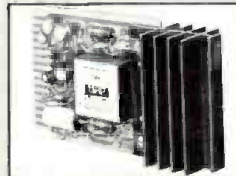
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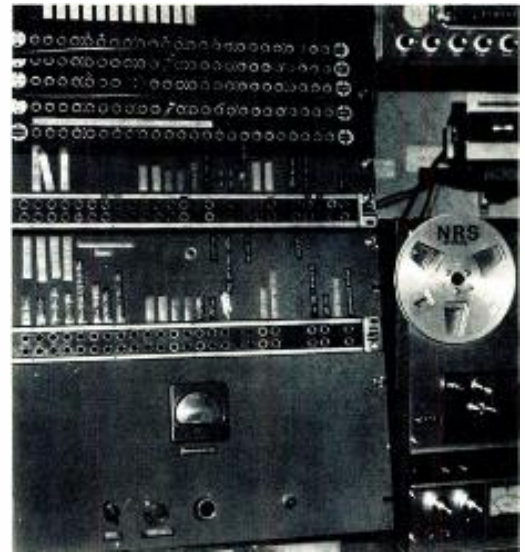
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A view down the console.



The patch bay with the compressor below.

one such customer who decided he'd try me anyway. He was not satisfied. He *had* to have name brands after all, in order to be good. He went to one of the surrounding "biggies." He compared both tapes. He compared both prices. He returned to me stating that he could not hear any difference in sound, and he liked my atmosphere better! It did my ego good.

Now, we have established that in general, by its very nature, a garage studio must also be a budget studio, but, must it necessarily be a marginal quality studio? I don't think so. I cannot of course, speak for the other garage studios around, wherever they are, but I can speak for this particular studio. Hopefully, some of the other garage studios will come forth at a later date, and give their experiences.

But then, why are they "hiding"? Why do they not advertise? It could be that they have all the business they seek. Perhaps some are "moonlighting" without a city business license. Who knows?

My garage studio has been licensed since 1942, has been listed in the Billboard Directory for the past several years, yet I have never advertised. People find me through word-of-mouth. Satisfied customers.

I work elsewhere during the days, and have only the evening hours to devote to recording; thus my time is limited. I have enough business for my limited time.

I stem from the "old school," long before tape, when everything I did went directly on the disc. The band had to *know* its material; the disc did not accommodate mistakes! The band had to be *together*, as there was no "tracking." The band had to blend its own sound, for you didn't mic every instrument. Mics in those days were not used to pick up *instruments*, they were used to pick up a blend of sound, created by the band. The studio acoustics then, were very important to a "one-mic" pickup, with a solo mic for the vocalist. The level-balancing portion of a session was far more important then, than the actual "take." The engineer was under far greater stress, for there was no "rewinding," and let's do it again! At least, not cheaply.

Then came wire as a recording medium. Great! Now we could erase our errors. Then came tape. Much better response. My studio thus grew like Topsy.

No, I don't have a super board, just "home brew," as can be seen from the photographs. My patch panel is probably as big as the one at Columbia-Coast, and I definitely can patch anything to *anything!*

With the exception of the mic lines themselves, absolutely all equipment input and outputs are available on the patch bay. Any piece of equipment can be bypassed, or inserted further down the line, if required. In case of a power amp failure, it can be patched out and a substitute amp patched in, and the session keeps rollin' along.

They are all normalled, so that no patch cords need be used for normal operations.

GOOD EQUIPMENT PLUS KNOW-HOW

The studio mics consist of two Electro-Voice Soundspots, four Sony condenser mics, one Shure 556 cardioid, one Shure gradient ribbon, two E-V RE-15s, and some others of perhaps antique vintage, but good. How the acoustic guitarists love the mellowness and richness of the old RCA 44!

To clarify my technical thinking for a moment, I firmly believe that if an engineer *knows* each piece of equipment, and exactly what it will do, and exactly how far it can be pushed, then a good quality of sound can be achieved with *good* equipment, though it may not necessarily be name equipment. To me, that's the whole ball of wax—know your equipment! While many sunrises have set, I continue to learn.

