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THE SOUND ENGINEERING MAGAZINE

SEPTEMBER 1975 $1.00

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THE SOUND ENGINEERING MAGAZINE

SEPTEMBER 1975, VOLUME 9, NUMBER 9

coming next month

• The source of the polished and impeccable programs Americans associate with British imports is examined in detail in THE STATE OF BRITISH BROADCASTING, by distinguished engineer Angus McKenzie.

• A BETTER WAY TO COPE WITH STEREO PHASING is offered by Harold E. Ennes, describing a simpler and more accurate indication of phase differences than the X-Y scope plot.

• If you've come across an expensive Catch-22 situation after obtaining a new transport with a d.c.-controlled servo system and discovering that your existing auxiliary equipment is not compatible, Brian C. Lowe has an ingenious solution, telling HOW TO CONVERT A 92C RESOLVER.

• Our regular columnists will be on hand with their special views of the audio panorama.

about the cover

• An unusual view of Record Plant's plush studio in Sausalito, Calif., showing its "subdued freak" decor that was designed with the richer labels in mind.

db is listed in Current Contents: Engineering and Technology

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db letters

THE EDITOR:

Your article on San Francisco audio was a surprise, and I was anticipating something interesting when I turned to it. Too bad for me. I found it pretty trivial, and I think the author missed the point anyway. Those garage studios are probably the most important element in the San Francisco scene for anyone except people with a vested interest in expensive equipment and high overhead recording. I, for one, would have liked to have found out a good deal more about these studios—where they are, why the people are operating garage studios, what kinds of equipment and expertise they offer, etc. As a producer of records in the Bay Area, this information is valuable to me. That froth in the article about ". . . . recording-in-the-round with a twist" is a drag.

I note that Leo's recording school is certainly not the only one in the Bay Area. Raccoon Studios in Tomales, Family Light in conjunction with the Church in San Rafael, and Blue Bear Studios all have offered recording courses in the past year, and, so far as I know, still do.

ED DENSON
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THE EDITORS:

I have noted several errors in my article, "A Simple High-Quality High-Speed Tape Duplicator," which would be misleading to one making the modifications. First, the heavy vertical line of Figure 2 should not be discontinuous. This diagram shows how to apply the silver paint to the head, should it be necessary. The paint must form a continuous path for the grounding of the static charges that build up on the heads as a result of tape passage. Another item which may give trouble is Figure 5, where V7 and V6 are shown as 12AT7s. The tube indicated as V6 is not V6. If the real V6 were to stand up, it would be the tube directly above the one shown as V6, the one tube in the picture which has no designation. The one incorrectly called V6 is actually a 12AX7 which serves the purpose of meter amplifier and rectifier. If someone changes that one to a 12AT7, he will certainly do the recording circuitry no good and will be upsetting the metering circuit.

BOB S. WHITE
Sumas, Washington 98295

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PRODUCT ROUNDUP

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MULTI-TURN TRIMMER

A two-page color data sheet on model 64 ⅜-inch multi-turn square cermet trimmer, with six product photos shows configurations, line drawings, specifications, resistance values, and ordering information. Mfr: Spectrol Electronics Corp.

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Audio Cookbook is the name of a 20-page book describing standard audio tests using the 5L4N spectrum analyzer. Mfr: Tektronix

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CALENDAR

SEPTEMBER

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

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

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

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

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

OCTOBER

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

12-14 Atlanta

15-17 Boston

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

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

NOVEMBER

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

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

9-11 New Orleans

12-14 Chicago

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DA-6RS/E	Rack mount. 1 in/6 out stereo or 2 in/12 out mono.	$229
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db theory&practice

NORMAN H. CROWHURST

• Since I wrote the last column, another BYU workshop has come and gone, and a mighty interesting experience it was. I know now what Dean Austin means when he says that every year's group of participants is different. And I guess that the difference shows up more because of the way we handle the workshop, which is to stay loose. to provide what the students need. rather than having a cut-and-dried presentation that we try to pour into them come hell or high water.

Which reminds me, there is some unfinished business that I want to talk about, relative to the relationship between learning and tests, or vice versa: what they are. as opposed to what they should be. The way it is, most people spend time preparing for tests with little thought about whether in doing so they are also learning something: just so long as they get that all-important diploma!

I've said before what I believe the relationship should be. Testing should be part of the learning process—students should concentrate on learning the subject, of which taking the test would merely be a proof of success. But beyond that generalization. which may start you thinking. I'll go no further at the moment. because when I got back from BYU I found several letters waiting for me relating to what I said in the June issue, to which some experiences at BYU also have relevance.

DISTORTION—AN ILLUSION OF LOUDNESS

First, let me say, that while I prefer other forms of music, I am not averse to rock. But I am very definitely averse to the variety in which the whole effect is lost if distortion is absent. And this is not confined to modern rock. When I was a lot younger. I used to hear whatever was in vogue at the time blaring forth from the latest type of portable radio. It might have been good music, if the kid with the radio would have turned the volume down.

The set probably was capable of 500 milliwatts. tops. half a watt. But operated at the level to which its user turned it. the distortion level was about 50 percent and it sounded loud. That was, in fact. the only reason it sounded loud. because actually it wasn't loud.

An experience on the other side of the coin is also quite typical, and there have been (and probably still are) several examples at BYU. A high quality sound reinforcement system (but not high fidelity, about which I still need to say more) has been demonstrated to a musical group (rock or otherwise) so they can see whether they need their own reinforcement.

Often, if the equipment is good and natural sounding, which is what it should be, they get the impression that there is no reinforcement system used, so they ask, "Is it on?" Only when it is switched off, and everything goes quiet, so the building seems to "soak them up," do they realize what a good system is, or should be.

Yet the natural sound they were hearing is probably many dB louder, as measured on a sound pressure level meter, than the little portable radio (now it would be what the kids call a *transistor*) we were talking about just now.

I will not argue, as one reader suggested that distortion is often, as in the case of rock music, in the ears of the listener. I know that some people find something they don't like loud simply because they don't like it. But I was not referring to that. And perhaps I was wrong to suggest that appreciation of purity, in sound or anything else, is something that comes with maturity. Maybe there is no essential connection between the two.

The same reader wrote, "If the material presented to the listener is as the artist desired, then no undesirable distortion is present." Maybe he has a point. After all, some rock groups employ fuzz boxes to introduce deliberate distortion, as we mere mortal electronic engineers would view the matter. But if that is the effect they desire to create, it is no longer distortion, in the sense of not being what they want.

However, that does not influence what I was saying, as I see it. Because it introduces such a splutter of spurious frequencies, by which I mean frequencies not natural to the guitar strings, or whatever musical original source is used, it does sound louder than it would if all the frequencies produced were what are usually regarded as harmonious.

Musically, any kind of generator that produces a single note, such as a guitar string, produces harmonically related frequencies. I am there using *harmonically* in its mathematical sense, not its musical one, in case someone wants to argue. However, if the musician, or perhaps the group playing together, produce multiple tones, whether such a combination also sounds harmonious is a musical question based on prior conditioning.

OVERLOADING PRODUCES SPURIOUS TONES

No argument there. I agree. What once would have been considered discordant may now be considered harmony. That was not what I was talking about in June, either. When you deliberately overload an amplifier, or make a device that is intended to overload, playing two discordant notes (or more) will usually result in spurious tones not generated by the instrument you are trying to record. or reinforce.

Have you ever played on a guitar amp that had some distortion not supposed to be there and found that, when you played two notes at a close musical interval, it sounded as if something was buzzing? First maybe you suspected a flaw in the guitar itself. Having checked that out, perhaps by turning the amplifier off, and finding that then the buzzing stopped. you next suspected the loudspeaker grill cloth of buzzing.

So you looked for the buzz. maybe changed the loudspeaker, or listened on headphones. Whatever you did, if the real source was distortion in the amplifiers. you still heard it. The only way to stop it was to remove the distortion or play some other combination of notes that didn't excite that particular distortion.

Maybe, apart from the unwanted buzz, the sound is not that loud. But the presence of the buzz inevitably makes the sound seem louder because it grates on your nerves—unless you happen to be some screwed-up rock musician who thinks that buzz is music!

Now, I'm not knocking rock for its own sake when I say that. Or even off-beat ideas of what constitutes harmony.

But many is the time, particularly when I've been operating a reinforcement system for young people, that I've been told the sound isn't loud enough. Maybe. from force of good habit, I was operating just below the distortion point. So I turn it up, maybe 2 dB, so the amplifier is clipping good and well, and they say, "That's better."

Now I happen to know that if I

had been 2 dB below clipping and I merely turned it up that 2 dB, these same people would have been unable to tell that I had turned it up at all. For anyone, a 2 dB change in loudness is barely perceptible. For someone whose measure of loudness is really, whether they know it or not. measured in percentage distortion, 2 dB change in level just isn't perceptible at all!

ENVIRONMENT AND HIGHS

Now, the other thing that raised questions was whether the difference between home high-fidelity quality. and public address wide range quality, is merely what we expect in a certain environment. It is not so much a matter of expecting. If you think about it. you will realize that our hearing faculty works more on an economic basis; it tends to reject redundant information.

In a small-room environment, the highs contribute useful information about where the sound comes from, so a high-fidelity quality loudspeaker (or two or four of them) adds to our appreciation of the original sound. makes it more natural. But in a larger auditorium, less highs are necessary for two reasons. If they were there, the wavelength and multiple reflection effects would rob them of any usefulness as information.

Secondly, the air, as a transmission medium, attenuates the higher frequency end of the spectrum, above about 1000 Hz, at 3 dB/octave. So in a natural large auditorium—that is one without artificial reinforcement—the high frequencies that you expect to hear, as my reader put it, in a smaller room, just aren't there.

This is something that should be taken into account in room equalization. If you install wide-range speakers, say in a cluster, the response will roll off due to the size of the room. even if the absorption characteristics of the walls and other room boundaries are perfect. So to equalize the room to have a level response will make it sound as if you have put in a 3 dB/octave high-frequency boost—make it sound harsh.

A room should be equalized to sound natural. Keep in mind that high-fidelity loudspeakers do not have the acoustic output capability that reinforcement types do. For high-fidelity use, there are two main approaches. The first is to get wide. uniform response at any cost, possibly at quite low efficiency (as in the case of the bookshelf type). The second method achieves high efficiency (which involves large size for the low-frequency end) based on the argument that a high-efficiency unit is inherently more flat in its response.

THE POWER FACTOR

Without getting into that argument. either alternative is acceptable for high-fidelity use in small rooms because the needed power is cheaper to get than the speakers it has to drive. For larger-scale distribution in auditoriums, we have different picture: now efficiency becomes important. To fill that large space with low-efficiency speakers would require kilowatts of audio power, where one tenth as much would be adequate with higher-efficiency speakers, perhaps less than that.

Such large amounts of power not only cost more for the necessary amplifiers: even with solid-state amplifiers. that's an awful lot of heat to get rid of, and it has to be installed somewhere.

In your home environment, bi-amplifiers make sense, for various reasons that have been discussed time and again. Do they also make sense in a sound reinforcement environment, with all the extra wiring, as well as extra power requirement? Since nobody is going to hear 20 kHz, and possibly not even 10 kHz, in that environment, why provide it just to have it absorbed in air losses?

