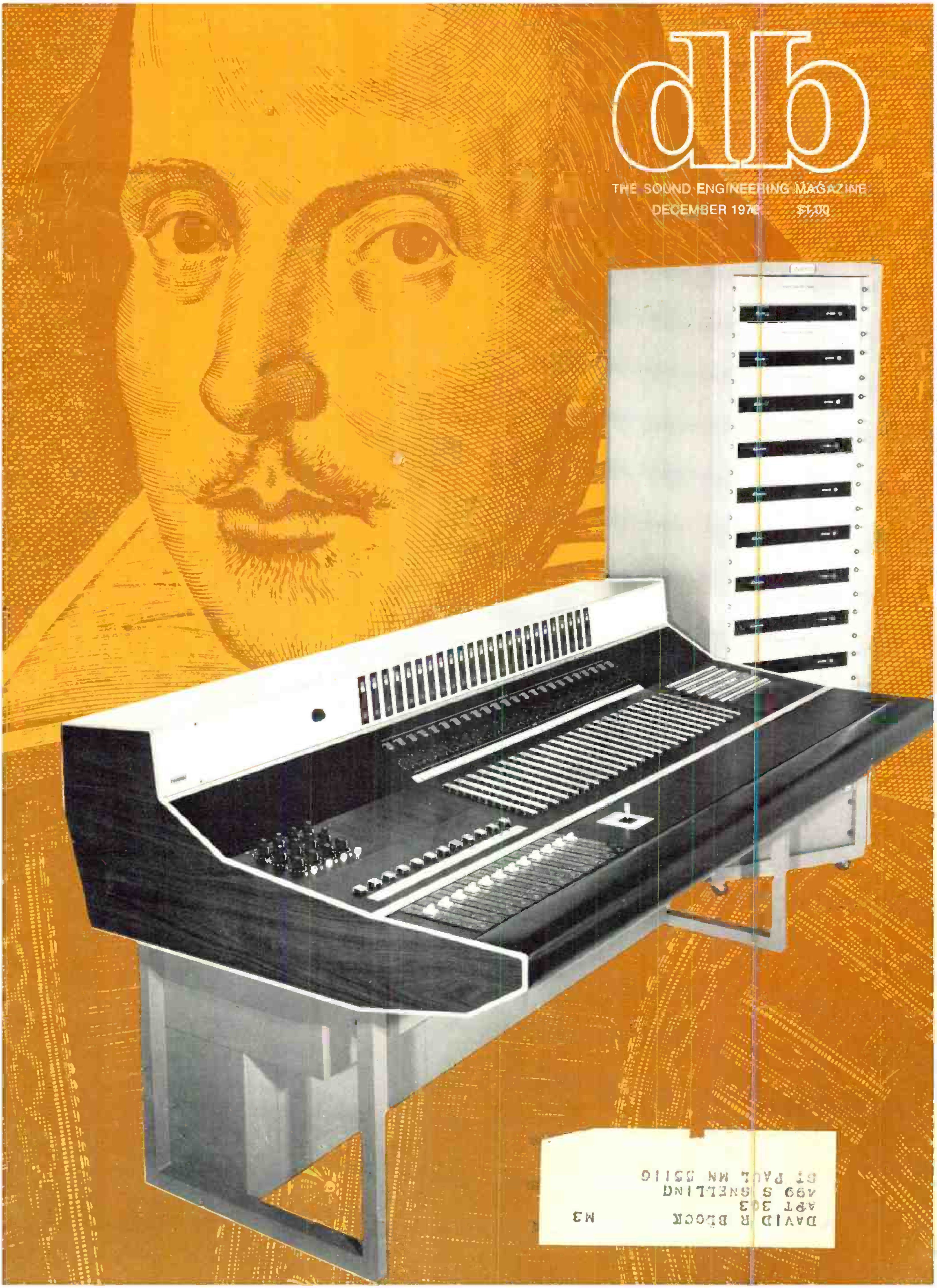
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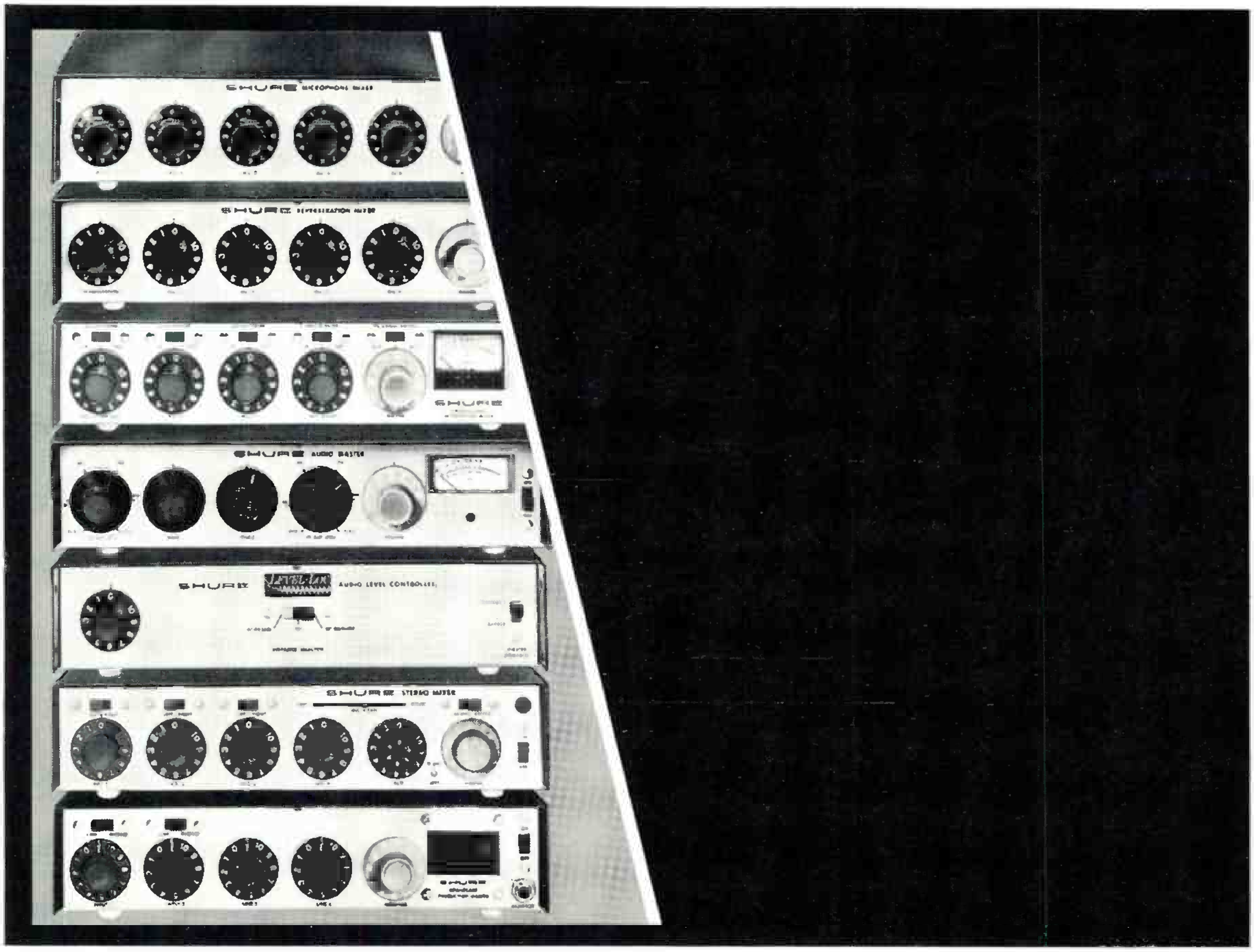

COMING NEXT MONTH

• Robert Ehle returns to our pages with not one, but two articles. The first is entitled WHAT TO LISTEN FOR IN ELECTRONIC MUSIC. Because it takes the composer's point of view, recording engineers and producers will want to read it—if only to gain a broader understanding of what it is they are trying to record. The second article is a light-hearted treatment of a long-standing hobby of the author's. It details some of his adventures collecting old radios. Lots of nostalgia here.

In a totally serious engineering vein, Walter Jung details OPTIMIZING OP-AMP SPEED. If you have used op-amps you know that many have high-frequency speed problems that limit their value. But this need not be so.

Two issues to specially watch for are February and March. These will contain a group of articles all on the subject of tape and tape recording. If you use tape, these will be reference issues.

ABOUT THE COVER

• The special console pictured was constructed for the Stratford Theater. Its use is detailed in the article on this system beginning on page 24.

Last month's (November) montage of electronics and musical instruments was constructed by Marshall King. The second part of his article on hearing appears in this issue on page 15.

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THE SOUND ENGINEERING MAGAZINE

DECEMBER 1972 VOLUME 6, NUMBER 11

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

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George Alexandrovich

THE AUDIO ENGINEER'S HANDBOOK

Remote Powering Condenser Microphones

● Condenser microphones have been with us for more than a decade. During this time the technology of sound pickup has made substantial progress. Earlier types of condenser microphones were designed around vacuum tubes (consuming a lot of power), they were sometimes microphonic (in competition to the cell of the condenser mic), and required a fairly big metal box with long a.c. cord, pilot light, fuses and other trimmings.

There is nothing wrong with this, particularly if the microphone does something other mics can't do, or at least can't do as well. But all of a sudden hunger for more microphones and more channels started growing and mushrooming. No longer were two or three mics enough to do the job. Bass drums were being decorated with different types of mics, cords from the mics were scattered over the studio floor as the spaghetti in Sloppy Joe's kitchen. I wonder how many broken violins and ankles can be attributed to mic lines.

Came the age of semiconductors—transistors and FETs! Before, about 40 mA at 105 volts was required to drive a single U47A microphone. Now, with f.e.t.s in the picture, all that is needed is something like 0.5 mA at 8-10 V to operate the solid-state amplifier. Naturally polarizing voltage has to be supplied to the microphone but there we use a couple of 21-volt batteries supplying only

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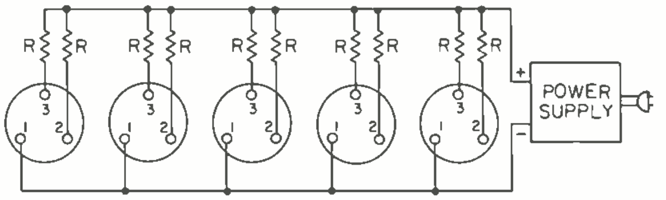

Figure 1. Connections are made from the power supply to the mic connectors through precision resistors.

polarizing potential to the diaphragms with service life equal to the shelf life of the cells.

With a current of only 0.5 mA one would think that a couple of batteries would last long enough to warrant the omission of an a.c. power supply, but we should remember that batteries of the size to be considered for microphone use are designed with current supply capabilities of 1000 mA hours on the average (mercury cells). If you consider that some studios may operate around the clock —or if somebody forgets to shut off the power switch on the mic (a most likely situation) the batteries will be exhausted in little over two months—and the time they will quit on you is when you need them most.