Meanwhile, back at the control room, the mics are all run balanced low impedance, directly to the mixers, which accommodate six mics for the left, and six for the right, with or without reverb. Treble and bass equalization is provided if needed.

The mixer is normalled, (through the patch bay) to the input of the Advent Frequency Balance Control, (stereo). This output is normalled to the input of the Advent two channel Dolby-B system, and from there to the input of the Sony tape recorder, which is 15 in/sec speed, two-track, logic motion controlled, with 0.04 per cent wow and flutter.

The output of this machine is normalled to the playback section of the Dolby, and from there to the monitor amplifiers, which are also the studio playback amps. There are four of these tube-type amps, at 70 watts continuous each, with 0.25 per cent distortion at full output, from 5 Hz to 100,000 Hz. One of these amps also serves to drive the disc cutter head.

The playback system for discs comprises the Shure Track-Two cartridge, with a Rek-O-Kut belt-driven turntable, and a Rek-O-Kut transcription arm for minimum

tracking error on normal records. I still like, on occasion, to play some of my old 16 in. transcriptions.

The Shure cartridge's being of rather low output necessitated that I build a f.e.t. preamp to get the level up to approximately 11 mV to accommodate a normal magnetic cartridge input on my H. H. Scott pre-amp equalizers. These units are then patched to the inputs of the power amps, and onto either the control room monitors, or the Altecs in the studio, and/or both.

The disc lathe is a Rek-O-Kut, with overhead spiralling feed, and a Presto 1-D cutter, to which I added a homebrew hot stylus assembly to be suitable for microgroove work, though it is strictly mono. I use 120 lpi for normal 45 rpm discs, and 240 lpi for 33 lps, giving me a full 15 minutes on each side of a 10 in. lp.

I have a Newcomb quarter-track stereo deck when needed, and a Sony 4-track (quad) to which I added Sel-sync. This unit has logic motion control, and 0.04 per cent wow/flutter. A Hewlett-Packard wow/flutter meter was borrowed, and it substantiated that Sony's specifications were conservative.

For back-up units and special effects, I have a Berlant custom deck, two Concertone decks (1/2-track), one Concertone two-track at 15 in/sec speed, and one Concertone quarter-track. (The old Webcor model 80 wire recorder is not used any more, but I won't part with it.)

The control room monitors are 15 in. Jensens, plus external Electro-Voice tweeters, mounted in bass reflex boxes, that they now call "ported." These four monitors, with the aid of the patch bay, can be used, either any one or all together for mono, any two or all four diagonally for stereo, or for quad.

A 15 in. Altec speaker in a Karlson enclosure is used for monitoring when cutting discs and can be patched in any place. One of the studio Altecs is used for talkback.

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There are however, some things that have never changed through the years. Distortion is still distortion. Wow and flutter is the same old wow and flutter. Frequency response is still frequency response, and noise is still noise, no matter how you look at it.

By using reasonable equipment, with judicious operating practice, there is no need for a garage studio to put out marginal quality.

I've been privileged to have one of today's "million seller" artists taping practice sessions here. He stated that regarding my sound, I didn't have to hang my head one bit, and studio-wise, he felt more comfortable here, than at the biggies. My ego doth rise.

On another occasion, I had a 63 piece choir, plus piano player and lead vocalist in my little garage. Agreed, it was a tight fit. After setting levels, and a trial run, we taped the first selection, and played it back in the studio. I was busy with rewinding and other usual chores of a session, but I kept hearing off in the distance, something sounding like applause. I checked all my equipment, and nothing else was running. Then I looked up and out to the studio. All 63 members of the choir had turned around, and were facing the control room windows, applauding me! It was a soul-stirring moment that I have never forgotten. It still makes me proud that I'm just a little Garage Studio, with perhaps, just a little better than "marginally acceptable quality." ■