So it is not only what we expect to hear, it is also what we actually can hear, in different environments, as well as the whole economic question of providing something that is unnecessarily costly. For reinforcement use. the emphasis is on power, *acoustic* power. not just *electrical* power. For home high-fidelity use, the emphasis is on full-range quality, not power as such.

This brings up one more point about which many people seem inadequately informed. They talk about how many watts (meaning electrical or audio watts) it will take to fill a given room, without ever thinking about loudspeaker efficiency. What fills a room with sound of some specified level is not electrical. but acoustical watts.

With a speaker system, using units of 0.5 percent efficiency (not uncommon for home high fidelity use) 1000 watts of audio power will produce only 5 watts acoustic. Put the efficiency up to 10 or 15 percent, and a 50-watt amplifier will produce as much sound. That is quite a difference! Have you ever heard a loudspeaker with efficiency approaching 50 percent? Let's talk more about that another time. ■

db sound with images

MARTIN DICKSTEIN

• An occurrence recently at a large company in New York prompted a senior vice president to distribute an 8½ x 11-inch white sheet on which he had the art department print, in very large black letters, the words "Never, never assume!" When you stop a moment to think about it, very rarely does much time go by when an assumption is not made. Sometimes it works out, but the many times that it does not could lead to a lot of trouble and possibly a disaster or two. This holds true in audio-visual work, too.

Take the case of the people who went to make a presentation at a client's office. They had rehearsed diligently, gotten all the material together to take with them, including the software, such as slides, sync tape cassette, film, and boards, and then decided on what equipment to take along. They checked and found that the client had a film projector and a screen which would be available in the conference room the evening before the meeting to be set up by the presenters for rehearsal if they wished.

Late in the afternoon, they gathered with all the material, and took a sync cassette machine and slide projector because these worked well in rehearsal and there was no sense worrying about the slide projector at the client's when it was easy to take one. Fortunately, one of the men had a spare hand and off they went. It was close to their office so if anything was missing, they could race back for it.

When they got where they were going, sure enough, a film projector was available on a small rolling table, and there was also a tripod screen. No problem. Everything was as promised and all it would take was to set up.

After a couple of mishaps, the 6 ft.-wide screen was figured out and set up, the table was rolled into place, the projector was faced in the right direction, and the people got to work getting the software ready for setting up one more time.

It didn't take long before one or two things were found to be missing. First came the easel, at least one of which every conference room normally has. Well, that could be easily taken care of by asking for one from the client contact with whom the arrangements were made for the meeting. Then, where was the lectern which one of the men would need as he was working from notes during the talk? The lectern had to have a light on it for use during the time the room was dimmed for slides. Also, they had to ask for a pointer to use during one of the chart talks. Speaking of dimming the lights, someone had to be assigned to do that before the slides began, and turn them on again during the board presentation, and then down again for film. One of the people could run the projector, since the film came during someone else's portion, but it would take a second person to work the lights, located near the door, quite a bit too far for the one working the projector.

WHERE WAS THE TAKEUP REEL?

So far so good—at least there was nothing major missing. The film was loaded on the projector—where was the take-up reel? Didn't anyone bring a take-up reel? Well, the client should have one of those, since he has a projector. Of course, if one was available, it might be locked up in a cabinet somewhere and the man with the key would not be in until tomorrow when the meeting was already in progress, or if one could be found, it probably would be too small for the amount of film.

Setting up the slide projector would be easy. Since the rolling table was too small for both projectors, and the shelf under the top was too close to the top to permit changing the drum, and the slide-sync cassette unit had to be set up, another table was necessary. The table that was found was too low, there was no a.c. extension cord to accommodate the three pieces of equipment, the 5 in. lens in the slide projector made the picture too large for the screen, and they had forgotten to take any extension cords for the remote control on the slide machine. Besides, how could one hook up the remote control at the same time the cable was hooked up from the slide-sync machine?

The same person running the film would have to change plugs at the back of the slide unit. Then it was necessary to readjust the projector in case it moved during the plug change. Oh, by the way, where was the tape recorder to play the reel-to-reel tape one of the people was using during the presentation? And wouldn't it have been better if the sound for the film could come from the screen area instead of from the back of the room? And the same for the tape and cas-

sound with images (cont.)

sette recorders, right?

Not any of this is made up! In fact, much of this takes place from time to time at different locations, in various circumstances—sometimes happening even to the same people. This has all taken place but maybe not all at the same time. There are probably even more bizarre cases in your own experiences, to be sure. Many times, the people involved with the preparation of the presentation material are unaware of the complexities of the actual showing. Anyhow, they figure that there's always someone at the client's who can supply the pieces that are missing, or it's just a short walk back to the office so the forgotten items can be gotten easily, or. . . . Many times everything finally works out, but how much less trouble there would be if a professional were asked for assistance, or if one of the people in the presentation just took the time to work up a list of essential items, considering everything as essential if it could be of any help at all in the presentation.

MAKE LISTS BEFOREHAND

Most important, never, never assume. For example, it's pretty easy to make the list of accessories needed, according to the pieces of equipment. For the film projector, there must be a take-up reel sufficiently large for the film to be played: the open-reel tape recorder needs a take-up reel and an a.c. cord, if it is not permanently wired in; for the slide projector there should be an extra remote control unit, just in case, along with an a.c. cord if it is a separate item; and for all the equipment, an a.c. extension cord or two which will also permit plugging everything in conveniently by running only one wire.

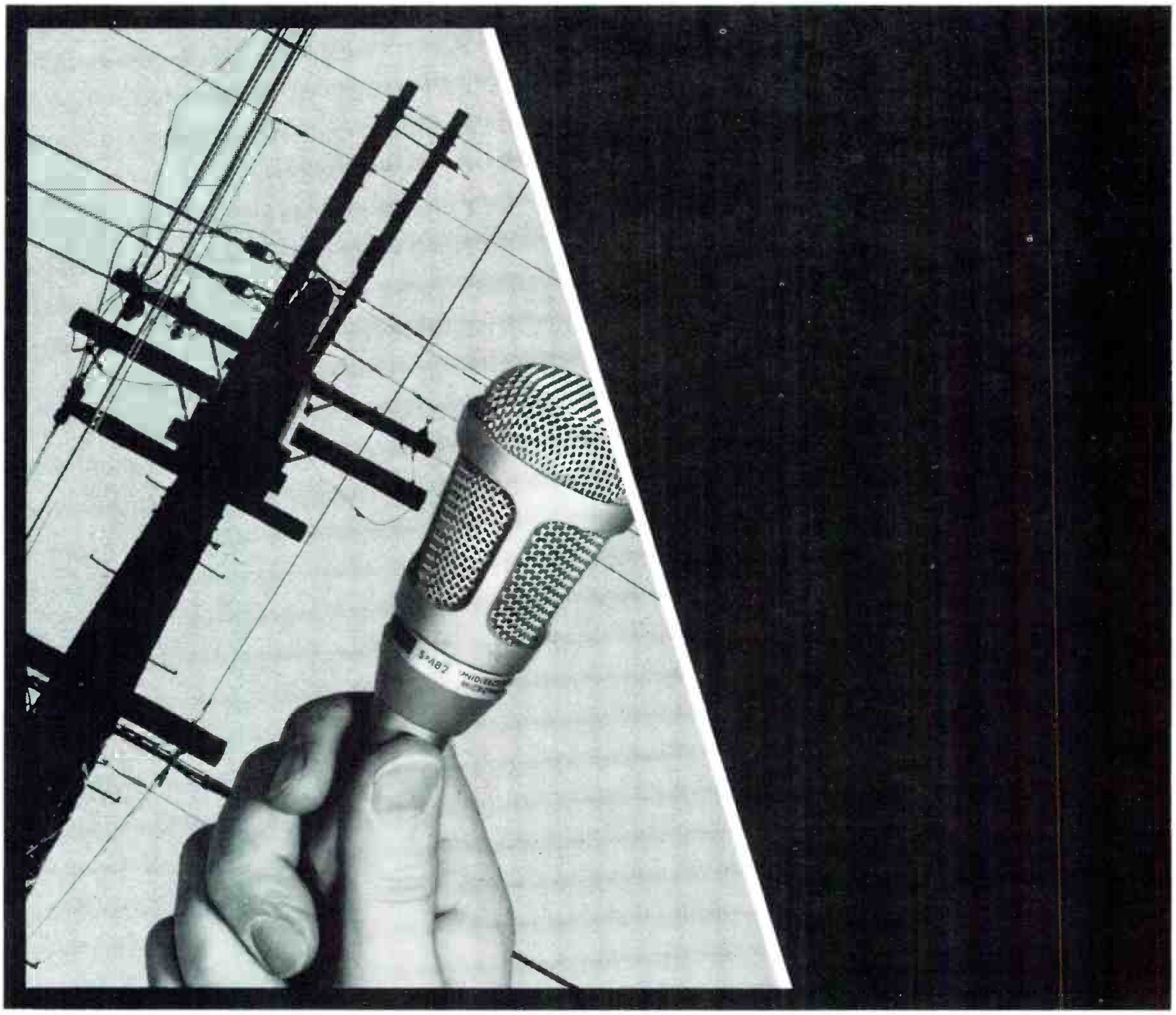
For the professional, this is not enough. For the film projector, there also must be a spare lamp, a spare exciter, possibly a spare spring for rewind and take-up if the projector is one of the manual types, some tape to hold the film together in case of a break, and even such a simple thing as a three-way a.c. plug and a three-to-two adapter for the three-pin a.c. plug. For the reel-to-reel recorder there might be a splicing block and tape in case the tape broke, for the slide projector, an extra 25 ft. extension cord for the remote control device, and a spare lamp. For both projectors, he would require a zoom lens or at least a 7-in. lens for the slide unit to match the standard 2-in. in the film projector.

Then there's the possibility of having a separate speaker for the tape/film sound which can be used for the projector and tape units with a switch box with proper inputs and output, or a "Y" connector with correct plugs—although this method might end in a mismatch if not properly done, with a resulting loss of sound quality. For the slide projector there could also be a "Y" to permit operation of the slides by either the person presenting or by the slide sync machine.

The professional might also bring the kind of tape that will hold down cables to keep them from being kicked around and the people that step over them from falling. There are also projection tables which the a/v man might decide to take along to set up for best projection with no interference with the seating arrangement.

A good audio-visual man usually carries, or has accumulated, a bag of tricks. In addition to all the little spare parts and accessories, there could also be blank slides to put into the projector's aperture to be able to change drums without turning out the projection lamp, and various cable adapters to permit feeding sound into existing sound systems, and . . .

And one thing the professional a/v man carries with him at all times is the constant reminder—never, never assume. ■



Hand-held hotline.

Finally there's a microphone that follows the news wherever it goes—to the end of a mile-long parade or to the center of a championship golf course. The new Shure SM82 super-rugged microphone—with its own built-in, line-level amplifier—is the long-distance hotline designed for broadcasting. Used with a telephone line or voice coupler, the SM82 becomes a complete remote amplifier/microphone with line-level output and a self-contained peak limiter to prevent overloading. All in the new Shure SM82, the long hotline for the short deadline.

Shure Brothers Inc.
222 Hartrey Ave., Evanston, IL 60204
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SHURE

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

Circle 28 on Reader Service Card

M. C. VOLKER

A Select/Cancel Channel Control

Here's a versatile, simple, and inexpensive design that will accommodate any desired number of channels.