No one would like this to happen to him. But it has happened many times and those with this sad experience have bought a.c. power supplies. Without abandoning the principle of variable capacitance transducer and its unsurpassed quality of sound transformation some clever engineer (whoever he is he has my admiration) thought of powering all of the microphones from a centrally-located power supply in such a way that standard three-conductor cable could carry needed power to the microphone and its amplifier, and the audio signals back without interference or degradation of performance of the microphone. For this the line has to be balanced and floating. The big advantage of the powering system is that it permits any other microphones to be connected in place of a condenser mic without affecting the operation of the powering system. Usually the power supply with well filtered d.c. is located inside the console or near the panel where microphones are plugged in. Connections are made from this power supply to every mic connector on the panel through precision resistors as shown in FIGURE 1.

From this drawing it can be seen that d.c. balance in the mic line depends primarily on the proper match of the resistors R. Equal potentials and currents appear at both red and black conductors. The shield carries the return curents. (It is often mentioned that the shield should not be allowed to carry any current otherwise it will affect conductors inside the shield. But in this case current flowing in the shield is pure d.c. with ripple currents well below the noise levels of the f.e.t. preamplifier.)

For this reason and for the reason of successful operation of the f.e.t. in the microphone, the power supply should be designed with multistage filtering with ripple voltages not exceeding few microvolts! If you consider that at mic levels of —60 dBm voltage is only about 1 millivolt and you have preamplifiers capable of maintaining input noise figure of —127 dBm, you should expect signal to noise would be 67 dB. One microvolt equals approximately 120 dBV, so seven dB below that is less than ½ a microvolt!

It is true that there is additional filtering in the f.e.t. preamp itself, but don't count on it too heavily since

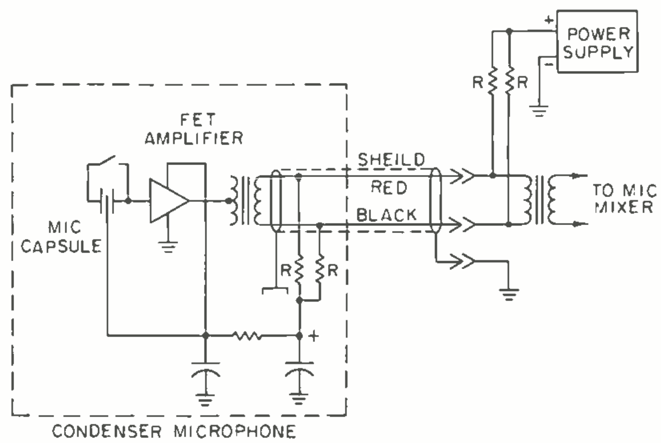

Figure 2. The complete circuit of a condenser powering system.

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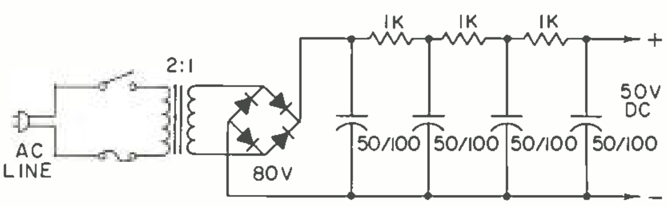

Figure 3. A simple low ripple supply for remote powering.

any inbalance in the powering system heads you for trouble.

Regulation of the power supply is not that important because most of the f.e.t. amplifiers are class A and do not interact one with the other—as some class AB do unless there are "stiff" power supplies involved and adequate decoupling between the amplifiers.

Voltages are not critical most of the time because they affect only voltage handling capability of the amplifier and not distortion, noise, or other parameters (within reason, of course).

The polarizing voltage affects gain of the capsule and some of its dynamic properties (electrical damping because of electrostatic attraction of the diaphragm to the plate).

Resistor valve in a power distribution system usually is a few thousand ohms, depending on the requirements of the f.e.t. preamp.

For many years Europeans have run condenser microphones without preamplifiers in the console similar to high-level inputs, but Americans have never adopted the European way of mixing. In order to make everyone happy why not add just a little more *umpf* in the mic f.e.t. preamp by adding one more stage (wouldn't cost much more and wouldn't draw much current either) so that mic could be plugged in directly into the high-level input. If one is afraid of overload characteristics of the preamplifier we can prevent overload of the first stage using the same f.e.t.s for limiting or compression. This way all the noise generating stages would be concentrated in the well-shielded enclosure of the microphone.

In conclusion I would like to write a few words about the operation of a condenser microphone. Most of you know how a microphone is constructed—very thin conductive Mylar (or similar material) diaphragm stretched close to a rigid metal plate with perforations to allow passage of a certain amount of air. Capacitance between the diaphragm and the plate is on the order of several tens of picofarads—sometimes as high as 100 picofarads. Polarizing voltage applied to the capsule maintains a charge on the capacitor formed by the diaphragm and teh plate. From the basic formula

$$Q = VC$$

where Q is the charge in Coulombs
V voltage in volts
C capacity in Farads

If we consider the charge to be constant and we vary C, voltage should vary also in order for the equation to hold true. This is how a condenser microphone operates. By varying C we vary V which is applied to the gate of the f.e.t. and amplified for further processing. Sound pressure, of course, is the factor which changes the position of the diaphragm with respect to the base plate-changing the capacitance of the capsule.

For an analogy, think of an inflated balloon. Air in it is a charge. Pressure exerted on the walls of the balloon is voltage, volume of the balloon is capacitance. Compressing the balloon without changing the amount of air inside of it will increase the pressure on the walls of the balloon. If you start sensing the variations in pressure you will be sensing the variations in pressure applied by hand to the balloon. ■

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John M. Woram

THE SYNC TRACK

● NARAS—the National Academy of Recording Arts and Sciences—held another of its always welcome, but all too infrequent, meetings here in New York City ome time ago. The meeting was called to discuss the precarious condition of the recording industry here in Fun City.

Although the meeting addressed itself to the particulars of New York life, I suspect the same meeting might have been held almost anywhere in the country.

No one needs to be told that a lot of recording work has left these shores [west or east coast, as you like] for studios in Europe. Still other work now gets done in American locations far from the traditional recording centers of New York, Hollywood, and Nashville.

And so—the NARAS get together at which representatives of NARAS, of the musicians and their union, the mayor's office, and the engineering profession (or cult, maybe?) sat down to discuss what's to be done.

A certain amount of decentralization must always be expected as an industry grows up and hopefully, expands. Because there are now studios in Muscle Shoals and Detroit, to say nothing of—for all I know—Council Bluffs, does not mean that New York (or *your* favorite city) is necessarily doomed. Nevertheless, the prophets of doom are at hand, and although one hopes they are guilty of overstatement, there is at least some cause for concern. Otherwise there wouldn't have been a meeting, would there?

From the floor, there were several protests against companies that go to Europe to do their recording work. Many present were ready to suggest all sorts of penalties against those who would do such a thing. Very few were prepared to consider that maybe there was a rational reason for the exodus.

Successful individuals in any facet of recording are usually reasonably well paid. In short, their work is profitable. And yet, how many of us seem to be scandalized that a record company would seek to be profitable too. There seems to be a semi-religious conviction that companies should be honored to spend $10,000 here, when they could do the same job elsewhere for much less.

The recording of classical music in this country has almost stopped completely. Whatever shall we do, everyone cries?

In a recent *New York Times*, there was a story about the then just finished recording session of *Carmen*. The budget was $275,000! In order to break even, about 125,000 albums will have to be sold. I don't know what the odds are on this sort of sale, but if I were looking for a sure thing, I think I'd keep looking. On the other hand, Deutsche Grammophon, the company doing the recording, has impressive worldwide distribution facilities. The global classical market accounts for 20 per cent of sales compared to 4 per cent here in the United States. Nevertheless, $275,000 is a lot of money, and, the last time a complete major opera was recorded in this country was in 1965. That's a long time between sessions, if you're counting the days.

Not too long ago, a smaller classical album was also recorded in these parts. One night, the session ran half an hour overtime, for which the orchestra and chorus were paid the appropriate overtime rate. Just before the end of the half hour period, it was seen that a final take would be needed, but this would run a minute —more or less—into an additional overtime period. The union representative pointed out that there wasn't time to re-do the take. So, it wasn't done. To do so would have cost a small fortune. Not $275,000 to be sure, but enough to even further lessen the very remote possibility that the session will eventually return at least a small profit.

In discussing this situation at the NARAS meeting, the union officials pointed out that their musicians had been unfairly treated in the past, and that they had to be on the lookout for any and all abuses of their rights. So, the union won another moral victory that night, and the producer will think twice before attempting another session in this country.

Let's face it—we all go to work to make money. Ideally, we can make our little bundle without exploiting others. There are, of course, those who will attempt all sorts of abuses if not carefully watched. However, anyone bright enough to make it in this industry should be able to distinguish unlawful exploitation from the mutual give-and-take of creative cooperation. Union justice cannot afford to be blind. Or at least not until people come here to record, rather than flee the country every time a big budget job comes up.

Of course, the musicians' unions are not the only ones standing in the way of progress. Consider the myopic vision of one of the prominent recording engineers' unions. Some time ago, during a visit to their office, I asked why they didn't get some IBM electric typewriters.

What an uproar! I really expected the ghost of Samuel Gompers to come haunt me. It seems that the IBM employees did not belong to a labor union, and so it would be unthinkable to touch anything they made. Again, the union leaders were in-

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capable of discrimination.

There is certainly a point to boycotting grapes that were picked at starvation wages by migrant workers begging for support in their cause. There is *no* point to boycotting typewriters that were assembled by workers who are conspicuously well off without a union. (Other than sour grapes, of course.)

Now that that little editorial is over, the same union insists on two union employees on every recording session even if it is a single voice, doing a mono narration. And on the other side of the coin, if one of these union men should persuade an important client to do a lot of expensive recording in the studio, management will pay him not a penny more than if he spends his time copying tapes.

On yet another front, I recently heard one of New York's best recording engineers describe his adventures in attempting a remote session in one of Fun City's prestigious(?) convention centers. The squabbling between rival unions over who had "jurisdiction" over what, all but destroyed the session. Months later, when a similar event came up, the recording was done without a hitch —but a long, long way from New York City.

Usually when these little situations turn up, everyone pretends to be somewhere else at the time, and figures that if the condition is ignored long enough, it will go away. And to discuss these things in public has been almost akin to blasphemy.

It must also be said that it is pointless to think about penalties against those who would work abroad. Trying to save money is not a crime. Our standard of living makes it inevitable for certain things to be less expensive abroad. (Of course, the Administration is doing everything it can to take care of that, but we must give it time.) In the meantime, we might all try a little harder in those areas not directly related to the dollar sign. Like service, cooperation, creativity, and so on. Once people *want* to record in New York, or California (or wherever) half the battle is won. Going to Europe, or for that matter across the country, to do a recording session is *not* a pleasure trip. The producer is miles away from his office, living out of a suitcase, trying to adjust his solar clock and digestive tract, while coping with an involved session on unfamiliar turf. Certainly he would be glad to pay a reasonable amount more for the luxury of saving those long plane rides for vacation time.

So, if I may be permitted to offer

a little free advice; whoever you are, if you find someone who is trying to do a job in your home town, don't drive him away. The industry you save may be your own.

The NARAS meeting hasn't yet produced any dramatic results. But at least people are beginning to face the fact that all may not be well with the recording industry. There must be more meetings of this nature, and once everyone gets over bitching about how *they*—meaning everyone else—are ruining the business, maybe we can get down to some constructive work. A "well done" to NARAS for at least getting us out in the open to talk.