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MODERN RECORDING TECHNIQUES by Robert E. Runstein. The only book covering all aspects of multi-track pop music recording from microphones through disc cutting. For engineers, producers, and musicians. \$9.95 prepaid. **Robert E. Runstein, 44 Dinsmore Ave. Apt. 610, Framingham, Mass. 01701.**

PROFESSIONAL MONITOR TUNING. Even the finest control room designs require speaker line tuning for accurate response. Milam Audio uses only the finest Real Time equipment to read and correctly perform monitor tuning. For information, contact: **Milam Audio Co., 1504 N. 8th St., Pekin, Ill. 61554. (309) 346-3161.**

ELECTRO-VOICE SENTRY PRODUCTS. In stock: Sentry IV-A, Sentry III, and Sentry II-A monitor loudspeaker systems for professional monitoring and sound reinforcement. Immediate air freight shipment to any N. American destination. Florida dealer inquiries invited. **National Sound Corp., Ft. Lauderdale, Florida. (305) 462-6862.**

TASCAM WARRANTY SERVICE STATION. Mixing consoles, \$1,350; 1/2" recorders, \$1,950; 8-track machines, \$2,950. All shipped prepaid & insured, including free alignment + equalization + bias + calibration + life test. **Sonic Engineering Labs, 11 1/2 Old York Rd., Willow Grove, Pa. 19090. (215) 659-9251.**

Note Special Prices

DON'T MISS THE "DISCO WAGON"! Excellent complete line of discotheque equipment is available to fulfill your needs. Request your information package today. Write to: **D.T.S., Dept. DISCO, P.O. Box 16049, Seattle, Wa. 98116.** Reserve your dealer territory in time!

AUDIOGRAM—Equipment reviews that are clear, concise, and comprehensive. **AUDIOGRAM** will not leave you in doubt as to what a component sounds like. Rate: \$10.00, 12 issues. Write **The Audio Advisor, P.O. Box 17202, Washington, D.C. 20041.**

SCULLY 16-TRACK. Probably the finest M-100 ever built. Extensively modified electronics, with improved s/n headroom and silent punch-in. Options include: remotable 16-track meters, a transport remote, and an LED readout counter, 15/30 cards, variable speed, and extensive parts inventory, including complete spare electronics. Schematics, maintenance history, excellent condition—a gold recorder. Price for quick sale—we are going 24. \$10,000 firm. **(415) 864-1967.**

FOR SALE. Scully 284-8 tape recorder, very good condition, \$6,200. Audio Designs console, 10-in/4-out, wired for 8-track recording, \$9,500; excellent condition. **(419) 241-5961.**

FOR SALE: 16-in/3-out board. (expandable to 6-out), \$2,000. (1) dbx-154 \$650; (1) TEAC 33405 4-track recorder w/remote \$1,000. All units new w/carton and warranties. **Blue Diamond, RD #1, Box 102C, Chubbic Rd., Canonsburg, PA 15317. (412) 746-2540.**

DUPLICATOR REPAIR CENTER for all brands of in-cassette duplicators. Factory-trained technicians. Work warranted. Also big selection of new and used duplicators. **Tape and Production Equipment Company, 2065 Peachtree Industrial Court, Atlanta, Ga. 30341.**

WANTED

WANTED: HAECO SC-1 stereo cutter. **Roland Jordan, 812 Young Street, Selma, Ala. 36701. (205) 874-8009.**

WANTED: ALTEC 443A frequency shifter or similar. **D. Senft, Box 1300, Regina, Sask. Canada.**

EMPLOYMENT

CHIEF ENGINEER for NYC recording studios. Must have heavy experience in all facets of electronics and automation for audio, film, video; leadership qualities. **Dept. 73, db Magazine, 1120 Old Country Rd., Plainview, NY 11803.**

SOUND ENGINEER needed to travel with country-rock act on national college circuit. Send resume, references, and salary requirements to **Promising Artists Management, 456 East Beaver Ave., State College, PA 16801.**

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● Scheduled to work with distributors, **Raymond Beier** has been appointed general line distributor sales manager for **Switchcraft, Inc.** of Chicago. Mr. Beier, formerly with **Harry Beier Studio**, has been serving as a sales consultant for Switchcraft for a number of years. Other personnel changes at Switchcraft include the promotion of **Ken Kline** from sales office manager to eastern regional sales manager and the promotion of **Ronald Larson** to the post of Chicago district sales manager. **Ronald Pitchford** has been named as sales manager of the Switchcraft Assembly Centers. **Norman Luksik** is now serving as the sales office manager.