IN NUMEROUS applications, you may want to select a particular input or channel while simultaneously canceling a previous selection. Additionally, you may desire to cancel all selections. (That is analogous to the push-button station selectors of car radios.)

An obvious broadcast console application is that of previewing a program source while canceling a previously cued selection. Here we present a very versatile and yet inexpensive means of providing such a control function on a single-wire common bus. The common bus feature permits the accommodation of any desired number of channels.

The inherent simplicity of the circuitry is most appealing. The circuit consists of two TTL open-collector NAND gates (e.g. 7401) and one JK Flip-Flop (e.g. 7473) plus an optional driver or buffer circuit. The circuit shown in FIGURE 1 operates as follows: If the pushbutton switch is pressed once, the output, Q, of FF2 is at logical 1. This output level can then activate, via a buffer or driver if necessary, an electronic audio switch, lamp, or relay, thus effecting the desired switching operation. At the moment when the switch is activated, the output at gate G1 is momentarily at a logical 0 level. This sets the FF2 outputs of all other channels on the bus to 0. The output of the circuit corresponding to the pressed switch will not go to 0 since inputs J, T, and K are all momentarily at logical 1. If the bushbutton switch is activated a second time, then FF2 will toggle, causing that output to clear. All other circuits on the bus remain at 0. That will cancel all channels.

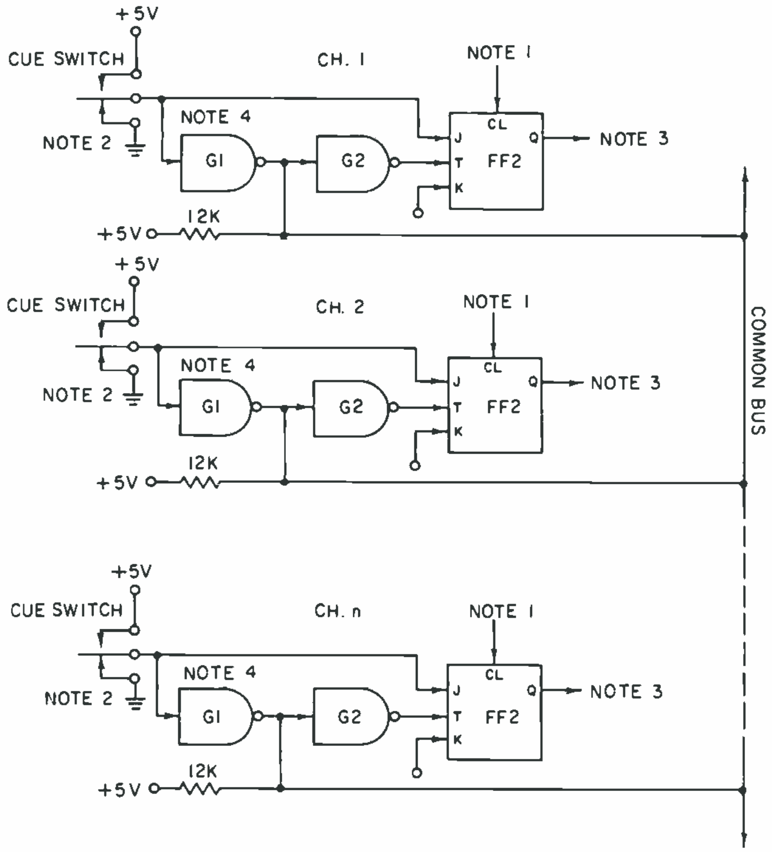


Figure 1. Channel select/control logic.

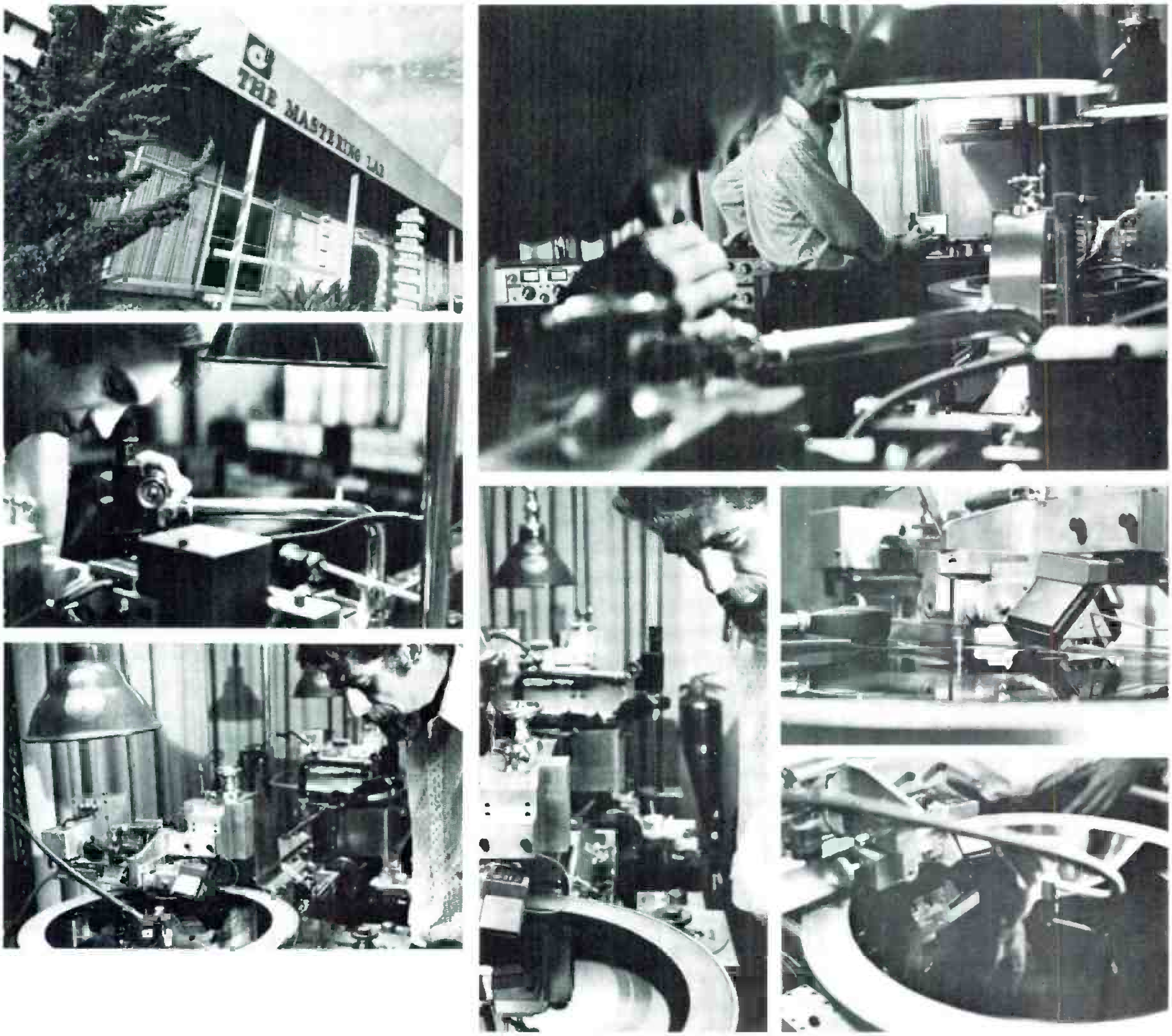
NOTES:

1. *Optional additional clear Input.*
2. *Momentary Contact push-putton switch, normally at O.*
3. *TTL Output to electronic switch or relay driver.*
4. *NAND gates must be open-collector, e.g. 7401 type.*

The availability of a clear input to FF2 permits remote canceling of that particular circuit. An application exists when the circuits are used for cueing program sources. In this case, if for example, a record or tape has been cued, then the control signal which starts the tape deck or turntable can simultaneously "kill" the cue.

This circuit has proven itself adaptable to a broad class of channel control requirements. Its simplicity and the single common bus feature render it practicable for many control situations. ■

M. C. Volker is president of Volker-Craig Ltd., Waterloo, Ontario.



Top Disc Cutting Studios, like The Mastering Lab, rely on Stanton's 681-Calibration Standard in their Operations.

Not everyone who *plays* records needs the Stanton Calibration Standard cartridge, but everyone who *makes* records does!

At The Mastering Lab, one of the world's leading independent disc mastering facilities, the Stanton 681 Triple-E is the measuring standard which determines whether a "cut" survives or perishes into oblivion.

A recording lathe operator needs the most accurate playback possible, and his constant comparing of lacquer discs to their original source enables him to objectively select the most faithful cartridge. No amount of laboratory testing can reveal true musical accuracy. This accuracy is why the Stanton 681 Series is the choice of leading studios.

When Mike Reese, principal disc cutter at The Mastering Lab, plays back test cuts, he is checking the calibration of the cutting channel, the cutter head, cutting stylus, and the lacquer disc. The most stringent test of all, the evaluation of direct to disc recordings, requires an absolutely reliable playback cartridge . . . the 681 Triple-E.

All Stanton Calibration Standard cartridges are guaranteed to meet specification within exacting limits. Their warranty, an individual calibration test result, comes packed with each unit. For the technological needs of the recording and broadcast industries, and for the fullest enjoyment of home entertainment, you can rely on the professional quality of Stanton products.

STANTON

For further information write Stanton Magnetics, Inc., Terminal Drive, Plainview, N.Y. 11803

Circle 29 on Reader Service Card

db new products & services

AUDIO CONSOLE

● Console component SR101 is a rack-mountable, eight-channel mixer/preamplifier which can be custom-installed in a desk or console. The unit accepts up to eight balanced low-impedance microphones, each with individual controls for volume, reverberation, high- and 102-frequency equalization, and input attenuation. Switchable inputs on two channels accept auxiliary high-level signals or high impedance microphones. The SR101 provides simultaneous program and monitor outputs, each controlled by its own master volume control. Additional switches allow the operator to route input signals in any combination to either output. Dual link jacks maintain connections to other components.

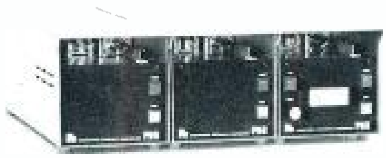
Mfr: Shure Bros. Inc.
Price: $960.00
Circle 50 on Reader Service Card

HORN LOUDSPEAKER

● Developed for public address and entertainment applications, this 4 kHz horn loudspeaker can provide wide horizontal sound dispersion from a single source, through the action of its unique high but narrow mouth. The acoustic distribution is over 150 degrees in the horizontal plane and 30 degrees in the vertical, with a claimed maximum acoustic loss of 2 dB at 12 kHz from the response on the axis. Made of heavy-gauge steel treated with acoustic damping compound, the horn is 6½ in. long. It has a heavy-duty mounting bracket.

Mfr: Vitavox Ltd.
Circle 51 on Reader Service Card

REPRODUCER/RECORDER



● Trimly fitting units of PD-11 series can be accommodated side by side on a 19-inch rack. Both the reproducer and recorder/reproducer feature direct-drive motor, air-damped solenoid, ½-inch thick aluminum deck, plug-in circuit cards, adjustable tape guides, micro-adjustable head assembly, and lubrication-free operation.