On another "cheery" note—the past Audio Engineering Society convention in New York City saw an impressive amount of very inexpensive recording equipment being shown, in addition to the regular top of the line (and top of the budget) stuff.

The Tascam exhibit alone produced more ulcers that a Gelusil executive dares dream of.

With recording costs being what they are, it is inevitable that even more artists will attempt to save money by doing their recording work outside the pro studio. Although there is certainly a limit to how far one can go without the facility of a fully equipped studio, there is little doubt that at least some work can be satisfactorily produced without a multi-thousand dollar installation.

Many amateur recordists may decide to try their hand at full-time operation. Although even more studios are not exactly what industry insiders are praying for at the moment, we may as well face up to the fact that it's going to happen. As usual, it won't be as bad as the pessimists would have you believe.

With a full line of budget equipment available, studio operators are going to find even more reason to put pressure on manufacturers to keep costs within reason. The pro studio man is going to think long and hard about buying some new kilo-buck whatchamacalit, and the recently formed National Council of Recording Engineers (see the SYNC-TRACK —October 1972) may find itself with a lot of very interested members.

To wrap all this rambling together —new budget equipment may help jolt the industry into giving some serious thought to just how far to go with planned obsolescence, and fancy price tags. The precarious condition of the recording scene, in New York at least, is finally getting some long overdue attention. Pehaps we shall see some changes made. And in the long run, we may all benefit, readers and advertisers alike. ■

Norman H. Crowhurst

THEORY AND PRACTICE

T & P in Educational Audio/Visuals

● The column that appeared in the July issue, about giving help to hidebound educators in optimizing the use of media, produced good responses from a number of readers. And since I wrote that piece, I have gathered some more experience in the subject.

Everyone agrees that something should be done to improve education. The problem that confronts us all seems to be "how?" Having an engineer's background, my approach is to analyze the problem(s), then devise solutions to them. Pardon me, if that sounds deceptively easy, because I know from experience that it is not as easy as it sounds!

Difficulties arise from a variety of superficial reasons. Dig a little deeper, and you will find they arise *because* educators look to "funding" to achieve whatever changes they hope for. In one sense, nowhere is the saying more true, "He who pays the piper calls the tune." In another sense, it is not quite as true as it ought to be!

In the final analysis, the American taxpayer pays the piper, but he certainly does not call the tune! The funding agency, in this case most often the United States Office of Education, is the immediate piper payer. But, in a superficial endeavor to "protect taxpayer interests, the Office of Education puts in all kinds of rules that, in theory, insure that the taxpayers' money buys useful work, rather than lining somebody's pockets.

It is in the *application* of these rules that theory *really* departs from practice. Let me recount a recent example. We developed this math analysis course, using tape/slide presentation, with pulsed coupling from the audio tape to automatically advance the slide projector. This was an experimental model of the course, to be pilot tested, as required by Office of Education rules, in a number of schools, before deciding that the course is ready for production.

Speaking personally, I would welcome all this testing, because it would give opportunity for feedback, based on how students respond, to improve the ultimate course material. The fact that testing costs more than developing the material is presumably okay, since government funds are footing the bill. But to give the taxpayers value for money, shouldn't we use the testing to make sure that the ultimate course is the best possible we can make it?

The reason for using slide/tape as the experimental medium was that it is versatile to modify. When the course goes into production, it would be easy to transcribe into any other medium that uses a similar combination of audio and visual presentation. That could be decided later. Right now, we wanted to develop the best possible audio/visual presentation for inducing learning.

But then came the kicker. With the apparent intent of protecting taxpayers' money, another regulation of the Office of Education restricts transfer of funds between budget line items. The planners of this program (who planned it before I was retained) did not foresee that they might want to purchase a few slide projectors and tape recorders to issue to schools participating in the test, for less than $200 a set.

They had not overlooked possible need, just *this* possible need! The budget contained plenty to cover evaluation, but it was specified for evaluation, not for equipment with which to evaluate! So Office of Education regulations require that the money not be transferred in that way. The materials (software) must be converted to something that schools can try out using equipment *they already have.*

So the whole thing must be rushed, with no time in which to do it, into a different form—tape/filmstrip, with beeps on the tape that cue the student when to advance the filmstrip himself. In such a rush, with a now impossible deadline to meet, slides were rushed to filmstrip copiers, tapes were dubbed, sometimes by inserting spaces into which beeps were put, sometimes by just dubbing the beeps over the audio.

This week I visited a school where this hurriedly (working the clock round for a couple of weeks) remade material is being tested. It is almost impossible for the student to view the presentation as the design intended. For example, he misses beeps, because they are 'buried' in the audio, or else sentences don't make sense, because of unduly long pauses that had to be inserted in illogical places, and so forth.

Even so, students are grappling with it and love the idea. Degraded this much, it still helps them learn math as previous materials did not. Just think what it could have done!

In the evaluation, where students are asked for their reactions, between 90 and 95 per cent of their responses relate to things like, "It would be better if the filmstrip stayed in sync with the audio script," or "we had trouble following this point, and had to play it several times before we got the right pictures to fit with the words that related to them."

Bear in mind that all this happened, at a cost, for producing these badly-done rushes, far higher than that of the few projector and tape sets that would have been needed, as a result of regulations ostensibly intended to save the taxpayers' money.

That is a heavy criticism. If I were to suggest that the personnel should have foreseen this specific contingency and included an item for the needed equipment in the budget, I would be unrealistic. When the project was planned, the exact form in which the experimental program would be issued for pilot test was not known. They had put plenty in the budget for pilot testing.

But when testing time came, they were not allowed to use the material as it should have been used, because of Office of Education regulations, ostensibly intended to save money, but which actually caused the expenditure of more money, and resulted in a much inferior test, because the kind of feedback we really need is likely to be obscured in comments about many problems encountered by students that need not have been.

Perhaps we should Dolby-ize the U.S. Office of Education! But this is not unique. Regulations of government agencies, intended to protect expenditure of public funds, invariably have the reverse effect. I could quote scores of examples, but here's a typical one.

On the project at Teaching Research where I worked for 15 months, government funded, our secretarial staff used about a dozen IBM Selectric typewriters, which the agency hired at $30 a month each from IBM. Toward the end of my work, I borrowed one of these to type my reports directly, because I found that quicker and more accurate than writing the stuff out longhand to have a typist transcribe it. My handwriting is not the most legible!

When I left the agency, I wanted to take over the rental of this IBM typewriter to continue work on my own. I called IBM, who made the transfer and sent a man round for me to sign up my contract. Now I learned that I could rent this Selectric 1 for $30 a month, on a month-by-month basis or, if I committed myself to a minimum of 6 months, for $25 a month.

Then I remembered hearing about the Selectric 2, which is a far more versatile typewriter, so I asked about the relative cost. The man told me I could *buy* this better typewriter, on a 2-year contract, for only $24 a month. You know what I did! That is possible for me, without asking anybody, because it's *my* money.

But government agencies have their rules. They are not allowed to make that much more economic choice. During that one project, they must have paid out thousands of dollars in rentals that could have been saved, and paved the way for future saving, by avoiding the need for such rentals on future projects. However it seems that such saving would be a prohibited "waste" of taxpayers' money.

To an individual, or a private company, that kind of saving is only common sense, but not to a government agency.

As I see it, the only way to get out of this kind of bind which, as well as crippling efforts to produce effective work, is wasting many times as much of the taxpayers' money, is for private companies or individuals to undertake such work on a contract basis, instead of looking for funding. That is not easy to do, because the Office of Education people want to fund things, so they retain *control*—if you can dignify such misuse by that word—of the operation, at this high cost to the taxpayer.

How can we make that change? The schools belong to the people. Having the middle man—the U.S. Office of Education, between the people as taxpayers and the people as recipients of education via the schools—is what squanders the money. The solution is another example of "eliminating the middle man!"

For some months now I have been working on this angle, with considerable success. That could make a whole report in itself. My main reason for doing it is to improve efficiency in achieving results, by avoiding their being sidetracked by such stupidities. But as this kind of thing happens more, it will also move toward getting big government whittled down a bit.

In my case at least, this demonstrates the truth of a scientific principle: "Every action is accompanied by an equal and opposite reaction!" In mechanics and physical things, that is immediate. In human affairs, as suggested by the Declaration of Independence, it takes a little time. ■

MARSHALL KING

The Business of Hearing, part 2

In this second and concluding chapter, the author brings the concepts of the first part into the reality of the audio control room. What we are doing to our hearing is bleak, but not beyond redemption.

ONE OF THE QUESTIONS heard most often in an audio booth is: "Why do you monitor your work so loud when the final result in the home is monitored at living-room level?" It's a good question, for it is true that music sounds different at different volumes. In a moment we'll look at the damage done to our ears by being exposed to loudness, but first, why *do* we keep raising the control room speakers up to strident levels? The reasons are several.

In television, the mixer is obliged to monitor many sources of sound. I mentioned in an earlier article (**db**, July, 1969) that he cannot enjoy the luxury of listening only to the program monitor speaker. There are, as well, speakers and intercoms from the director, the stage manager, from video tape, the second audio man (A-2), the boom operator and other sources. The result is that, instead of turning *down* the level of these speakers in order to hear the one of the most momentary importance, he gradually turns *up* one after another, as their messages demand his attention. Over a period of several hours this can be a vectorial disaster.

Again, whenever the mixer wants to concentrate on a particular, he usually turns up the monitor to analyze it. It's much like the t.v. camera lens that zooms in to show an expression. What we often forget to do is to zoom out again after our investigation is through; that is, turn the speaker back down. The trouble is, after doing this a dozen times or so, the mixer is probably suffering from some amount of hearing fatigue whether he knows it or not, and the speaker volume stays at the upper level. Like any of the other senses, hearing does take a beating with prolonged exposure and becomes less responsive to stimuli. It's much like our accusing the bartender of watering down our drinks after the first one tasted so good. It takes more and more to get the same effect. Too often we monitor our work at dangerously high levels, and this leads to an occupational hazard that warrants our serious attention: hearing loss, either temporary or permanent.

Before looking closely at this dilemma, let me say that it isn't too difficult these days to find expert opinion on any subject, audio included, but I learned long ago that an expert is an ordinary man a long way from home, just as a specialist is one who knows more and more about less and less. Anything can be proved with the right set of statistics,[1] so rather than depend entirely on official reports, or solely on our own observations picked up along the way, it might be worthwhile to measure the findings of researchers against what we find in daily practice, and perhaps come up with a significant idea as to where we are headed in the business of hearing. Some items:

[1] For example, it's a fact that when I say "Fetch" my dog will bring in the newspaper. It's also a fact that when I say "Fetch" after cutting off his legs he will not bring in the newspaper. It is thus proved that cutting off a dog's legs will make him deaf.