● **Martin Gittleman** has joined the staff of **Quad Eight Electronics** of N. Hollywood, Ca. as vice president and director of engineering. Mr. Gittleman's most recent association has been with **Modular Audio Products Corp.**

● The **National Academy of Engineering** of the U.S. has elected twenty-one distinguished foreign engineers as foreign associates. Included was **Masaru Ibuka**, co-founder of the **Sony Corporation**, Tokyo, who was cited for the development of the **Trinitron** color television audio/video magnetic tape equipment and the transistor radio. The Academy was established in 1964 to share in the responsibility given the **National Academy of Sciences** under its Congressional Charter to examine questions of science and technology at the request of the federal government.

● Executive responsibility for marketing **RCA** broadcast systems in the Far East has been assigned to **Thomas E. Newman** as manager, field sales. Mr. Newman, who has been promoted from the post of sales engineer, is headquartered at **RCA International Ltd.** in Hong Kong.

● **Tony Hawkins** has joined **Martin Audio/Video Corp.** of New York City as an outside salesman specializing in pro audio equipment/sales. Mr. Hawkins has had a considerable sales and service background, both in England and the U.S.A. with **Revox** and **Beyer**. Most recently, he was president of **Midsummer Sound Co.** in New York.

● Educator and sales executive **Morton G. Stone** has joined **Telex Communications, Inc.** Minneapolis as director of marketing for the **Instructional Products Group**. Mr. Stone will have responsibility for marketing the firm's audio visual tape cassette equipment, high speed tape copying systems and instructional headsets.

● **John Blache** has been named credit manager of the **TEAC Corporation** of America, Montebello, Ca. Mr. Blache was previously with **Fisher Radio** and **Delmonico/JVC**.

● **Superscope, Inc.** of Chatsworth, Ca. has completed an agreement with the **Sony Corporation** to become the sole U.S. distributor of the new **Elcaset** tape recorders. The new device combines features of cassette and open-reel recording. It utilizes a cassette shell slightly larger than conventional, operating on 1/4 in. wide tape with a speed of 3 3/4 in./sec. Head configuration can be either 1/2 or 1/4-track, with either two or three heads. The device will be introduced early in 1977.

● Two new management positions have been created within the technical operating sector of **Goldmark Communications Corp.**, Stamford, Conn. **Alfred Scipione** has been named director of systems engineering and **Arvind C. Desai** has been appointed chief development engineer, with responsibility for technical direction of the **Rapid Transmission and Storage** learning system that transmits pic-

ures and sound at high speeds to learning centers.

● Manufacturing of the **RAPID-Q** line of tape cartridge equipment and the **STE-100** stereo phase enhancer by **Garron Electronics** has shifted from California to Lexington, Kentucky. **Ron DeBry** and **Ron Eigenmann** have relocated to Lexington.

● A demonstration van, owned by **BGW Systems**, of Beverly Hills, Ca. will be wending its way through the U.S. and Canada. The van will be used for training **BGW** dealers and for demonstrating products, including seven models of power amplifiers, preamplifiers and laboratory testing facilities.

● A contest, run by the **Simpson Electric Company**, solicits new application ideas or names for two new digital test instruments, model 360-2 Digital VOM and model 464 Digital Multimeter. Prizes will be his or hers 14K gold-filled pulsar digital timepieces and Simpson test instruments. If you have some bright ideas, entry blanks may be obtained from Simpson dealers or at 853 Dundee Ave., Elgin, Ill. 60120. The contest closes September 30.