Mfr: International Tapetronics
Circle 52 on Reader Service Card

QUADRIPHONIC MIXER

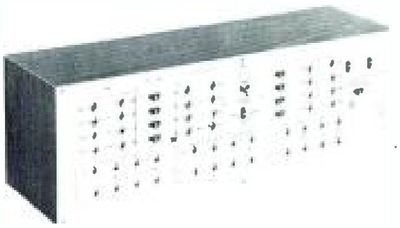
● Totally modular P/M-40 series quadriphonic mixer emphasizes flexibility, servicing any number of inputs, with modules expandable or removable at will. The unit contains a tri-state input l.e.d., dual power supply as a safety margin, phantom powers condenser microphones, and three submaster capability. B, C, and D mixes can be switched pre or post the A slider, are individually controlled on each channel with continuously variable settings that can be equal to, less than, or greater than the A slider. A, B, C, and D mixes can be used for combinations of functions, such as main, monitor, echo/reverb, submastering, recording, cue or quadriphonic p.a. A continuously variable pad on each channel provides attenuation for calibration to any microphone and most line inputs. The l.e.d. glows green and varies in intensity with the proper input signal, changing from green to red at clipping level. Three-way equalization gives a +20 dB of bass and treble and 3 dB or 6 dB shelving boost in the mid-frequency band.

Mfr: Malatchi Electronic Systems, Inc.
Circle 53 on Reader Service Card

COMPACT STEREO CASSETTE MACHINE

• Measuring only 7 x 2 x 7 in., CR134 stereo cassette machine can be used as a recorder with a built-in speaker or as a deck, driving two speakers directly with 1-watt output per channel. It can also be used in conjunction with an external amplifier or receiver. The head design incorporates four tracks in-line and has a photo-sensitive electronic control for the tape-drive mechanism, as well as automatic tape reversal. CR134, which operates on batteries, has a built-in condenser microphone and operates in both mono and stereo in both record and playback. The manufacturer claims wow and flutter less than 0.12 percent and frequency range of from 25 to 15,000 Hz, within 2 dB, and signal-to-noise ratio better than 56 dB.
Mfr: Uher of America
Price: $378.00
Circle 54 on Reader Service Card

PORTABLE PATCHING CENTER



• Live recording, mixing, signal processing, and dubbing in up to four channels can all be handled by the QT-1 patching center. The unit has 72 RCA-type phono jacks on the back panel which permit the user simultaneously to connect up to four tape recorders and other accessories and leave them connected to the rear panel. Interconnection functions are performed by front panel switching or changing patch cords, making possible numerous applications—coding, mixing, intermixing, reversing and rearranging channels, limiting and equalizing, playback, copying, monitoring, etc. The device is passive, with no a.c. power or active circuitry, except at tape recorder outputs. Included are twelve patch cords. The case may be removed for rack mounting.
Mfr: Russound/FMP, Inc.
Price: $249.95.
Circle 55 on Reader Service Card

products & services (cont.)

RECORDERS/REPRODUCERS

● Open reel series 1400 recorders/reproducers are built on a die cast aluminum main frame with a d.c. servo drive system that assures, according to the manufacturer, a timing accuracy of less than three seconds deviation per 30 minutes of operation, regardless of line voltage variations. Units are available in full, half and quarter track head configurations and operate at 3¾, 7½, and 15 in/sec. Solid state logic controls all tape transport functions. The amplifier provides balanced and unbalanced inputs and outputs. Units are equipped with dual tap transformers for 110-130 VAC and 220-260 VAC, 50 or 60 Hz. Rack mounted. Remote control stations are optional.
Mfr: Telex
Price: $1,645.00 up.
Circle 56 on Reader Service Card

PORTABLE TWO-CHANNEL REVERB

● Based on the Torsion Transmission Line principle, model BX-10 portable two-channel reverberation unit offers independent decay-time adjustment, high and low frequency equalization and reverberation/dry signal mixing. Decay-time is adjusted silently through motional feedback, enabling adjustment during program material. Reverberation/dry signal mixing enables reverberation to be added to a dry signal without the need for a reverb-return mixing section in the mixing desk. The two channels are electronically and acoustically separate. The unit, equipped with two-point suspension, may be rack mounted or used as a portable system.
Mfr: Philips Audio Vidio Systems Corp. (AKG)
Price: $1,400.00
Circle 57 on Reader Service Card

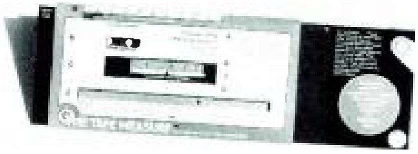
PORTABLE EIGHT-CHANNEL CONSOLE

● Production mixing console model ESC-8, called the Eight Pack, handles eight stereo channels and claims less than 0.1 percent distortion and −123 dBm equivalent input noise as well as balanced low impedance inputs and variable input gain. Control features include separate monitor mix, pan, high and low equalization, and overload indicators on each channel. Provided are a 9 watt headphone amp, an internal reverb unit, and two peak reading level meters. Input/output features include preamp outputs (patching or post channel out, optional), reverb mix output, left and right effects input, bridging/auxiliary out, and monaural output. The unit weighs 33 pounds.
Mfr: Head Sound, Inc.
Circle 58 on Reader Service Card

AUTOMATIC RELEASE CARTRIDGE MACHINES

● An automatic release deck is featured in series 3000 Spotmaster cartridge machines. Units in the series, including mono and stereo, record/playback/delay, with all cartridge sizes and in a choice of desk or rack mounting, have gold-plated connectors, plug-in electronics, direct-drive motors, noise suppression, and air-damped solenoids. F.e.t. switching, transformer output, and remote control connectors are standard. Stereo units are equipped with head brackets having independent azimuth adjustment for tight control of stereo phrasing. Options include all tape speeds, secondary and tertiary cue tones, fast forward and various operating voltages. A tape splice/fault detector accessory is available.
Mfr: Broadcast Electronics
Circle 59 on Reader Service Card

TAPE/TIME COMPUTER



● A simple and ingenious double-slide cardboard calculator, called The Tape Measure, computes the amount of recording or playing time remaining on a given amount of recording tape. It will work for regular 5 in., 7 in. or 10½ in. open reel tapes.
Mfr: Rothchild Printing Co. Inc.
Price: $1.49
Circle 60 on Reader Service Card

TAPE SPLICER

● An integrated self-sharpening shear mechanism replacing a razor characterizes this manufacturer's line of splicers. Model H-50-S, specifically for ½-in. tape, contains a precision dovetail aluminum groove which secures the tape during the splicing operation while Teflon-coated flat springs help keep it in position. The line also includes splicers for ¼-in. and cassette tape.
Mfr: Nagy Research Products
Price: $24.95
Circle 61 on Reader Service Card

GAUSS REPLACEMENT HEADS

● Exact replacement heads for Gauss (Cetec) type high speed tape duplicating systems are made of hot-pressed glass-bonded ferrite construction. They are designed to replace the original metal 4-track cassette and 8-track cartridge heads in the systems, and are fully compatible with existing Gauss electronics. The manufacturer claims that the new heads will outwear the original metal heads by ten to twenty times.
Mfr: Saki Magnetics, Inc.
Circle 62 on Reader Service Card

NORMAN H. CROWHURST

Being Practical About Feedback, part 1

This is the first of a three-part discussion of feedback, its characteristics, and how to work with it.

FROM TIME TO TIME, we've covered pieces about feedback in my column, Theory and Practice. Also, a few months ago, I mentioned the more thorough treatment that I once covered, first in a little book on just that specific subject, and later in a textbook that is now out of print. Several readers wanted to know where they could get this information, and it seems to be unavailable in print. So your editor invited me to write this series, which will also update the information to apply to the new devices that have since come into use.

In this first part, we will discuss what feedback can do, within the somewhat limiting assumption that we are talking about something that can be either positive or negative—no in-betweens! In practice, that is never true because phase shift always gets into the picture somewhere. So that what starts out being negative feedback can turn itself around and become positive at some frequency or other. That is where trouble starts. We will avoid confusion by deferring that kind of discussion to the second installment.

EFFECT ON GAIN

Whatever else feedback may do, it will always be related to one primary effect: on gain. So we start with that. First, assume we have an amplifier (FIGURE 1) that has a gain we designate A. That will have the dimension of either a voltage gain or a current gain, or else a transconductance or transresistance. So if you want to give it a dB figure, it will be 20 $\log_{10}$ A. Thus, if output voltage is 100 times input voltage, we would say that A = 100, or the dB gain is 40.

Now, for the moment we will assume that feedback is also designated by voltage ratio and is given by the symbol β. To work with voltage ratios in each case requires the configuration shown in FIGURE 1. Now let's put in some figures to make it easier to follow because letters are not all that easy.

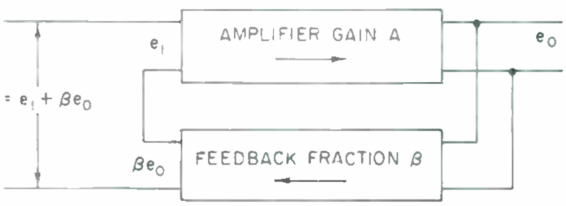


Figure 1. The classic feedback block schematic: voltage in, voltage out.

We assume, let's say that internal input voltage, e_1, is 10 millivolts. Because the gain, A, is 100, the output voltage, e_0, is 100 × 10 mV, or 1 volt. Now, let's assume that β, the feedback fraction, is 0.09, which is about 1/11. Then the fed-back voltage is β times 1 volt, or 90 mV. Because it is negative feedback, the external input, e_i, must be the sum of these 10 + 90 = 100 mV.

So with feedback, an external input of 100 mV will produce an output voltage of 1 volt. The gain has been reduced from 100 to 10, or from 40 dB to 20 dB. As a formula, we write that:

$$A_F = \frac{A}{1 + A\beta} \quad (1)$$

where A_F is the gain with feedback.

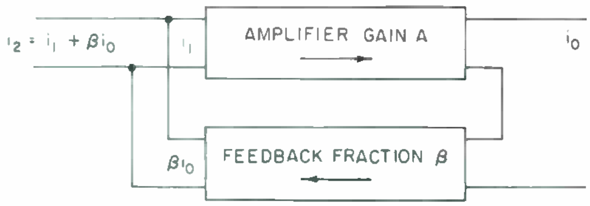


Figure 2. An alternative feedback block schematic: current in, current out.

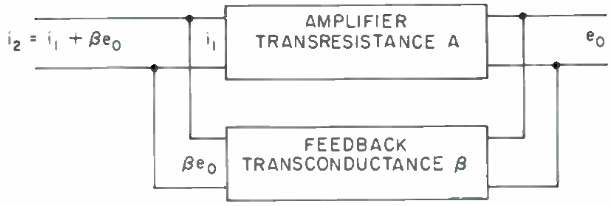


Figure 5. The fourth possibility: current in, voltage out.

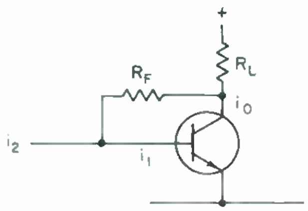


Figure 3. A typical transistor stage, that can be analyzed in terms of Figure 2.

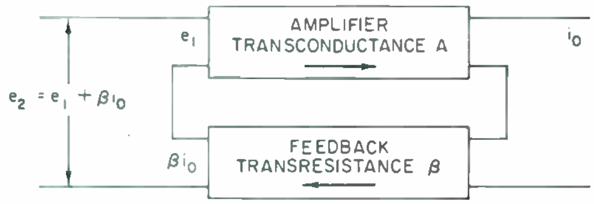


Figure 4. A third alternative feedback schematic: voltage in, current out.