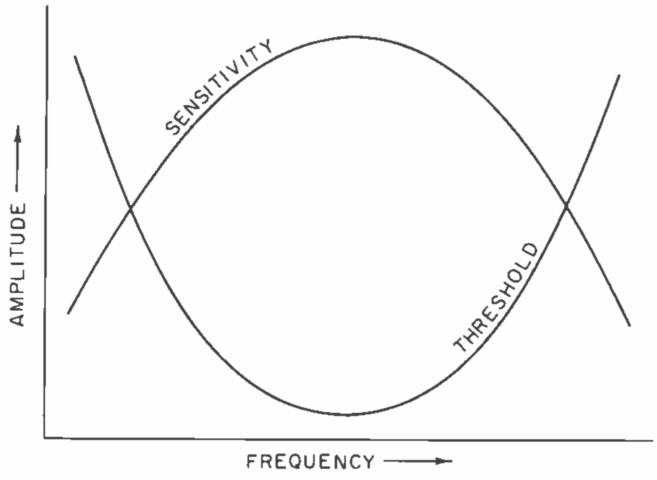

Figure 1. The general relationship between hearing sensitivity and hearing threshold. The threshold curve represents the relative loudness which a sound must have at any frequency in order to be perceived. The shape of this curve is a mirror (and a result) of the shape of the sensitivity curve, which shows how normal hearing falls off at very low and very high frequencies.

• On June 9, 1971, our news broadcasts quoted the International Standards Organization (ISO) as saying that "urban noise is increasing at the rate of 1 decibel per year." From this we can see that, since general traffic noise is considered to be 85 dB, and since damage to hearing is thought to begin at around 120 dB, the general outdoor background noise will, in thirty five years, be the same as if we were standing directly in front of the stage at a rock concert.

• In the same radio report the ISO suggests that, in view of the louder and more traumatic sirens being used by the New York Police Department, efforts should be made to soften the *nature* of the sound. We can only wonder if this is a remedy at all, for it must be obvious that even the sound of a marshmallow being squeezed will be traumatic if it is amplified to a level of 120 dB.

• Quoted in *The National Observer*, Stanford Medical Center audiologist Donald A. Belt says, "The onset of permanent hearing loss from noise exposure is usually insidious and deceptive. There is no pain, no bleeding. A person may have a feeling of temporary hearing loss, some singing in his ears, and then the symptoms seem to disappear. But the hearing does not completely recover." It is of interest to us here that Belt was speaking mainly of outside noises. The damage which comes from indoor, or more concentrated sounds which audio personnel must work with, is certain to be greater.

We should note here that when a degree of loudness is referred to by hearing specialists, their reference point of 0 dB is usually taken to be the lowest sound which healthy ears can hear. This is in contrast to the 1 mW reference for 0 dB used in audio transmission work. The difference is unimportant; in both cases a 10 dB increase in sound level means a tenfold increase in power. In the discussion of loudness or hearing damage, it is also relevant to note the distance of the ear from the source of sound. An amplifier which puts out an audio level of 30 dB will not make a loudspeaker deliver much volume to a listener five feet away. But if that 30 dB is fed into a headset worn squarely over the listener's ears, the perceived volume can be as painful and damaging as the 140 dB roar of a jet plane one hundred feet down the runway.

Time magazine (Aug. 8, 1968) lists the following chart as a general guide for the way audiologists rate sound levels:

0 dB	The smallest sound man can hear.
60 dB	Ordinary conversation.
70 dB	Fortissimo singer, three feet away.
85 dB	City traffic, as heard from inside a moving car.
95 dB	Subway train, as heard from inside.
100 dB	Noisy kitchen.
107 dB	A power lawn mower.
120 dB	Amplified rock music, six feet from the amplifier speakers.
130 dB	A pneumatic riveter.
140 dB	Jet aircraft, 100 feet away.

On the above scale it is likely that most of us run our control room speakers from 95 to 105 dB. Now we have something to talk about. *Time* goes on to say: "From industrial and military experience, the experts set certain standards for safety. Any prolonged exposure to a noise level above 85 dB will eventually result in a loss of hearing acuity for sounds in the frequency range most important for understanding human speech. This range is roughly from 256 cycles per second, the pitch of middle C, to about 2,000 c.p.s., or the C three octaves higher. Acuity is impaired even earlier for the higher pitches, such as violin overtones."

With regard to tests on teen-age ears which had been exposed to rock amplifiers wherein the sound intensity was 108 dB in the middle of the dance floor and 120 dB directly in front of the band, *Time* continued: "The greatest damage was in the high-frequency speech range, involving consonantal sounds, similar to the loss felt by oldsters who complain that 'everybody mumbles nowadays.' "

As to *why* the trend has gone toward volumes exceeding 100 dB is a curious phenomenon in itself. Sound levels in general are up throughout the world. Restaurant managers seem not to care that their bus boys literally toss dishes into their portable carts a few feet from the patrons' ears. Gardening equipment is almost sadistic in the torture it bestows on anyone within a thousand yards, particularly those hungry pulverizers that feed on tree branches tossed into their gullet by indifferent yard workers. The horror of sound emanating from a jet airport is too prosaic to warrant comment here, as is the explosive nerve-jangling racket from any of the motorcycles on the market today. Otherwise fine restaurants have succumbed to the belief that even exquisite dining must be accompanied by the excrutiating sounds of an unknown guitar player who owns a lot of equipment. It's as though laws have been passed to preclude any possibility of normal conversation.

The absurd levels of sound put forth by rock and other musical groups is known by now to most everyone. Wally Heider, who had just returned from recording a well-known group in Detroit, told me that he was obliged to put an Altec A-7 speaker, driven to its capacity, directly over the drummer's head, so he could hear himself play. The only thing fed to that speaker were the drums. I was incredulous, and when I asked if such a move didn't cause tremendous feedback, Heider merely grinned and said, "We'll never know."

It has been suggested that one reason they play so loud is so the customers can't possibly think of anything else and will give them their undivided attention. While this thinking may represent new highs in insecurty, it does nothing but alienate many people who still feel that if music has value they'll listen voluntarily. And it may be true that, just as a loud p.a. doesn't make a comedian's jokes funny, loud guitar amps do not good music make!

Another reason put forth for today's barrier-cracking volumes is that, since the Establishment has left today's youth with a feeling of emptiness, loud musical messages are the only answer. There's no denying that Nature abhors a vacuum, but for that matter so do a lot of people, but they're careful what they fill it with, and how much.

Still, as audio technicians we can't avoid the exposure. A couple of years ago my company televised the Chambers Brothers as they appeared in concert at the Whiskey-A-Go-Go on Sunset Strip. Mixing outside in the truck, I could run the monitor at my own comfortable level, but inside, the cameramen had to wear jet airport headsets over their regular small earphones so they could hear the director calling his shots. Even so, they did not hear a word from the director, and very little else from the rest of the world for about two days.

A SPECIAL BRAND OF PLUGS

The chief engineer of a prominent recording studio here in Hollywood asked me to not quote him by name when he told me: "Whenever I have to set mics or check sound levels throughout the house on a remote set-up, I wear my own special brand of earplugs. They're filters from cigarettes!" He went on to say that wearing earplugs is not uncommon. "A lot of performers do it, and they're smart. 120 decibels is not an unusual level of sound directly in front of a rock band." Do those musicians lose their hearing in time? "Personally, I have no doubt that many of them have lost some of their hearing," he said, "but it doesn't affect their playing. They *know* what the music should sound like, and they *know* what to do with their voices and their instruments to make it sound that way.

Even more amazing were his opinions about the continuing ability of mixers who have suffered some hearing damage. "I can tell you for a fact that there are top-notch mixers working in this town whose ears have taken such a pounding that they can't hear much over eight thousand and very little under a hundred. Yet, they do consistently good work. Why? I guess it's just like those musicians. They know what it should sound like, and because of having done it so much, they know what to do to make it sound that way. It's some kind of osmosis, I guess, but believe me, they *know* when it's right and when it's not."

This was interesting. It must be very much like the blind person who moves about as a person who can see. All his other faculties seem to be called upon to fill in where his eyes have failed. Perhaps this could account for some mixers with damaged hearing being able to perform well. While this may not be a dramatic display of high-speed evolution, it certainly is a remarkable example of how ersatz faculties can be developed on-the-spot and made to render up a psycho-socio-acoustic interpolation of the real thing.

WHAT'S HAPPENING

Apparently, the days when moderate sound prevailed in the control room died with radio. Now, the excruciating volumes of p.a. systems and rock amplifiers are invading the booth, where a new breed of cat who seems to come with the performers is prodding us to bring up our levels. What this is doing to our ears I discussed with Dr. Roy Griffiths, Associate Professor of Psychology at the California State University at Northridge.

"We now find that hearing is more than what meets the ear," he said. "That's what the kids who go to rock concerts are trying to tell us. You feel it in the pit of your

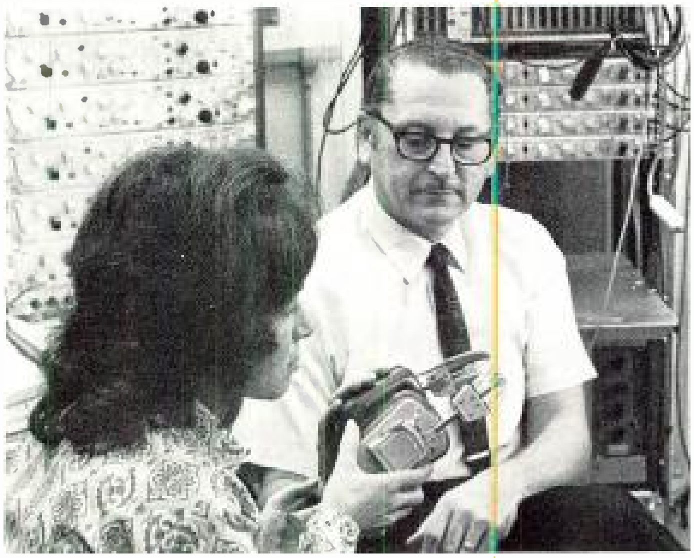

Figure 2. Sophisticated audiometric equipment is being used by Dr. Roy Griffiths, Associate Professor of Psychology at CSU in Northridge, California.

stomach. This is part of the new musical experience. I have a hi fi system at home with 18-inch speakers so that when the organ is playing its almighty most I feel, acoustically, the music through the soles of my feet. And that's a great experience. But when you turn the volume down to a "home" listening level, maybe only 90 dB, which is really quite loud . . . you wouldn't hear the full organ in a month of Sundays . . ."

Dr. Griffiths described the unit of measure used by audiologists and others to gauge the ear's ability to do its work. This is the Temporary Threshold Shift (TTS), a measure of the ear's capacity to shift its sensitivity to sound in order to accommodate a wide range in volume, just as the resistor-multipliers in a voltmeter can shift its sensitivity to accommodate a wide range of voltages.

For example, a healthy ear in a rested condition can hear sounds of a very low magnitude—say, 5 dB—but after being exposed to a rock concert it may be that the lowest volume it can hear is, say, 40 dB. In other words, it has suffered a shift in threshold of 35 dB. With an adequate amount of rest, the hearing threshold of a normal ear will return to its previous sensitivity, so that we may picture the ear's threshold of hearing as a constantly falling thing, constantly falling toward its normal minimum, until another loud sound brings it up again. Theoretically, in the absence of sound, it stays at this minimum (5 dB in the above example). It is the ear's ability to *return* to this minimum, after exposure to loud sounds, that is one measure of its health.

This protective device in the ear is analogous to the iris of the eye. Walking from bright sunshine into a darkened room renders us nearly blind for a short time, until our iris opens up to a new low level of sensitivity. It is only then that we begin to see objects in the room. It is the same with hearing. During exposure to loud sounds, the "iris" of our ear closes down a bit to protect the hearing nerves leading to the brain, so that when we move back into an area of low level sound we are apt to be nearly deaf for a short time, until our ear's "iris" (the threshold of hearing) shifts to a lower level of sensitivity. As stated, if it does not make this shift, we may have suffered a serious, if not permanent, hearing loss. And this creeping deafness, which for a decade or more has been the private concern of jet airport mechanics, rock devotees, tree-topping technicians, and Yamaha riders, finally has a firm foothold in most every audio booth in the world.