● For the first time in Europe, broadcasting for the two days April 2 and 3, **Radio Picadilly** of Manchester, England, broadcast in quadraphonic. The station used a **Sansui QSE-5B** broadcasting encoder; coordination was done largely by Mr. **Ishikawa** of **Sansui**. It is hoped that, beginning on an experimental basis, quad broadcasts will become a regular feature in the United Kingdom and the rest of Europe.

● Two new manufacturing representatives have been appointed by **Pentagon Industries** of Chicago. **Evans Marketing Co.** of Burlingame, Ca. will be their representatives for Alaska, Northern California, Northern Nevada, Oregon, and Washington. **Master Recording Supply** of Los Angeles will represent Pentagon products in Arizona, Southern California, and Southern Nevada.

● **Frank D. Lintern** has formed his own firm, **Lintern Associates**, in Chicago. The firm will represent **Dynaco**, **High Energy Design**, and **Elwin Electronics** in Illinois and Wisconsin.



We added your inputs to ours.

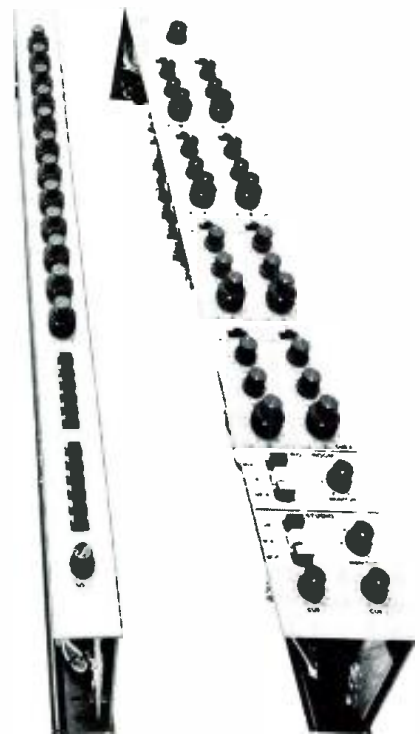
The result is the Model 10B – a good thing made better. Now there are peak reading LED indicators on each input, chassis mounted ¼" phone jacks for added stability, and the echo busses can be used with the program busses for 8-out capability.

An 8-channel Monitor Mixdown Module (Model 116) is now available optionally for direct interface. Each channel may be switched selectively to monitor buss or tape, and individual pan and gain controls are provided. Additionally, there is a split mono cue send (1 & 2), and an outboard automatic switching matrix.

When you want to expand the capabilities of the Model 116, the Model 120 Input Cue/Solo Module allows you to mult the accessory send signals from up to 12 inputs for a mix of tape cue and input cue on the split mono cue buss. And you can solo any of 12 active input channels.

The Model 10B is new. But it's built with the same design philosophy and integrity that has made the Model 10 one of the most popular mixing consoles ever. It's a creative tool that gives you the practical capabilities your imagination demands.

So if you have more talent than money, look into the Model 10B at your nearest TEAC Tascam Series dealer. Just call toll free (800) 447-4700** for the name and location of the one nearest you. **In Illinois, call (800) 322-4400.



Model 120

Model 116

Model 10B

TEAC

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Think of them as your musical instruments.



The audience can't see you. But they can sure hear you.

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It's not something an amateur can do. It's an art. And that's why Yamaha has designed 3 superb mixing consoles with the qualities and range of controls that the professional sound reinforcement artist needs.

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isolated inputs and outputs, dual echo send busses, an input level attenuator that takes +4 dB line level to -60 dB mike level in 11 steps, and 5-frequency equalization.

Whether you choose the PM-1000-16, the PM-1000-24 or the PM-1000-32, Yamaha gives you the flexibility you need to turn your job into an art. And because they're designed from the ground up to perform on the road, more and more professional sound men around the United States and the world are depending on Yamaha, night after night, gig after gig.

If you've never thought of your mixing console as a musical instrument, we'd like to invite you to stop by your Yamaha dealer. Once you've checked out the operation manual and tested for yourself what the PM Series can do, we think you'll come away a believer.



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