That is the most important formula in all of feedback theory.

Before going further, we need to define terms. β is called the feedback fraction. The product $A\beta$ is called the loop gain. In the example we used, the loop gain was 9. It could be given in dB as 20 $\log_{10}$ 9, which is about 19 dB. Finally, the important factor, $1 + A\beta$ is called the feedback factor. If it is expressed in dB, it will be called the dB feedback.

In this case, $9 + 1 = 10$, and $20 \log_{10} 10 = 20$ dB. If you substitute, 100 divided by 10 is 10, giving A_F as also 20 dB. Working in dB, you subtract the dB feedback from the dB gain without feedback to get the dB gain with feedback. But it is best to work with the formula directly, using the numbers and fractions rather than their dB equivalents because that 1+ has to get in there, which working in dB makes a little awkward.

TRANSISTORIZED AMPLIFIERS

Now, in FIGURE 1 we were working with voltage gain and a voltage fraction fed back. That is not the only form that feedback can take, although the formula is the same whichever form we use. In the old tube amplifiers, input was usually in the form of a voltage. But with transistors, except the f.e.t. variety, input is essentially a current, although in a composite transistorized amplifier we may be back to voltage again.

Essentially, a transistor is a current amplifier; it gives an amplified current output for a smaller current input. The symbol β is also used for the current gain of a transistor. But as we are using that for feedback fraction in this series, we will avoid talking about the same symbol for transistor current gain, or else we will spell it out, and call it beta when we mean current gain.

If we redraw the block schematic of FIGURE 1 for current gain instead of voltage gain, it will look like FIGURE 2. Applied to a practical transistor stage, it might look like FIGURE 3. Here R_L is the collector load resistor, and R_F is the feedback resistor. The current through R_F will be $R_L/(R_L + R_F)$ of the transistor output current. That is the value β will have in formula (1).

Now, let us suppose we have a transistor with a working beta of 300, that R_L is 10 KΩ, while R_F is 90 KΩ. β calculates to 1/10, or 0.1. A is 300, so $A\beta$ is 30, and the feedback factor $1 + A\beta$ is 31. Gain with feedback is 300/31, which is about 9.7, slightly less than 10.

To pursue that example a little further (although we will deal with this more fully later), a transistor with a nominal beta of 300 might be bracketed to have a range of betas from 150 to 450. Without feedback, that means current can vary over a 3:1 range, which is nearly 10 dB. But now let us look at what feedback can do to it, in theory.

If beta is 150, $A\beta$ is 15, and the feedback factor $1 + A\beta$ is 16. Gain with feedback is 150/16, which is 9.375. And if beta is 450, $A\beta$ is 45, and the feedback factor is $1 + A\beta = 46$. Gain with feedback is now 450/46, which is about 9.78. So the gain without feedback, which changed by almost 10 dB, is reduced to a change of less than 0.4 dB. We will have more to say about this later.

We have shown two possible configurations for feedback. There are two more. The two we used were for straight voltage gain, or straight current gain. Now suppose the gain is given as a transconductance: current output for voltage input. Then feedback must be in the form of a transresistance: voltage fed back for current output. The configuration is shown at FIGURE 4.

The other possibility is one we can use in many transistor circuits: voltage output for current input, which is a transresistance. So feedback must be given as a transconductance: current fed back for voltage output. And the configuration is shown at FIGURE 5. The complementary quantities for transconductance and transresistance are micromhos and megohms.

A transconductance of 2,000 micromhos means that an input of 1 volt produces an output of 2 milliamps. A transresistance of 0.5 megohm means that an input of 2 microamps produces an output of 1 volt.

For the moment, we will leave using specific examples of each kind until we've taken a look at the things we can expect feedback to do for us.

EFFECT ON DISTORTION

Effect on distortion is what feedback was first known for. So let us figure out what we can expect it to do. Suppose that without feedback the amplifier, for an input of e_i, produces an output that is $e_o = Ae_i + A\delta e_i$ the first term being amplified fundamental, and the second term being a percent, δ of distortion, of designated harmonic content. Thus, if the distortion was 5 percent, δ would be 0.05.

If we proceed to apply the fraction β to this, we will have a distortion component in the fed-back signal that does not offset the input signal as the fundamental does. That distortion would be amplified again, and we would never solve the problem. We must assume that the external input, e_i, is what has no distortion, so that the input now consists of $\hat{e}_i = e_i - \theta e_i$, where θ is the component of distortion fed back, reversed in phase, because it has no offset in the input, e_i.

So the output will now be:

$$e_o = A(1 + \delta)e_i = A(1 + \delta)(1 - \theta)e_i \qquad (2)$$

And the fed-back voltage will be:

$$A\beta(1 + \delta)(1 - \theta)e_i$$

The input voltage, e_i is the internal input voltage, $\hat{e}_i = e_i(1 - \theta)$ plus the fed-back voltage, or:

$$e_i = [1 - \theta + A\beta(1 + \delta)(1 - \theta)]e_i \qquad (3)$$

Multiplying this out, and keeping the fundamental and distortion terms separate, we get:

$$e_i = [(1 + A\beta)e_i + (A\beta\delta - [1 + A\beta]\theta - A\beta\delta\theta]e_i \qquad (3a)$$

The first term is the fundamental input, required in the absence of distortion. The second term contains all the distortion products, none of which is present in the external input, so that term must be equated to zero. Equating the first order terms to zero is easy, but the second order term, $A\beta\delta\theta$, represents a distortion of distortion component.

If the distortion is second harmonic, second of second is fourth, and if it is 5 percent without feedback and, say 0.5 percent with, 5 percent of 0.5 percent is 0.025 percent. We could go around again, and introduce a term for that, but it never ends. Similarly, if the distortion is 3rd harmonic, 3rd of 3rd is 9th. And if more than one order of distortion is present, you will have combined products, such as 6th, and so forth, but all second order and much smaller than the first order—in theory, at any rate. More of that later.

So we equate the first order term to zero:

$$A\beta\delta = (1 + A\beta)\theta \qquad (4)$$

From which

$$\theta = \frac{A\beta}{1 + A\beta}\delta \qquad (4a)$$

Substituting this into (2) and simplifying:

$$e_0 = Ae_i + \frac{A\delta}{1 + A\beta} e_i - \text{(2nd order term)} \quad (2a)$$

Note that the distortion term δ has been divided by $1 + A\beta$. That is the important result.

GAIN STABILIZATION

You could arrive at these conclusions by application of logic in different ways. For example, distortion occurs because of change in gain over different parts of a signal waveform. So the reduction in distortion could be regarded as being due to gain stabilization over the various parts of the waveform. From this we would expect both to be reduced by the same factor, $1 + A\beta$.

But here is another way to go. Gain is usually quoted in dB units, which is logarithmic. Using the symbol Δ for incremental change in gain, without feedback, this would be $\Delta \cdot \log A$. With feedback, it will become $\Delta \cdot \log A_F$. So reduction in gain variation, due to feedback, will be:

$$\frac{\Delta \cdot \log A_F}{\Delta \cdot \log A} = \frac{\Delta \cdot \log A_F}{\Delta A_F} \cdot \frac{\Delta A_F}{\Delta A} \cdot \frac{\Delta A}{\Delta \cdot \log A} \quad (5)$$

Now substituting equation (1) for A_F, and treating A as the variable, as implied by equation (5), this reduces to:

$$\frac{\Delta \cdot \log A_F}{\Delta \cdot \log A} = \frac{1}{1 + A\beta} \quad (5a)$$

Thus, adding the feedback reduces the change in gain, from whatever cause, by the feedback factor, $1 + A\beta$. This is something about which we will have much to say in later parts.

EFFECT ON IMPEDANCES

Feedback also changes input and output impedances of active devices or circuits. Look at FIGURE 1 or FIGURE 4—that is, when you look at input impedance, it is the input configuration that is important. The current input is determined by the amplifier's internal input resistance or impedance. Suppose this is 1000 Ω and the input voltage is 10 mV.

Without feedback, the input current would be 10μA. But now put in 20 dB of feedback, requiring a $1 + A\beta$ of 10, and only 1 mV of the 10 mV total input will be across the 1000 Ω. The other 9 mV will be supplied by the feedback. It does not matter what the feedback network's impedance is, from the viewpoint of change to input impedance, because the input current is determined by that 1000 Ω. And feedback has changed it so that, from the viewpoint of the 1000 Ω, the current has only 1 mV driving it, instead of 10 mV.

Thus, the effective impedance with feedback is 10 mV taking 1 μA. This is 10,000 Ω, meaning that feedback has increased input impedance by the feedback factor, $1 + A\beta$.

That is for voltage feedback, or series injection of the feedback. Input impedance is multiplied by the feedback factor. What about shunt injection, which is more often used with current type amplifiers, such as ordinary transistors? That is represented in FIGURE 2 or FIGURE 5. Now the input voltage does not change, but the current does.

If the input voltage is 10 mV, and the input impedance without feedback is 1000 Ω, without feedback the input current will be 10 μA. But now, if 20 dB of feedback is applied, the $A\beta$ will be absorbing an additional 90 μA, to bring the total input current up to 100 μA. So with shunt injection, or current feedback, the input admittance or conductance is multiplied by the feedback factor. If,

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like many of us, you find it easier to think in resistances or impedances, then this means that the input resistance or impedance is divided by the feedback factor for this form of input combination.

A similar set of deductions can be made about output impedance. One way to think about that is to consider what happens, in theory at any rate, when you change from the working load to either open or short circuit, one of which will effectively remove the feedback.

For voltage feedback, better called voltage-derived feedback, if the output is short-circuited, there is no voltage to feed back. Suppose the output with the normally connected load is 1 volt, with feedback, and that 20 dB feedback is used, meaning $1 + A\beta$ is 10, again. That means that removal of feedback would put the output voltage up to 10 volts.

So whatever current is flowing, with the normal load connected and feedback operative, will go up to a current limited only by the amplifier's' internal resistance, from 10 times the voltage when the output is short-circuited. That means the effective internal resistance, with feedback, is divided by the feedback factor, 10 in this example.

Similarly, if the feedback is current derived, open-circuiting the output will remove the feedback. So the output current will rise to 10 times, absorbed only by the internal conductance or admittance of the output stage. That means that feedback divides the internal conductance or admittance by the feedback factor, or multiplies the internal resistance or impedance.

NEGATIVE OR POSITIVE FEEDBACK

So far, we have, without saying so, been talking about negative feedback, so-called, because it offsets the original input, reducing gain. In applying feedback, we must ensure that it *is* negative, because if we get the phase wrong, we could be in trouble. To apply the formula we developed for negative feedback to positive feedback, we just put a minus sign in front of β. Thus, if β is a numeric fraction, such as to produce positive feedback, we rewrite equation (1) as:

$$A_F = \frac{A}{1 - A\beta} \qquad (1a)$$

Now, you will see that, if the loop gain product, $A\beta$, becomes 1, $1 - 1 = 0$, and the reciprocal of zero is infinity, which means the amplifier achieves infinite gain, becoming an oscillator. For positive feedback, you can use loop gains of only less than 1, unless you want an oscillator.