Incidentally, measuring our own TTS is something most mixers do whether they're aware of it or not. At the beginning of each working day we usually have to turn *down* our monitor pot setting from where it was left at the end of the preceding day. As already mentioned, we often find it hard to believe that we could have been listening at such a loud volume the night before. Yet, before the new day is over, we will probably have inched it up, a decibel at a time, to the high mark again. This is a measure of our threshhold shift between the beginning and end of a workday. No hardcore statistics have come to us showing what degree of shift represents real damage, but some researchers have gone on record to say that noise exposure may be serious and the damage permanent if the shift is 40 dB or more, *or* if the ears are re-exposed while still fatigued (**db**, June 1970, p. 28). For a rough idea of where you stand, you can calibrate your monitor pot and run your own tests.

Before going on to the subject of hearing loss, Dr. Griffiths had another word about the trend toward excessive volumes. "Your hearing threshold at both the very low and very high end of the spectrum is very high (see FIGURE 1). They're beginning to find if they can jack the volume of playback up high enough, we can hear in the so-called ultra-sonic range. But most transducers which we have, such as those used in your professional studios, don't produce past twenty thousand cycles because existing data shows that that's the limit of our frequency range. But there's a lot of meaningful information that we don't repeat, process, or amplify for usage, but which exists in reality. We now find that trucks that rumble along the freeways put out a prodigious amount of energy at five cycles or less, and we haven't a bit of data to indicate how deleterious this is. Yet, certain recent occurrences have caused us to start paying more attention to these so-called "extreme" frequencies. Take the heavy earthquake we experienced on February 9 of last year. One of the things we all noticed was the strange behavior of our animals. Cats don't normally leave home, but the low rumble of the earthquake caused them to run away, go beserk, or go into detrimental hiding. Certainly those low frequencies of the earthquake affect our nervous systems if not our hearing. I suspect that the animals didn't get the alarm through their ears but through the pads of their feet."

PERMANENT DAMAGE?

While it may be true that gargantuan playback levels may allow us to hear funky sounds we may have heretofore missed, another glance at FIGURE 1 shows us what we can expect to happen if we jack up those volumes to accommodate our insensitivity to the extremes of the spectrum. Obviously everything goes up together, so while the extremes are brought up to where we can hear them, the center section of the spectrum is goosed up beyond the threshold of pain. And of course, that's where the trouble starts. It is those day-to-day useful frequencies that are the first to be wiped out in the creation of our creeping hearing loss. It makes us wonder if the ultimate fate of hard rock fans is to fall in love with five hertz and twenty thousand hertz at the expense of being unable to extract a useful message from anything in between. We'll know this has finally happened when sign language replaces drivers' ed in our public schools.

Of more importance to us is the question: is the pounding our ears take in the control room causing permanent damage or merely a day-to-day shift in threshold? Dr. Griffiths says, "As far as I know, the restoration is complete, if we're talking about fatigue from volume. However, if we mean prolonged exposure to dangerous sound levels without reasonable periods for rest, that's another matter. Only professional hearing tests will tell you where you are.

"The kind of sound, or noise, which can most easily render unrecoverable damage to the hearing is the type represented by downtown traffic, which has three deleterious elements going for it. It is broad band, it is of high level, and it's of long duration. It is the combination of these three that causes the surest damage.

"It is possible to lose only part of our hearing, even temporarily. I can put a short, husky blast of 1,000 cycles into your ear which will render you deaf to a much lower level of 1,000 cycles, for a period of time that it takes your threshold of hearing to fall back to normal. During this time, however, your ability to hear frequencies other than 1,000 cycles has not been impaired. It's like disengaging only one key on the piano. Again, your ability to hear a low-level 1,000 cycle tone will come back in time, unless permanent damage at that frequency has been inflicted due to excessive volume."

TRAINING HELPS

Now for the good news. If we in the audio field have escaped serious damage from sounds that are broad band, high level and of long duration, Dr. Griffiths feels we may have better hearing than most. "I would say that with persons in your field, because of so many years of critical listening, your hearing may be superior simply because *we* merely have been hearing while *you* have been listening. While I have no data to support this, my own observations have convinced me that people in our environment who seem to hear everything are the ones who have trained themselves to listen. You go to the Philharmonic, and if you don't know the work you don't hear the music. You know the old saying "If you don't use it you lose it"? There's something to that. A withering from dis-use. Don't forget, just because someone chooses to sit in silence in order to protect his hearing doesn't mean he's going to have that sharp ear ten years later. You can't save it for old age. The more you use it the better, but by *more* I don't mean *loud*. The secret is application. I would say that the work you are in, listening critically to music, provides the optimum input pattern for hearing longevity."

All right, we work in the field of audio and are exposed to prodigious volumes of sound, so what do we do? From the foregoing we can see that common sense will probably keep us out of trouble, although sometimes we proceed as though we've forgotten it. We've heard of the concert pianist who would never expose his hands to the hazards of handball and the opera singer who is ever on guard against a sore throat, but can you think of an audio technician who has taken consistent action over the past five years to protect his ears? Here are some of the things we tend to forget:

• Headphones are dangerous! Most of us have learned, perhaps the hard way, not to wear phones directly over our ears while plugging into a jackfield or other source. Just when we are looking for a nice line-level tone of +4 dB, we jack into a +38 amplifier output and nearly rip out the lining of our cranium. Such damage may be permanent. Just as it's the suddeness of a karate chop that breaks a plank, the sudden blast of even a moderate sound from flush-worn headphones may tear an eardrum from its delicate moorings.

• Ears need rest! Get away from loud sounds as often as possible. Let your ears "catch their breath" from time to time. One sure way to tell that you need a moment's rest is when you find you can't seem to bring your monitor pot back down to the mark where it was at the beginning of the day. Take five!

• Our ears need to be flushed out and our hearing needs to be checked on a regular basis. Beltone Electronics, longtime makers of reputable hearing aid devices, reminds us that one kind of hearing loss is nothing more than wax in our ears! Incidentally, their advice on *hearing health*, while directed toward the layman, may be of special interest to professional audio people. While they emphasize that no two hearing problems are identical, they list six preventative steps which go a long way toward protecting our hearing, and a seventh which may be a bit more difficult to observe. Here they are.

1. Keep all foreign objects away from your ears.
2. Have your ears tested immediately after any serious ear infection.
3. Follow a regular pattern of hearing tests, just as you have regular physical check-ups and eye examinations.
4. Keep ears free of wax.
5. See a doctor if you . . . suspect damage to an ear, from a blow or a jolt, from a sudden sharp noise, or even a head injury where there is no obvious damage in the neighborhood of the ear.
6. Protect your ears from water damage. Extensive swimming, in either salt or fresh water, may cause bony growths which narrow the ear canal.
7. *(Here it comes, folks)* Avoid persistent loud noises.

In closing, here's a word about test equipment. Most of us deal with an array of gear that we couldn't even cram into a husky station wagon, everything from oscilloscopes and notch filters to assorted detectors and spectrum analyzers. If we have to transport these from one place to another we take care to box them carefully and surround them with pads or quilts so they don't get joggled in transit. True, insurance policies may replace them in case of damage, and they have the marvelous feature of being real tax deductions as necessary tools of the trade; still, we don't like the idea of having to replace them, even though it's possible to do so. That's why we give them supergentle care: these delicate tools are our life's blood.

Yet, as audio technicians, we are somehow not so careful about the most valuable tool we own, one which is absolutely irreplaceable: our hearing. We take our ears with us wherever we go, almost never protect them from shock, expose them to such extremes as scuba diving, Kawasaki windblast, not-so-gentle passionate whispers, and amplified music which can blow out a Tiki torch at 50 feet. Even more disheartening is that we get no credit for their extreme importance to our livelihood: we can't get them insured as a valuable tool separate from the rest of our body, and the Internal Revenue Service will not allow us to claim depreciation on an implement which, in thirty years of professional work, can bring in a gross income of a million dollars. In short, our ears need our own loving care, for they have enough trouble coping with such terrible sounds as "Not tonight, Charlie" without getting blasted into calcification. ■

DAVID ROBINSON

A Stereo Phase Indicator

This easily built component can be of inestimable aid in multi-channel work - and in the checking of the final mix.

SOME YEARS AGO I built a visual stereo phase indicator which enabled stereo microphones to be correctly phased before a recording session. It also allowed the phase and width to be monitored throughout the recording. This unit was based on a cathode ray oscilloscope display similar to the Lissajous figure experiment—the left channel was applied to one set of deflection plates, and the right channel to the other. Thus in-phase signals deviated along one axis, and out-of-phase components along the other (FIGURE 1).

Cathode ray tubes are bulky devices, requiring high voltages as well as having a heavy heater current consumption. I had often considered designing a simpler circuit but as usual nothing was done until the oscilloscope failed at an important session. This of course was not disastrous since ears can always be used with usually identical results; but sometimes it is possible to become confused in reverberant situations. There are also a few occasions when it is not possible to monitor the signal for one reason or another. After this particular session I decided to build a simple phase detector circuit which would register the phase between two signals on a meter, thus giving an unambiguous indication.

A little thought showed that a circuit which showed instantaneous phase differences between signals would be misleading. With all but truly coincident microphones, signals arise with phase differences corresponding to frequency and separation of the microphones. It is the average phase difference which is important, so that some method of integration is required; quite apart from the need to read the meter! A quick experiment showed that the integration time of the moving coil meter was not sufficient by itself, so that some electronics would be

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David Robinson is well-known to British audio pros. This article is adapted from one which orginally appeared in the British publication Studio Sound.

necessary to provide the necessary information storage and averaging.

Conventional phase metering techniques were examined, but soon rejected. Procedures normally used are to take the two incoming sine wave signals and square by either overdriving and clipping, or by using a Schmitt trigger circuit, or by detecting zero-axis crossovers. Two trains of square waves are then produced, differing in on-off tone positions according to the relative phase of the two incoming signals. The two trains are used to turn a further two-state stage on and off, producing a square wave whose on-off time varies according to the phase. This difference can then be read out on a meter which responds to the average d.c. component of the pulse as shown in FIGURE 2.

This represents a complicated piece of electronic equipment, and is generally only suitable for sine waves or regular shaped input signals. A much simpler scheme, following some of the basic reasoning of the complex arrangement outlined above, was tried and found to be entirely satisfactory. FIGURE 3 is a block diagram of the meter.

Incoming signals pass to addition and subtraction stages; if we call our input signals A and B then the outputs from these stages are (A+B) and (A−B), respectively. Diodes D1 and D2 rectify the signal and a center zero meter is connected between them. Consider what happens if the two signals are of equal amplitude but out of phase, e.g. B=−A. The output from the sum channel is A+(−A)=0; from the difference channel A−(−A)=2A. A current flows from point Y to point X, and the meter deflects accordingly.

If the signals are in phase, A=B. The sum output is 2A, the difference 0. The direction of the output current flow is reversed, from X to Y, and consequently the meter deflects in the opposite direction.

If input B is missing, the outputs from both sum and difference stage is A, so no deflection occurs. (The circuit as drawn is not fully satisfactory, since, according to the drawing, with input A=0 the meter will deflect; however, it serves to explain the design concept.)

The easiest method of realising the sum and difference amplifier is to use integrated circuits. Operational amplifiers can be obtained with high open loop gains that with the addition of feedback produce arithmetic accuracies far beyond the requirements of this application. Integrated circuits used in this way are a boon to a constructor, allowing complicated circuits to be wired up with the minimum of effort. High loop gain also allows for the possibility of considerable closed loop gain without degradation of the circuit operation.

To buffer the i.c. from input and output loading, another i.c. is used. I.c. is somewhat of a misleading term here, for although fabricated on a single chip, the elements inside are four discrete transistors. In practice, such a device is only useful in highly automated mass production situations, where assembly time is significant. For building experimental circuits the time spent in figuring out the interconnections makes this i.c. somewhat useless, but I must admit the total package looks better.

FIGURE 4 shows the finalized circuit. Incoming A signals are passed to Tr-3 acting as an emitter follower; the input impedance is about 20 k Ω. Tr-3 output drives both i.c. amplifiers (actually both are in a single package) via R3 and R13, feeding the negative or inverting input in both cases. Channel B, on the other hand, feeds the inverting input of one i.c. amplifier, IC2a, and the non-inverting input of the second, IC2b. The output of IC2a is therefore —(A+B) (negative as the amplifier inverts), and from IC2b is —A+B, or −(A—B).

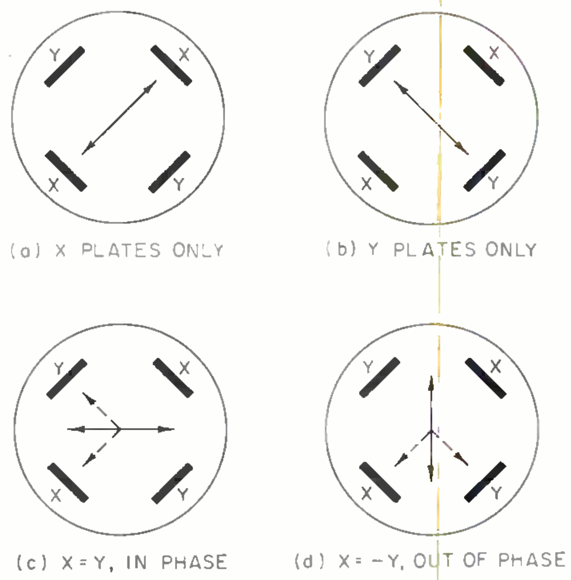
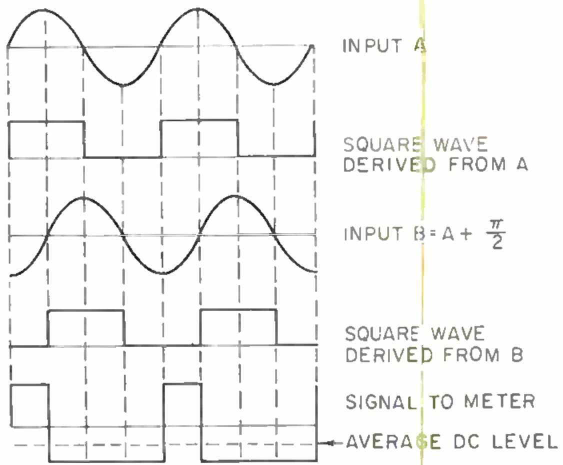


Figure 1. Oscilloscope presentations of phase.

Detailed arithmetic gives the gain into the subtraction terminal of the i.c. as $G = -\frac{R15}{R13}$ while into the summing terminal as $G = 1 + \frac{R15}{R13}$ (not $\frac{R15}{R13}$). Thus for small closed loop gains the extra factor 1 must be taken into account, the input to this terminal must be reduced, and this is the function of the attenuator R14/24. The gain using this added circuitry is $\left(\frac{R24}{R14 + R24}\right)\left(1 + \frac{R15}{R13}\right)$ and this must also equal $\frac{R15}{R13}$. Further arithmetic gives

$$R24 = \frac{R14 \times R15}{R13} = R15 \text{ (as } R14 = R13).$$

Figure 2. Phase measuring techniques.



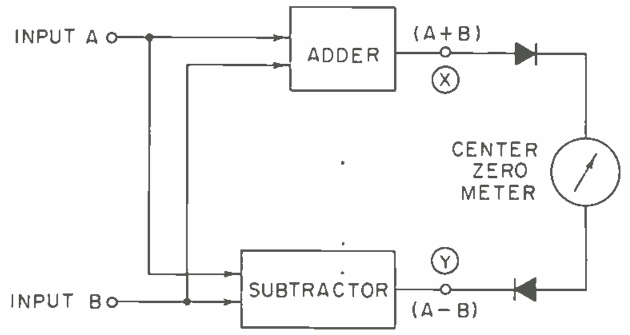


Figure 3. A simplified diagram of the phase indicator.

Thus if R15 is altered to change the over-all gain to suit different input signal levels, R24 must also be changed accordingly. (Because of the difficulties in circuit layout on the printed circuit board, it was easier to return R24 to 0V via C13; in a wired layout, R24 can be returned directly to the mid-voltage supply V_2, omitting C13). The gains of both IC2a and IC2b are controlled by the two feedback resistors R5 and R15 respectively, and can be adjusted to increase or decrease the sensitivity; increasing R5 increases the gain; R15 must always equal R5 for correct operation. With a large open loop gain (80 dB) and a closed loop gain of 6 dB, the amplifiers are almost ideal; there is no interaction between channels, and common mode rejection (measure of the effectiveness of giving no output from IC2b for A=B) is excellent.

Most integrated circuits suffer from too much gain at high frequencies. Since the connections are short, and the transistor sizes so small, the natural cut-off frequency may be many hundreds of megahertz. With components so close and because of the method of construction, there will be inevitably stray capacitance between parts of the circuit. This often turns negative feedback paths into positive feedback routes, and results in the amplifier oscillating at high frequency. It is therefore necessary to shape the amplitude/frequency response to prevent there being greater than unity gain at the point where the feedback changes sign. Two networks are used to perform this bandwidth restriction; C10 and R21 shape the response of the input stages, and C9 tailors the output side of the i.c.

The two combined signals are taken to two emitter followers Tr2 and Tr5, part of IC1, which isolate the detection circuitry from the adder and subtractor amplifiers. The rectifiers charge capacitor C5 either positively or negatively. Although C5 is a polarized device, it can stand the small reverse voltage if a tantalum device is used. The capacitor feeds a 50-0-50 μA center zero meter. The prototype used a Japanese meter; the original scale was sprayed white, and a new center line with — and + signs added with dry marker on appropriate sides.

The detection circuit works as follows. For all signals, the output of Tr2 is —(A+B), and from Tr5 is —(A−B). If A=B, then Tr2 output is −2A, and Tr5 is zero. C5 is charged on the positive half-cycles of this wave, and the meter deflects to the right.

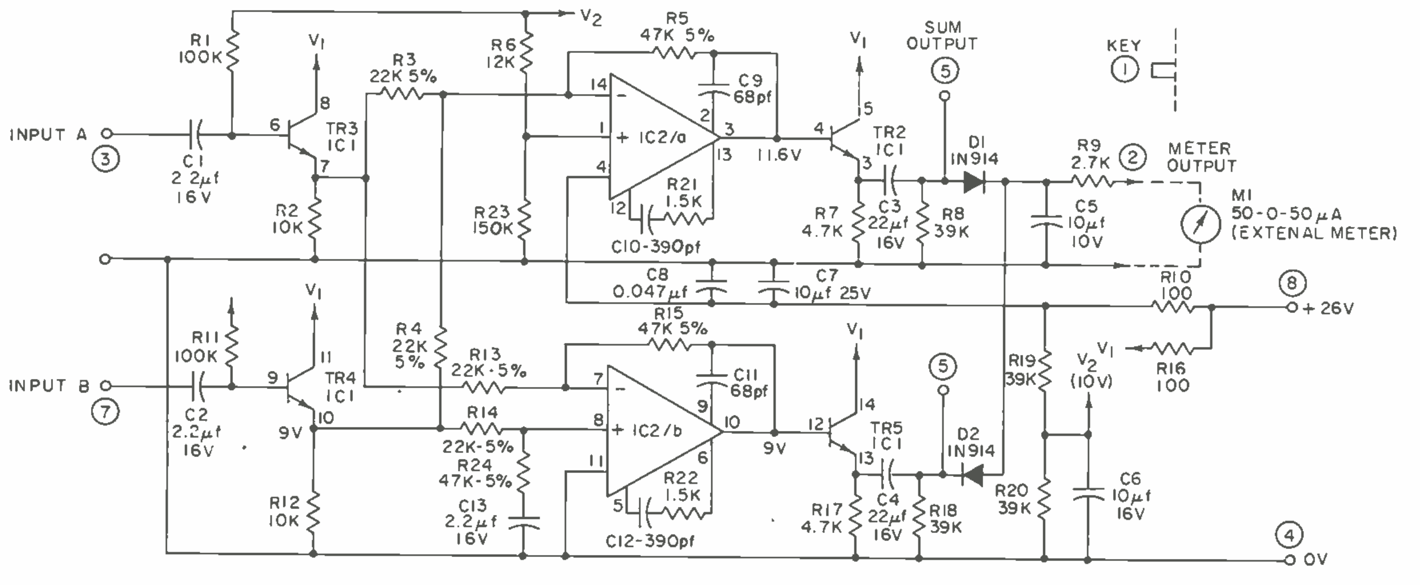
If A = −B, then Tr2 output is zero and Tr5 output is —2A. D2 is connected so as to pass negative half-cycles and therefore C5 is charged negatively; the meter deflects to the left.

If only signal A is present, Tr2 output is −A, and Tr5 output is also —A. On one half-cycle D1 attempts to conduct, on the other D2 in opposition; the net average charge on C5 is zero and no deflection occurs.

If only signal B is present, then Tr2 output is −B, and Tr5 is +B. Again, remembering the − and + signs here represent phase of the signal only (IC2 inverts A signals, but not B), the net charge in C5 is zero, being determined by the polarity of the two diode connections.

The circuit is easy to set up. Applying the same sine wave 1 kHz signal of 0 dB to both A and B inputs should cause positive full-scale deflection, or slightly over, with the values given. (If a negative indication occurs, reverse the meter connections.) This input signal should correspond to a signal of somewhere about 4 dB below peak recording level, that is, about 0 UV. If the unit is being used with other signal levels, a wide range can be accommodated by changing R5 and R15, up to a maximum of 470 k Ω for 120 mV sensitivity or down to 10 k Ω for a 6V input. The unit is then set up, and can be fully checked if a suitable transformer or phase reversing circuit is available. If out-of-phase signals are fed into the circuit, the meter should deflect to the other full-scale position.

Figure 4. The complete phase indicator circuit.



Component Suppliers

1. Texas Instruments for Integrated Circuit type SN72709N available from Charles Levine, Buyer, Radio Shack, 2617 West 7th Street, Fort Worth, Texas 76107. This presumably means all Radio Shack outlets can supply; a call to your local shop would answer this one.