If the loop gain is a loss of 6 dB, $A\beta$ is 0.5, then $1 - A\beta$ is also 0.5, and gain increases 6 dB as a result of feedback. If loop gain is a loss of 2 dB, which means $A\beta$ is approximately 0.8, then $1 - A\beta$ is 0.2, and gain is multiplied by 5, or an increase of 14 dB, as a result of feedback. Here it gets very critical.

WHAT ABOUT PHASE?

As stated at the outset, so far we have assumed that feedback is always simply negative or, just at the end, positive. But all practical circuits contain something beside resistances and conductances, such as reactances. And at some frequency or other, every reactance introduces phase shifts. Then the feedback signal is neither in phase nor out of phase with the original input signal, exactly. It must be added vectorially.

Whether we like it or not, this is a fact of life. We may design a circuit to have negative feedback all right, but somewhere, at some frequency, that negative feedback leaves off being simple negative, so that the factor $1 + A\beta$ ceases to be a simple addition. ■

R. S. MINTZ

A Simple and Superior Microphone Preamplifier

This effective design uses an integrated circuit with few external passive components for far better performance.

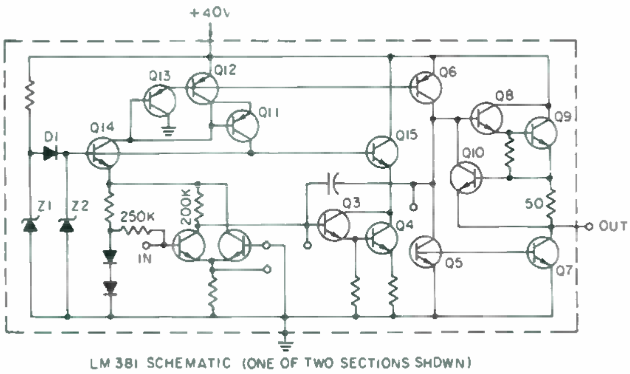

Figure 1. LM381 schematic (one of two sections shown)

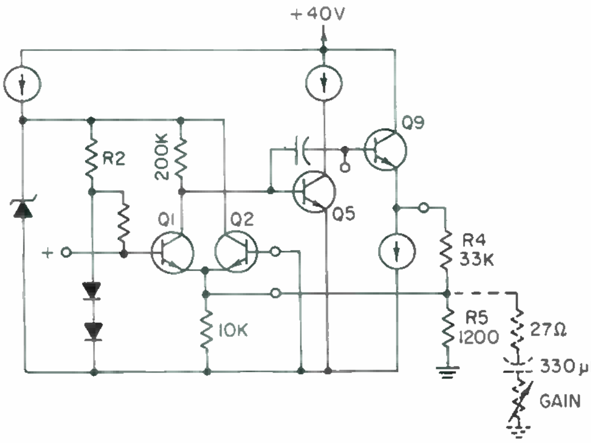

Figure 2. A.C. equivalent circuit.

R. S. Mintz is associated with Custom Sound Productions, New York City.

HERE'S A MICROPHONE PREAMPLIFIER design that takes advantage of the newest technology to produce a simple, reliable, and effective way to improve existing audio equipment. And, it produces a new audio system with a performance that is superior to designs employing conventional transistors, tubes, hybrid components, and/or general-purpose op amps.

The preamplifier uses a National LM381AN integrated circuit and a minimal number of external passive components. FIGURE 1 shows the schematic diagram of the LM381. The operation can be described as follows:[1]

A low-level input is coupled to the base of Q1 via a 0.1 microfarad external capacitor. Q2 is turned *off* to achieve the noise advantage of a single high-gain input stage rather than a differential input pair. Q3 and Q4 operate as a Darlington emitter-follower driving a common-emitter amplifier Q5 with current-source load Q6 and output current sink Q7. The voltage amplification of the first stage is 160 and that of the second stage is 2,000. Thus the open loop gain of the entire amplifier approaches 320,000. Capacitor C1 compensates the amplifier to unity gain at 15 MHz, with provision for additional compensation to limit high-frequency noise in audio applications. The output stage is a Darlington emitter-follower, Q8 and Q9, with transistor Q7 acting as a current sink. Transistor Q10 limits the short-circuit output current to 12 milliamperes.

Zener diode Z2, driven from a constant-current source Q11, provides a biasing reference. Q11 and Q12 provide the high current-source impedance necessary to maintain a power supply rejection ratio of 120 dB. (The LM381 has an internal voltage regulator which prevents interaction between several units operating from the same supply.)

AMPLIFIER A.C. CIRCUIT

FIGURE 2 shows the equivalent a.c. circuit of the amplifier. The output quiescent point is established by negative feedback through an external voltage divider, R4/R5. The a.c. and d.c. gain of the amplifier is equal to R4/R5. However, by shunting R5 with a capacitor and resistor in series, the a.c. gain of the amplifier will be equal to the ratio

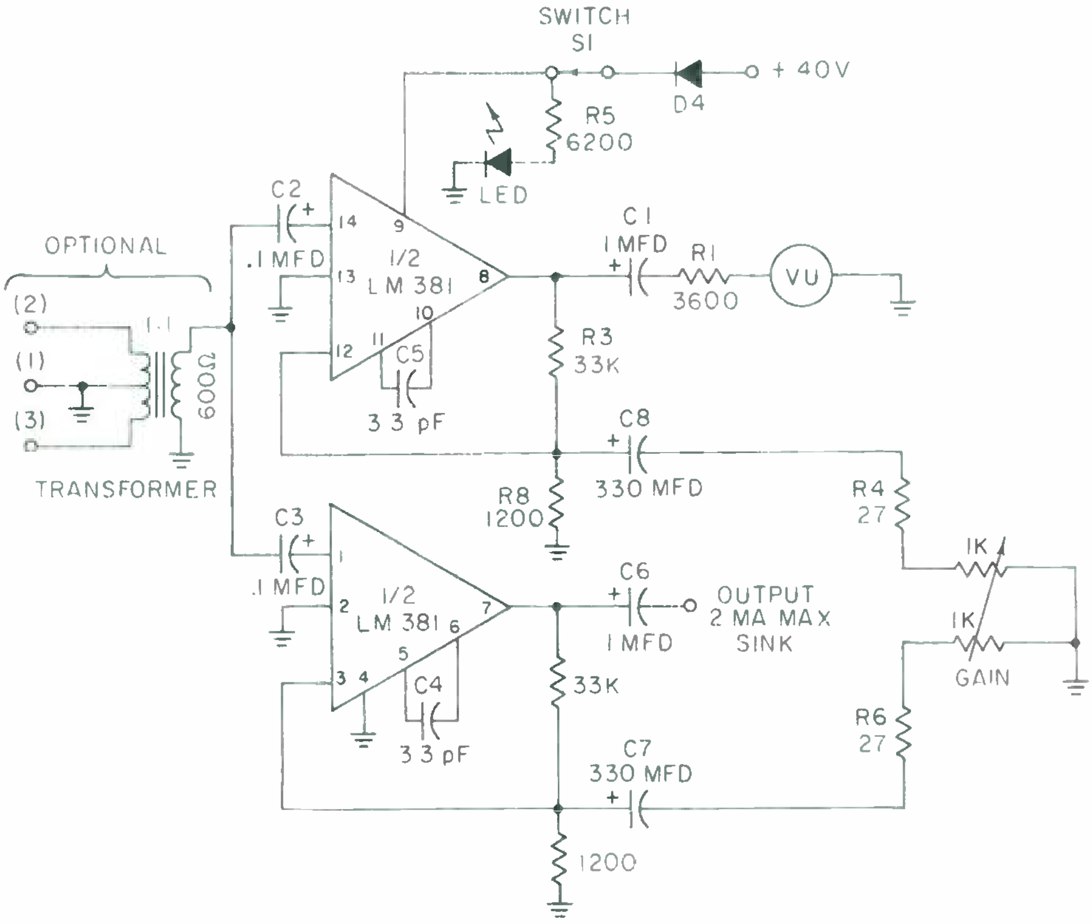

Figure 3. Microphone preamp schematic.

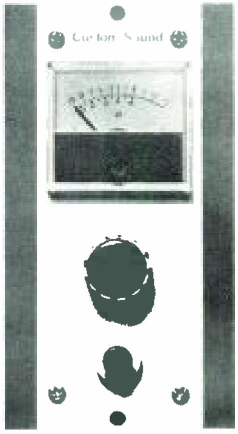

Figure 4.
The finished package.

of R4 to the shunting resistance. The a.c. gain will approach the open loop gain of the amplifier (i.e., 320,000) as the shunting resistance approaches zero. However, the low-frequency 3 dB corner (cutoff frequency) is equal to:

$$\frac{\text{open loop gain}}{2\pi \times \text{shunting resistance} \times \text{shunting capacitance}}$$

Therefore, low-frequency gain is limited by the size of the shunting capacitance; for a gain of 1,000 and a low-frequency 3 dB point of approximately 20 Hz, a 330-microfarad capacitor and a 27-ohm resistor are used. A 1,000-ohm audio potentiometer is placed in series with the shunting resistor and capacitor to enable the gain to be varied continuously from a maximum of 1,000 to a minimum of 33. (If the shunting network were removed, the minimum gain would be about 27.5, as established by the ratio of R4/R5.)

Since the internal noise generated by this amplifier in the single-ended mode of operation is extremely low, special considerations must be made to maintain ultra-low noise in the operating circuit.[2] FIGURE 3 shows the schematic diagram of the complete microphone preamplifier.

INPUT TRANSFORMER

In order to cancel out common-mode noise in long microphone lines, an input transformer is used with a grounded center-tap primary. Input and output impedance of the transformer is 600 ohms (nominal). The low secondary impedance provides an exceptionally smooth frequency response and a minimum of transformer-induced distortion. Since the secondary-coil resistance of the transformer is about 80 ohms, very low noise-voltage is generated in it. The total equivalent input noise of the preamplifier circuit is −130 dBV. An improvement of 20 dBV over this value could be achieved by an ideal input transformer with a gain of 10.

However, all input transformers of this type introduce a certain amount of signal distortion, and the low noise of the LM381AN allows us to avoid using them. Additionally, we have the advantage that even the loudest rock band would have difficulty overloading the input of the preamp circuit, since the input from the microphone may approach 300 millivolts without producing input distortion or output distortion with the gain set at its minimum

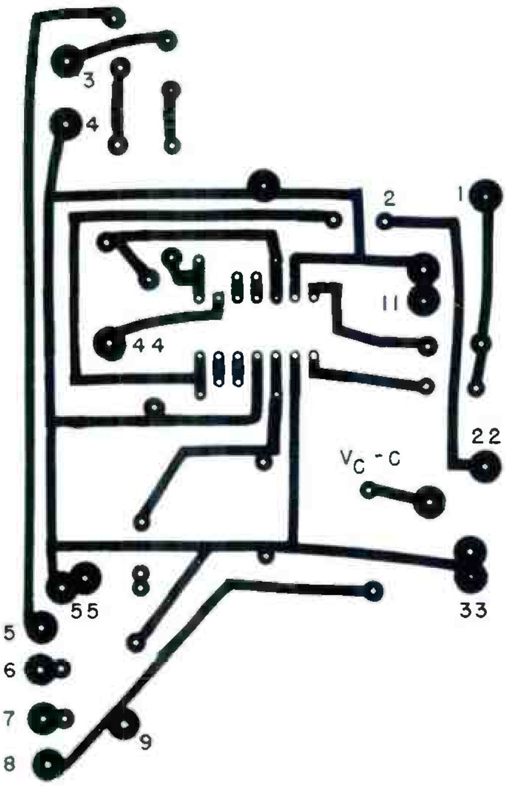

Figure 5. Printed wiring mask.