2. Union Carbide for dipped tantalum capacitors. Type numbers are the same, but they are in the midst of changing to a new computorized scheme. It would be best to quote both.

K3R3E15	T 360 A335 M 015AS
K22E15	T 360 B226 M 015AS
K10E20	T 360 B106 M 020AS
K6R8E35	T 360 B685 M 035AS

or T 362 etc. for all.

from Schweber Electronics, 11590 Jericho Turnpike, Westbury, New York, or Semiconductor Specialists, 195 Spangler Avenue, Elmhurst, Illinois.

3. RCA for Integrated Circuit CA3086. RCA's response was to get the UK branch to send me the UK list, which wasn't very helpful. However, if you contact Mr. J. F. Wilhelm, Manager Commercial Engineering, Central and Terminal Avenue, Clark, New Jersey 07066, he should be able to give you all the details. Prices for components can be had from the addresses listed above.

A signal applied to any single input should cause no deflection, although one or two mm is permissible—further deflection indicates that the resistances R3, 4, 13, 5 and 15 are not as precise as they might be. If the deflection is considerable, R15 *or* R5 may be slightly varied to correct the meter deflection. A significant variation (more than 10 per cent) implies some circuit error.

Construction is not critical, except that power supply decoupling must take place near IC2 with both electrolytic and non-electrolytic capacitors (C7, C8); the minimum impedance of electrolytic capacitors is about 4 Ω which is often insufficiently low to prevent h.f. oscillation. The circuit operates on any voltage from 28V to 12V with no component or performance change. Current consumption is 10 mA at 24V, which means batteries can easily be used if necessary.

After the initial testing, much innocent amusement was derived from playing tapes and records into the unit, before settling down to use it in recording sessions. Multi-mike techniques showed up clearly as either no or little deflection, as did early stereo records with only left and right signals. Even older mono records showed a steady deflection to the right, as expected of course. I even rediscovered one out-of-phase record which I had been keeping as an example of how the early stereo record producers had not yet organized foolproof procedures. Phasing didn't matter in mono days, and there are very many transformers between master tape and master disc cutter, each with the possibility of phase reversal.

Those constructors who wish to mount the unit in their mixers will, I am sure, not find any difficulty in squeezing in the meter. An alternative display would be a miniature edgewise version; accuracy is not required, just the ability to register a positive or negative deflection. In the months since it was built the prototype has already proved itself very useful, and has helped to clarify many a doubtful phasing problem. ■

ROBERT SCALES

The Sound System of Stratford

The Festival Theatre of Stratford, Ontario, Canada installed a new playback sound system with versatile control characteristics, not the least of which is quad panning.

THE 1972 season opened at the Festival Theatre with several new technical improvements. One is the introduction of a new sound playback system for using recorded music and effects in the course of a production as well as enhancing the live music and effects from the traditional orchestra loft.

The Festival sound system is designed primarily as a playback system; therefore, the functions of the system are much simpler than if the console were to be used as a record, mix down, and remix system.

The primary function of the new playback system is to provide the means for one operator easily and accurately to place any sound—without extraneous noise or mechanical difficulty—into the theatre so that it appears to be coming from a certain direction, from no direction, or from all directions at any level desired.

The new system is composed of three units—tape recorders, the sound console, and power amplifier and speakers.

TAPE RECORDERS

The theatre has two Scully 280, ¼-inch, two-channel portable tape recorders. A special control device, *Auto-*

Robert Scales is the technical director of the Stratford Shakespeare Festival Foundation of Canada, located in Stratford, Ontario.

Cue-2, has been engineered, built, and installed on these two machines by Sound of Minneapolis, Minnesota. By using a photo cell arrangement forward of the heads in the head canopy and a related logic amplifier card, the Scully machines automatically cue up on the tape after white leader. The special control device is unique in that no matter how much leader one puts between cues, the machine will play through to the next cue and stop just before the tape of the next cue hits the playback head. A photo cell auto-cue device was chosen for this function because the Festival generally uses white leader in preparing tapes. White paper leader makes a good surface for writing identification of each cue cut. In addition when the tape machine stops and starts on the paper leader, there is no static or electrical noise caused by the head's contact with the leader.

When the Auto-Cue-2 is engaged, the operator threads the machine with the beginning of the show tape which is prefaced with white leader. After the machine is threaded, all the operator must do is push *play;* the machine will then run until the photo cell senses tape (black), and it will stop the machine. At 7½ in/sec this places the start of the cue about two inches from the playback head. Auto-Cue-2 functions only on *play*. When *play* is pushed, the machine will run until it senses leader (white) and will automatically turn off once it senses tape (black). The machine is automatically disengaged when *fast forward*, *reverse*, and *stop* buttons are in operation.

The operator merely starts the machine for each cue to run a show. He has remote switches on the console enabling him to start two or more machines with one hand and still fade up volume controls if necessary. Once the machine has started, it will continue to play until it stops at the point where it is already cued up for the next cue.

We would like to include another feature to our tape machines that would enable the operator to call up any cue on the tape and automatically and accurately go to any spot on the tape by giving a simple command on the console. As soon as funds are available, plans are to add a four-channel Scully 280 with Auto-Cue-2.

THE SOUND CONSOLE

The usual design of radio, t.v., and recording studio consoles is to take numerous input channels and to mix and remix them down to one-, two-, or four-output channels. The Festival Theatre console is designed to do the opposite of this function. The Festival console is designed to take one to twelve inputs and to place the sounds about the theatre in a very specific manner. On the right side of the console the most important information at the console is displayed in advance of a cue—that is, what is happening or going to happen at each speaker in the house. There are twenty-four speakers; each one has a visual indicator monitoring level with individual volume control and a vsual display in lighted switches of any or all of the inputs which have been selected to each speaker. All of the monitor functions about each speaker that the operator needs to know are easily read out in a staright line on the right side of the console.

The operator has all active functions for operating a cue on the left side of the console, whereas all preset functions are on the right side of the console. The active functions include the remote controls for the tape recorders, attenuator controls for the inputs, and by the quad pot.

With the quad pot it is possible to take any or all inputs and channel the signal through the quad pot to any or all of four channels selected by the quad pot. The quad pot shares channels 9, 10. 11, 12 with inputs 9, 10, 11, 12, The quad pot is mastered by a separate attenuator.

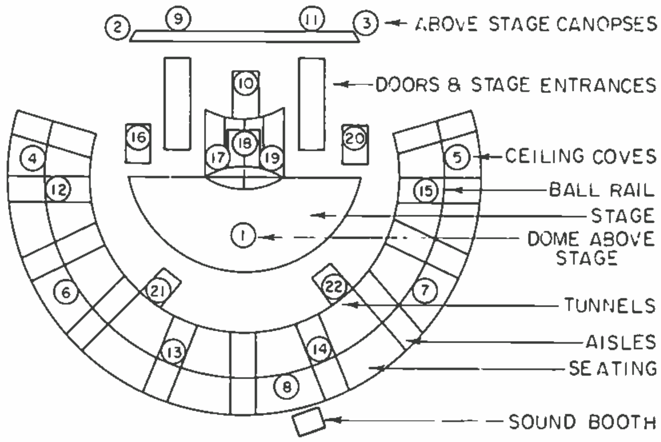
One of the unique features of the Festival console is that it enables presetting of cue switching in advance. For instance, we are presently using two and sometimes three machines, four channels of sound. Each of these channels can be programmed into more than one input. We label our machines *A*, *B*, and *C* and *A1*, *A2*, etc. for channels on each machine. Normally we use two machines, each with mono signals on each channel of the machine. For cue *one*, tape A1 on input 1 is used; for cue *two*, if there are speaker switching changes, tape A2 on input 2 is used; for cue *three*, if speaker switching changes are needed, tape A1 on input 5 is used, etc. The quad pot enables a four-preset speaker selection to any single input or single mix of inputs.

Generally two tape machines are used for a total of four channels. It is possible to put these four inputs into the console three times which enables an operator to set up switching for several cues in advance. All the operator needs to do is start the tape machines and control the input volume levels to the various preselected switching.

The console is simple to operate. It is not cluttered with input to mastering switching, mastering devices, special effects equipment (although there are four channels of equalization), etc.

The Festival Theatre sound console was electronically designed, engineered, and built by Ward-Beck Systems, Ltd. of Scarborough, Ontario, Canada. The console and amplifiers were installed in the theatre by the Festival Theatre technical staff.

When the sound system is used as a public address system, portable microphone mixers are used in the theatre, backstage, or in the sound booth and programmed to any input channel of the console desired.



Color	Console Channel	Speaker Location
Orange	1	Dome
"	2	Above orchestra S.R.
"	3	Above orchestra S.L.
"	4	Back of house cove between bal. aisles 1 & 2
"	5	Back of house cove between bal. aisles 10 & 11
"	6	Back of house cove above bal. aisle 4
"	7	Back of house cove above bal. aisle 9
"	8	Back of house cove between bal. aisles 6 & 7
Yellow	9	Above louver door S.R.
"	10	Backstage of balcony entrance center stage
"	11	Above louver door S.L.
"	12	Balcony rail above aisle 2
"	13	Balcony rail above aisle 5
"	14	Balcony rail above aisle 7
"	15	Balcony rail above aisle 10
White	16	Backstage of S.R. door
"	17	Portable S.R. (3 outlets: S.R. corridor, center entrance wall S.R., bal. entrance wall S.R.)
"	18	Backstage under balcony
"	19	Portable S.L. (3 outlets: S.L. corridor, center entrance wall S.L., Bal. entrance wall S.L.)
"	20	Backstage of S.L. door
"	21	Tunnel S.R.
"	22	Tunnel S.L.
Green	23	Underworld (commonly used as monitor channel in control booth)
"	24	Under stage balcony (commonly used as monitor channel in control booth)

Figure 1. The table and graphic display of speaker locations at the Stratford Festival Theatre.

POWER AMPLIFIER AND SPEAKERS

There is one channel of a Crown D 150 stereo amplifier driving each of the twenty-four speakers. There is only one speaker on each channel. Plans are to add some speakers but no more amplifiers. The additional speakers will be paralleled with existing speakers and will make the coverage of the existing speaker locations more complete. All speakers in the theatre are 15-inch Tannoy Monitor Dual Concentric Gold in *Belvedere* enclosures.

The chart of Figure 1 shows the speaker locations in the theatre. ■

db Visits—Scully-Metrotech

SCULLY IS ALIVE AND WELL in northern California. We recently drove down the pike from San Francisco, passing along the way another famous tape machine manufacturer, and came to the new facilities built to house both the Scully and Metrotech divisions of the parent Dictaphone Corporation.

The modern plant has 41,000 square feet of space in Mountain View, California. The building is nestled in a large industrial park, but access is good, and location is ideal. The plant has been in operation since May 1 of this year. During our initial visit for that event, mostly Metrotech equipment was running, but another camera poking came up later with the illustrations of Scully construction that is now in progress. (For those that don't yet know, there is no facility left in Bridgeport, Connecticut.)

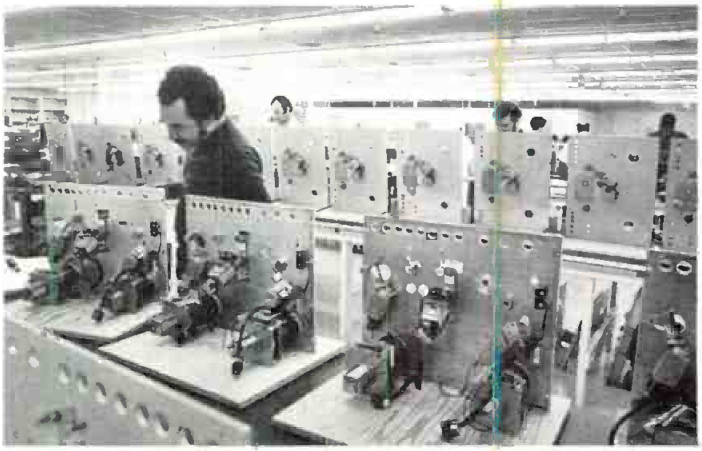
The new plant in a rare moment when autos are not driving by.

The engineering department at Scully-Metrotech. Kay Toyota, chief engineer (left center) is discussing product design with engineering consultant Jay McNight (center right).

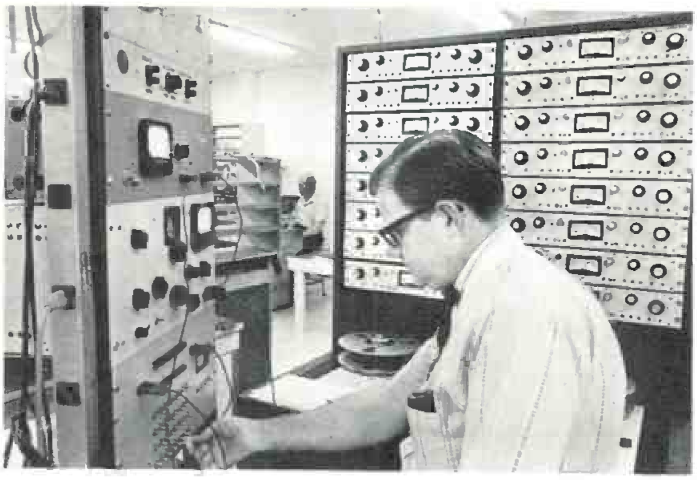
A view down the line as Scully 280 transports gradually become assembled.

A partly finished Scully 280 takes shape under the hands of Willie Pittman (right) and Ray Reynolds.

A technician checks partly finished 280 transports as they progress along the line.

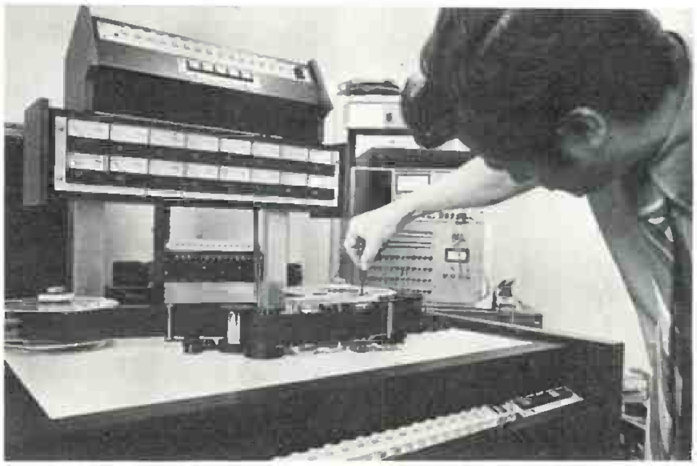


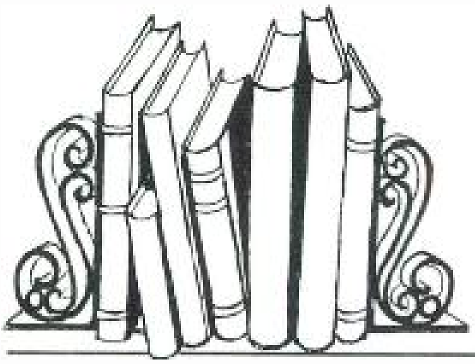
In other parts of the plant Scully 270 models are being assembled. This is a test station.



When the line work is finished, a Scully 280 goes to an individual calibration station.

Final test and adjustment of the new Scully 100 16-track recorder.





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32. Circuit Design for Audio, AM/FM, and TV. *Texas Instruments.* Texas Instruments Electronics Series. Discusses the latest advances in design and application which represent the results of several years research and development by TI communications applications engineers. Emphasizes time- and cost-saving procedures. 1967. 352 pp. **$14.50**

35. An Alphabetical Guide to Motion Picture, Television, and Videotape Productions. *Levitan.* This all-inclusive, authoritative, and profusely illustrated encyclopedia is a practical source of information about techniques of all kinds used for making and processing film and TV presentations. Gives full technical information on materials and equipment, processes and techniques, lighting, color balance, special effects, animation procedures, lenses and filters, high-speed photography, etc: 1970. 480 pp. **$24.50**

40. Radio Transmitters. *Gray and Graham.* Provides, in a logical, easy-to-understand manner, a working knowledge of radio transmitters for quick solution of problems in operation and maintenance. 1961. 462 pp. **$16.00**

23. Wide Screen Cinema & Stereophonic Sound. *M.Z. Wystozky.* First published in USSR in 1965 this excellent English translation covers wide gauge films, panoramic films, circular panoramic cinematography; technical fundamentals of stero sound recording for film, as well as details of the Soviet systems now in use. 284 pages. **$15.00**

33. Noise Reduction. *Beranek.* Designed for the engineer with no special training in acoustics, this practical text on noise control treats the nature of sound and its measurement, fundamentals of noise control, criteria, and case histories. Covers advanced topics in the field. 1960. 752 pp. **$19.50**

27. Noise & Vibration Control. *Edit. by Leo L. Beranek.* Practical design and regulatory information; formulas, choice of materials and structures, city codes and hearing protection; indispensable for design engineers, public officials who prepare regulations for noise control, safety and environmental engineers involved in noise and vibration controls. Covers data analysis, transmission of sound, psychophysiological design criteria, hearing damage risk, etc: Wealth of detail, comprehensive index and concise appendices. 650 pages. **$29.50**

28. Environmental Acoustics. *Leslie L. Doelle.* Applied acoustics for those in environmental noise control who lack specialized acoustical training. Basic information in comprehensible and practical form for solving straightforward problems. Explains fundamental concepts; pure theory minimized. Practical applications stressed, acoustical properties of materials and construction listed, actual installations with photos and drawings. Appendixes illustrate details of 53 wall types and 32 floor plans and other useful data. 246 pgs. **$18.50**

21. Acoustics—Room Design and Noise Control. *Michael Rettinger. 1968.* The enormous problems and hazards presented by noise are dealt within an orderly and practical manner. With many charts, graphs, and practical examples, the text covers the physics of sound, room acoustics, and design, noise and noise reduction. 392 pages. **$17.50**

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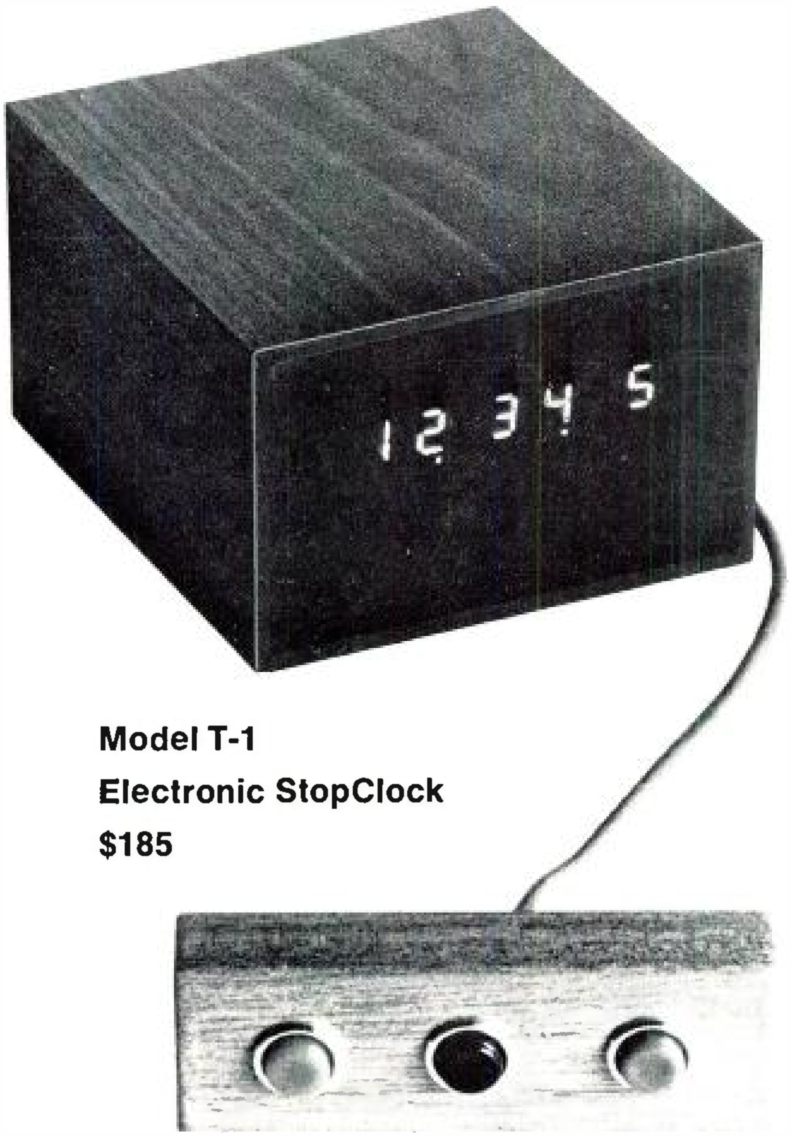
StopClock

A New, Accurate, Digital Timing Instrument for Recording Studios, Broadcasters, and Other Demanding Applications



Model T-1
Electronic StopClock
$185

Timekeeper is proud to introduce a new inexpensive *Electronic* StopClock—a compact instrument featuring an easily-read visual display.

Only 5⅛″ wide x 3¼″ high x 5½″ deep, it uses modern digital circuitry to provide accuracy of a very high order with exceptional long term stability. The large ⅜″ high, seven-segment numerals can easily be read from a distance of more than 15 feet. Maximum count is one hour (59:59:9).

Three remote-mounted push buttons are used for manual control: START, STOP, and RESET. These buttons may be placed in a console, operating desk or any convenient location. The clock may be remotely located in the equipment, or on a desk or table. (A mounting flange is provided.)

Operation is similar to any conventional stopwatch. The green button starts the clock; the red button stops it. The black button resets it to zero. These may be depressed in any order, or all at once, without damage to the clock. If it is desired to start the clock by releasing a button rather than depressing one, the green and black button are pressed simultaneously. When the black button is released, the clock will start automatically.

The accessory plug on the rear panel may be used for all remote operations. All BCD information is available at this plug for accessory units such as digital printers, slave units, etc.

The Model T-1 is supplied for 120 volt 60 Hz operation, in an attractive simulated walnut grained enclosure with a red lucite face. However, 120-volt 50 Hz operation is available at no extra charge if so specified at the time you place your order.

The Model T-1 is priced at $185.00. As with all Timekeeper products, it is fully guaranteed to meet with your complete satisfaction, or your money will be promptly refunded. It is guaranteed for one year against any defects in manufacturing.

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TIMEKEEPER

P.O. Box 835, Great Neck, N.Y. 11021

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