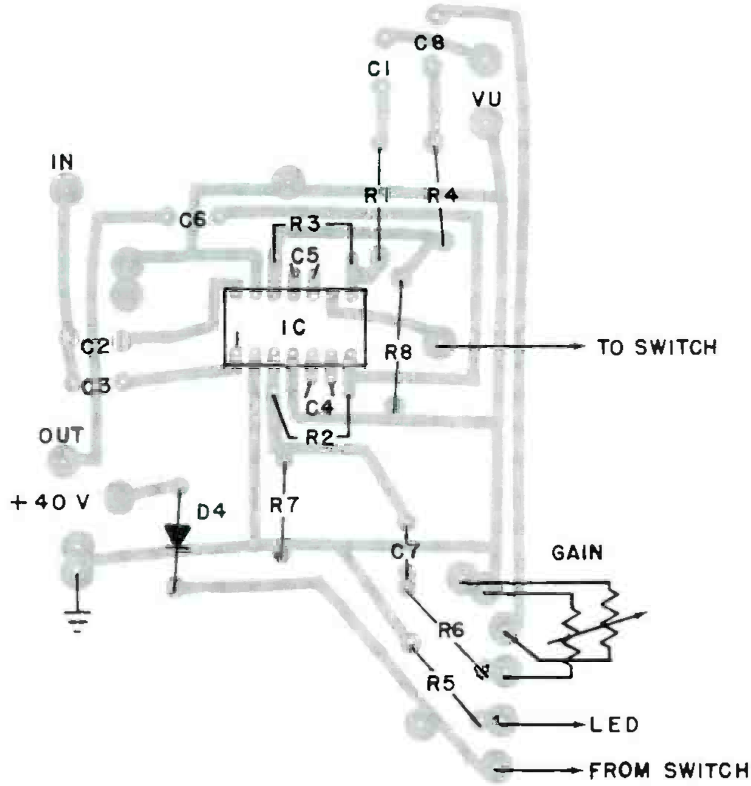

Figure 6. Circuit layout.

value. The input transformer may be left out of the circuit for unbalanced microphone lines.

FIGURE 4 shows the finished product packaged in suitable form for use in a recording studio. A Vector EFP module was used with a three-pin XLR-type connector on the rear for input and a phone jack for output. A dixson front-panel vu meter fits nicely, along with a gain control and an illuminated on/off switch. Since the vu meter is driven by a separate amplifier with 60 dB of isolation, no distortion is introduced by its use. The gain of both amplifiers is adjusted simultaneously by the use of a dual audio taper potentiometer. (The LM381 is a dual device.)

To avoid the amplification of high-frequency noise, a 3.3 picofarad capacitor is used as additional compensation. Input and output signals are coupled via small tantalum capacitors, and provision is made for the use of an l.e.d. in the on/off switch.

The LM381AN is sensitive to soldering heat, so it should be mounted in a 14-pin socket. A protection diode is provided to prevent a blown i.c. if the 40V power supply is accidentally hooked up with its polarity reversed. All components are mounted on a 3 x 4½-in. glass-epoxy circuit board which fits right into the enclosure. FIGURE 5 is a printed wiring board mask which may be used to make up your own boards, and FIGURE 6 is a component layout guide, both intended for use with radial-leaded tantalum capacitors.

ITS PERFORMANCE

In field tests by rock musicians, this preamplifier has performed admirably. It is very easy to build in any form since the components and layout are not critical. In use, its operation is almost foolproof, since the integrated circuit is short-circuit proof and will shut down if overheated. If built with military-grade components and packaged as shown, or in a well-designed console or rack, it should operate indefinitely and provide the best that modern technology can provide for a modern studio.

One word of caution: This circuit is primarily a voltage amplifier that provides up to 24 vu of output voltage, but very little current. The maximum output current you can expect the amplifier to deliver is only 2 mA. If you feed a high-impedance load, such as an amplifier, equalizer, console, etc., you won't have any problem. But if you feed a load of 6000 ohms or less, when the input signal increases to a point where the load would tend to draw more than 2 mA, the output voltage of the amplifier will not increase even if the input signal increases. In this case, harmonic distortion would result. Thus, when driving a 600-ohm line, for instance, the output voltage of the preamplifier would be limited. Since this preamplifier design is intended to be plugged into a high-impedance, high-level input, the problem would not normally occur.

If you intend to use several preamplifiers as a mixer, however, make sure that the input resistance of your summing network is at least 6,500 ohms for each preamplifier. Another solution would be using a voltage follower, or current-gain stage, after the preamplifier, such as the LH0002. The use of this voltage-follower will permit the present design to be expanded for use in driving 600-ohm lines or low-impedance devices. However, the circuit as described is normally adequate to improve the noise performance of any audio control console. It is a state-of-the-art mic preamp in its simplest form, suitable for use in film, video, and in any application requiring such a device. ■

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MICHAEL RETTINGER

Calibrate Microphones By Reciprocity

In place of a secondary microphone, rapid alternation of loudspeaker transducers calibrates sensitivity quickly and accurately.

IN THE CALIBRATION of microphones, sound-level meters, "noise dosimeters," magnetic tape recorders, etc., one generally uses a secondary standard microphone. However, the reciprocity technique of microphone calibration has found great favor among acousticians because of its simplicity and the fact that it constitutes an absolute measurement system.

The preferred type of microphone for noise and reverberation time measurements is a non-directional transducer. The problem which sometimes arises with microphones for noise level evaluation is one of calibration. In the absence of a secondary standard which may be used for comparison, the unit must be sent to one of the few laboratories in this country which is able to calibrate it. (The United States Bureau of Standards is one such laboratory.)

A number of electroacoustic equipment manufacturers have marketed so-called "Microphone Reciprocity Calibrators." The fallacy in using these is that they are generally designed for the calibration of the transducers sold by the same manufacturer and do not lend themselves readily to the evaluation of other sound-pickup units. But there is a simplified method of checking the sensitivity and frequency response of microphones by the reciprocity method.

ALTERNATION IN A FREE FIELD

FIGURE 1 shows a schematic diagram of the free-field measurement system. S_1 and S_2 are two small identical loudspeakers located in quiet and dead surroundings. The backs of the units are enclosed to prevent radiations from the rear (as by diffraction) which would interfere undesirably with the test.

A double-pole, double-throw switch allows the rapid alternation of the transducers as receiver and transmitter, as is the case when the loudspeakers are single-coil, single-cone direct radiators.

Another double-pole, double-throw switch, ganged with the first, allows the assessment of the open-circuit voltage of one of the two transducers acting as a microphone while the other operates as the sound-emitter.

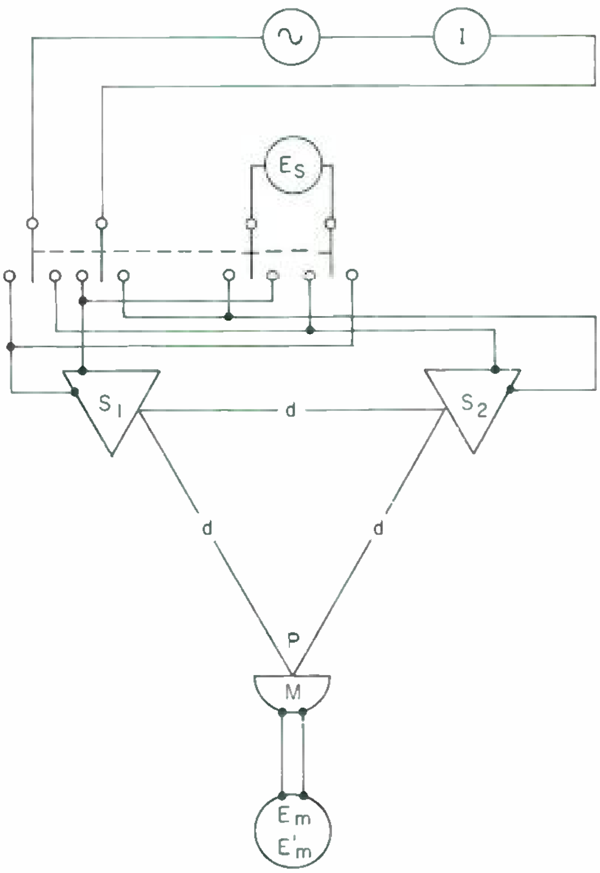

Figure 1. Schematic diagram of the free-field measurement system.

An ammeter in line with the oscillator establishes the current at all times.

When both the current (I) and the open-circuit voltage (E_s) remain the same in the alternation of the transducer functions, it may be said that a free-field exists in which the reflections from the room boundaries are negli-

Michael Rettinger, a valuable contributor for many years to practical acoustical knowledge, is a consultant, working from Encino, California.

gible, and that S_1 and S_2 are alike in performance.

Note the slanting angles between the longitudinal axes of the three transducers, which are located at the apexes of an equilateral triangle.

THE MICROPHONE TO BE CALIBRATED

The microphone to be calibrated is assumed to be a pressure-actuated unit. For a velocity of pressure-gradient transducer, unless all units are several feet apart, corrections have to be applied for the fact that near a point source, the sound pressure and particle velocity of a sound wave are not in phase.

When S_1 and S_2 are switched in their functions as loudspeaker and microphone, the open-circuit voltage of the test microphone normally remains the same, so that $E_m = E'_m = E$.

The sensitivity of microphone (M), in volts per bar (dyne per square centimeter), is given by

$$K = 0.013\sqrt{\frac{E_m E'_m d}{IfE_s}}$$

$$= 0.013E\sqrt{\frac{d}{IfE_s}} \qquad \text{if } E_m = E'_m = E$$

where E_m = open-circuit voltage of M when S_1 operates as loudspeaker
E'_m = open-circuit voltage of M when S_2 operates as loudspeaker
d = distance between transducers, cm
f = frequency
I = current for S_1 and S_2 (assumed equal), amperes
E_s = open-circuit voltage of S_1 and S_2 operating as microphones (assumed equal)

SOUND PRESSURE

To establish the sound-pressure at (P), we may write

$$P = \frac{E}{K} = \frac{E}{0.013E}\sqrt{\frac{IfE_s}{d}}$$

$$\frac{P}{0.0002} = \frac{1}{0.0002 \times 0.013}\sqrt{\frac{IfE_s}{d}}$$

$$SPL = 20\log\frac{P}{0.0002} = 20\log 77\sqrt{\frac{IfE_s}{d}} + 74$$

$$= 10\log\frac{IfE_s}{d} + 111.7$$

$$= 10\log IE_s + 132 \text{ if } f = 1000 \text{ Hz and } d = 9.25 \text{ cm}$$

As an example, when I = 0.01 amperes and E = 0.001 volts, and a sound-level meter is put at P, it should read

$$SPL = 10\log 0.01 \times 0.001 + 132$$
$$= 82 \text{ dB}$$

The frequency response of many loudspeakers is beset by sharp peaks and dips; frequencies may not become accurately identified by reading the frequency dial of most common audio oscillators. Incorrect identification of frequency results in incorrect assessment of microphone sensitivity. Moreover, standing waves between the various transducers may result from their housing, cones, and diaphragms. Therefore, it is recommended, in this step-by-step procedures of calibration, to employ narrow frequency bands of pink noise for the signal rather than single frequencies for the achievement of valid and accurate measurement results. ■

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DYMA builds custom studio consoles, desks, enclosures, studio furniture. **Dyma Engineering, Route 1, Box 51, Taos, New Mexico 87571.**

STUDIO SOUND—Europe's leading professional magazine. Back issues available from June, '73. $1 each, postpaid. **3P Recording, P.O. 99569, San Francisco, Ca. 94109.**

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NEW MODELS: Ampex AG440C 2-track, servo capstan motor; Scully 280B; used AG440Bs; used Scully 280, 8-track, new heads, in console, excellent condition; Sennheiser mics. Immediate delivery from stock. **Malaco Recording, Jackson, Miss. (601) 982-4522.**

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WANTED: Top $ paid for U-47s (tube type), M-49s, KM-56s, U-67s, and Telefunken 251s. **Sigma Audio Systems, P.O. Box 2469, Hollywood, Ca 90028. (213) 462-8515.**

WANTED: USED 12+ in, 8 out recording console in good condition. **P.O. 2468, Phoenix, Az 85003.**

WANTED: Educational public broadcast station needs surplus studio equipment, particularly magnetic tape and mixing equipment. Contact **Boulder Community Broadcast Association, 885 Arapahoe, Boulder, Colorado 80302.**

EMPLOYMENT

FILM SOUND MIXER/ENGINEER Complete Boston commercial film sound studio seeks experienced career person to take over while staff mixer goes on holiday. Operations include recording, transfer, screening, and 4-track 16/35 mixing with rollback. Please submit resume to: **The Cody Co., 24 Dane St., Somerville, Ma 02143.**

ENGINEER, to design audio equipment. **Ace Audio Co., 25 Aberdeen Dr., Huntington, N.Y. 11743. (516) 549-1233.**

PROFESSIONAL RECORDING PERSONNEL SPECIALISTS. A service for employers and job seekers. Call today! **Smith's Personnel Service, 1457 Broadway, N.Y.C. 10036. Alayne Spertell. (212) WI 7-3806.**

USED GEAR SALE: Ampex MM-1100 16-track, $14,000.00; Ampex MM-1000 8-track, $7,500.00; Gately 16 x 8 console, $9,500.00; Scully 284 8-track, $7,500.00; Ampex/MCI 8-track, $6,000.00; EMT 140S echo chamber, $4,000.00; AKG BX-20G echo chamber, $2,600.00; Ampex/MCI 2-track, $2,000.00; Tascam 8 x 4 console (demo), $2,000.00; Tascam S70 4-track in cabinet, $2,750.00; new Scully 280Bs; Klipsch monitors, Heresy & Cornwall in stock. Ask for Dave, Tom, or Emil. **Studio Supply Co., P.O. Box 280 Nashville, Tenn. 37202. (615) 327-3075.**

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• **Uher of America, Inc.** of Inglewood, California, will distribute the complete Lenco line of turntables in the U.S.A. The exclusive rights to the line were established in an agreement between **Uher Werke Munchen** and **Lenco of Switzerland.** Also news from Uher is the appointment of **Larry Deovlet** as national sales manager.

• Direction and supervision of operations at Technical Services of the **RCA Service Company** has been undertaken by **Martin H. Rubin,** recently appointed director of field operations. He will be headquartered at Cherry Hill, N.J. Mr. Rubin, who has been with RCA since 1948, was formerly manager of the Long Island Consumer Services.

• **Coil Specialists,** manufacturing coil and inductor custom items and offering custom sub-assembly work, has opened a new facility in Valentine, Nebraska. **Jerry Riewe** is the founder of the new firm.

• Two new appointments have been announced by the **Cannon Electric Division of International Telephone and Telegraph Corporation** of Santa Ana, California. **Robert J. Trivison** has been named vice president-director of operations. Mr. Trivison was formerly with **Trivex, Inc. L. Wayne Oliver** has been promoted to director of business development replacing Mr. Trivison.

• **Benjamin B. Bauer,** vice president and general manager of the **CBS Technology Center,** Stamford, Connecticut, was awarded a "Debby" by the **Society of Audio Consultants** for development of the SQ™ quadriphonic system. The award, co-sponsored by **High Fidelity Trade News,** was given in recognition of outstanding service to the audio industry.

• **Robert B. Thompson** has been appointed regional sales manager of **Columbia Electronic Cables,** a division of **Avnet, Inc.** of New Bedford, Mass. Mr. Thompson has been with Columbia for five years. Prior to that, he was with the **Grinnell Corporation.**

• **Telex Communications, Inc.** of Minneapolis has announced the appointment of **Norman H. Hansen** to the position of product manager in the professional audio products group. Mr. Hansen will be involved in expanding amateur radio and citizens' band product sales as well as with the sale of professional tape equipment and headsets. Before joining Telex, Mr. Hansen was affiliated with **Webster Electric Communications.**

• Professional acoustical consulting services associated with architectural acoustics, open office landcape design, electronic sound masking systems design, and tuning is offered by newly formed **Acoustical Design, Inc.** Their office is at 24 Pine St., Morristown, N.J. Principals in the new firm are **James E. Sulewsky, Donald R. Cunningham,** and **William E. Shinnick.**

• **Dr. Peter C. Goldmark,** president of **Goldmark Communications Corp.** has received the 1975 Trustee Award from the **National Academy of Television Arts and Sciences.** The award was presented on the basis of Dr. Goldmark's technological contributions in communications. Dr. Goldmark developed the long-playing phonograph, the first practical color television broadcasting system, and electronic video recording.

• **Auditronics Systems Division,** of Memphis, Tennessee has announced the appointment of **Bill Brock** as regional sales manager, based in Nashville. Mr. Brock's career includes sales and instructional work at **Scully** and at the **Ampex Corporation.**

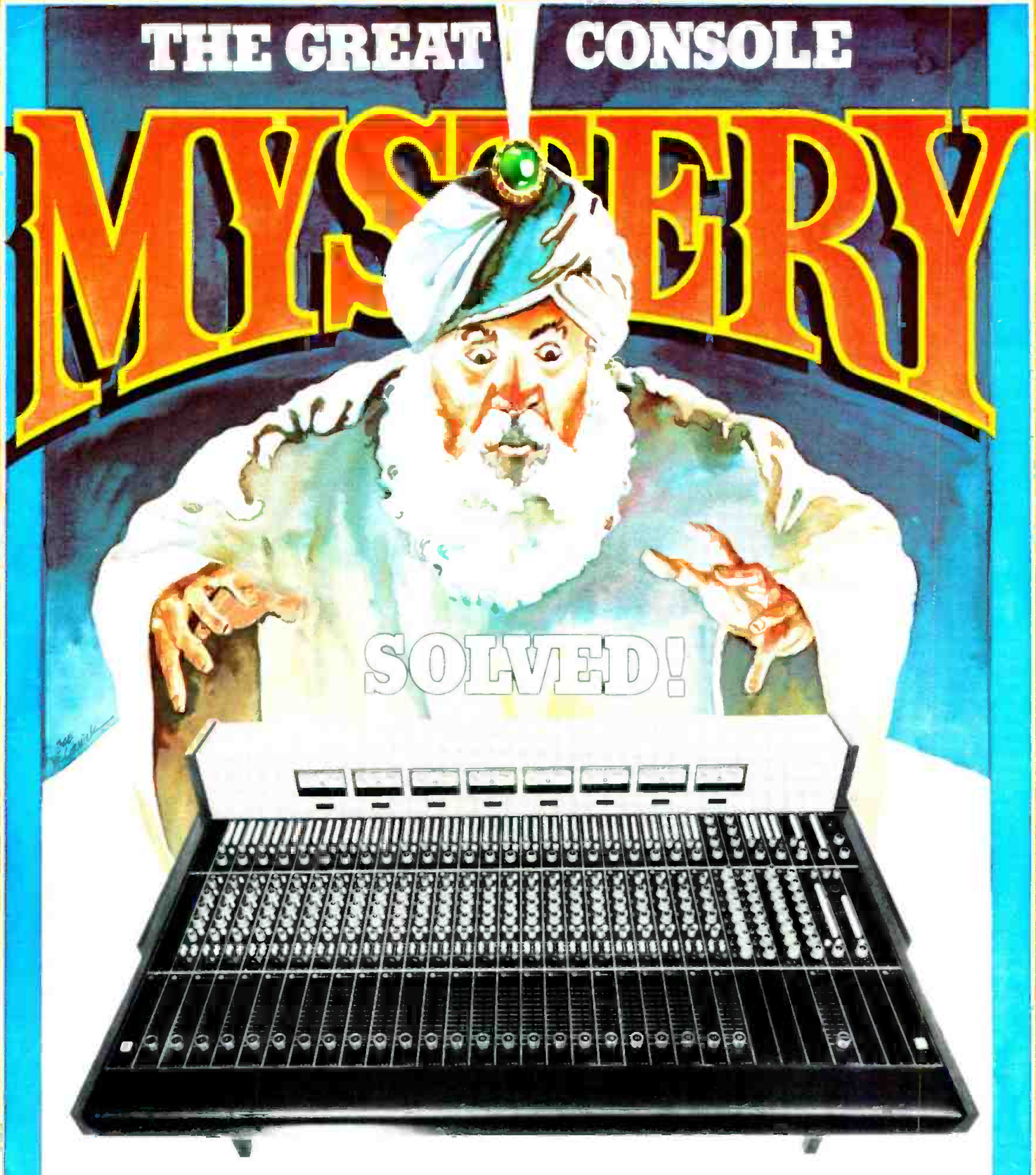
• **William Krucks** has been elected by the **Rauland-Borg Corporation** as Chairman of the board and chief executive officer. Mr. Krucks is a specialist in the field of corporate finance, taxation, and management. He has been associated with the transportation industry, most recently with the **Chicago and Northwestern Transportation Company** as corporate treasurer.

• Four additions have been included in the staff of **Sunwest Recording Studios, Inc.** of Hollywood, California. **Bill Lazarus** has been appointed vice president and director of engineering. **Cheri Wagner** as traffic manager and assistant to the vice president. **Phil Seretti** and **Tom Harvey** will serve as maintenance engineers.

• A milestone 50th anniversary was celebrated by **Shure Brothers, Inc.** of Evanston, Ill. The firm was started as the Shure Radio Company on April 25, 1925 by **S. N. Shure,** who still heads the company. Beginning as a distributor of radio parts, Shure now manufactures microphones, high fidelity phono cartridges, and sound reinforcement components. The products are sold in over 100 countries.

• **Sony Corporation of America** has established a broadcast service unit within its v.t.r. division The new department will cover marketing and engineering, as well as service and parts. Operation of the department will be limited to television and radio stations as well as production facilities servicing the broadcast and recording industries. **David K. MacDonald** will head the new department.

• A new Los Angeles agency, the **R. A. Neilson Co.,** will offer marketing services in research, advertising, sales promotion, industrial design and technical writing. Also, a personnel search and placement service will specialize in personnel for the audio/visual field. The agency is headed by **Ron Neilson,** formerly marketing manager at **Quad/Eight Electronics.** The address of the new agency is 3378 Oak Glen Drive, Los Angeles.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