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COMING NEXT MONTH

• STUDIO RUMBLES by Michael Rettinger is an examination by this noted acoustical consultant on the problems of low frequency rumble in the studio. Cures are offered.

Sidney L. Silver takes a look at the PSYCHOACOUSTICAL ASPECTS OF SOUND. The insight to be gained cannot help but be of considerable value to the audio engineer.

Part 2 of William Rheinfelder's article concludes what is begun in this issue with the MUSICIAN'S TONE CONTROL.

db VISITS—HARVEY RADIO. Associate editor John Woram and pictures of this important New York City distributor of pro audio and video equipment. Our excuse for going was a recent open house.

September is AES Convention month so we will have a map and rundown of hours and places.

And there will be our usual columnists: Norman H. Crowhurst, Martin Dickstein, and John Woram. Coming in **db, The Sound Engineering Magazine.**

ABOUT THE COVER

• This ultra modern record player is a portend of part of what's coming at the 25th anniversary Convention of the AES next month. Please do not send orders for the unit to us since we are not authorized dealers and have no stock.

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THE SOUND ENGINEERING MAGAZINE

AUGUST 1973 VOLUME 7, NUMBER 8

db is listed in Current Contents: Engineering and Technology,

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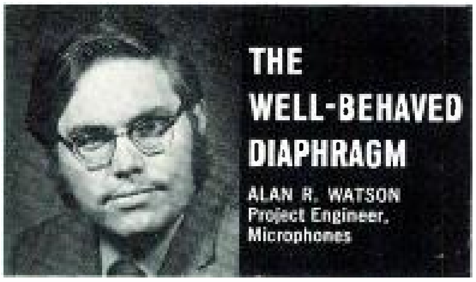
One of a series of brief discussions by Electro-Voice engineers



When a microphone design engineer finds dis-departing from ideal piston operation. The big microphone under test, he can usually assume that any peaks and/or dips are the result of either faulty damping or that the diaphragm is departing from ideal piston operation. The big problem has been to determine which fault is being displayed.

A powerful tool in determining actual diaphragm behavior is the holographic camera. It can reveal and measure the deformations of the diaphragm not visible by other means. Use of this research method led to the unusual diaphragm used in the new E-V Model DS35 Single-D microphone.

The problem was to design a diaphragm that offered high compliance at low frequencies yet maintained good rigidity at high frequencies to withstand the high accelerative forces without diaphragm breakup. The solution was to combine an Acoustalloy® diaphragm using a semi-toroidal surround plus a flat center section, to which is bonded a domed "pill" of molded polystyrene. This construction reduces piston breakup over a broad range of frequencies, and eliminates the minor resonant areas typical of more complex diaphragm designs. Mass of the moving system is also controllable within very close tolerances. The result is predictably flat response, especially at higher frequencies.

This flat response, in addition to being desirable in itself, makes possible more unform off-axis performance since adjustments can be made to the phase-shifting networks necessary for creating a cardioid pattern, without upsetting the on-axis response.

The holograms also revealed a need to mount the voice coil more rigidly to the diaphragm to eliminate the decoupling that can take place at high frequencies. This was done by recessing the rear surface of the diaphragm to permit the coil cement to operate in shear rather than the usual compression-expansion mode typical of other designs. This improved mounting was made possible by the unique volumetric nature of the diaphragm assembly.

The net result of this design program was to create a single-D microphone that is remarkably uniform in response both on-and off-axis, especially in the region from 3 to 10 kHz where non-linear diaphragm motion is relatively common with traditional designs. The same approach to diaphragm construction has also been applied to other E-V single-D microphones including the 670 series.

Where the microphone is used for sound reinforcement a distinct movement can be noted in gain-before-feedback as a direct result of the reduction of peaks in both on- and off-axis modes. In addition, elimination of peaks reduces the likelihood of input overload in critical installations.

For reprints of other discussions in this series, or technical data on any E-V product, write:
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letters

The Editor:

After my seventh article in three years appeared in your pages early this year I am reminded that I haven't been able to thank individually all those readers who have taken the time to give me some kind of feedback, through either constructive criticism or complimentary acknowledgement. I hereby do so, with sincere thanks for their remarks.

In an isolated case, the comments of one W. Dixon Ward, which you saw fit to publish in an un-rebuttable manner, deserve especial attention. For, his views on both the subject of hearing and my treatment of same have done more to prove one of my key points than anything I could have said myself. Namely: an expert is one who knows more and more about less and less.

Marshall King
Hollywood, California

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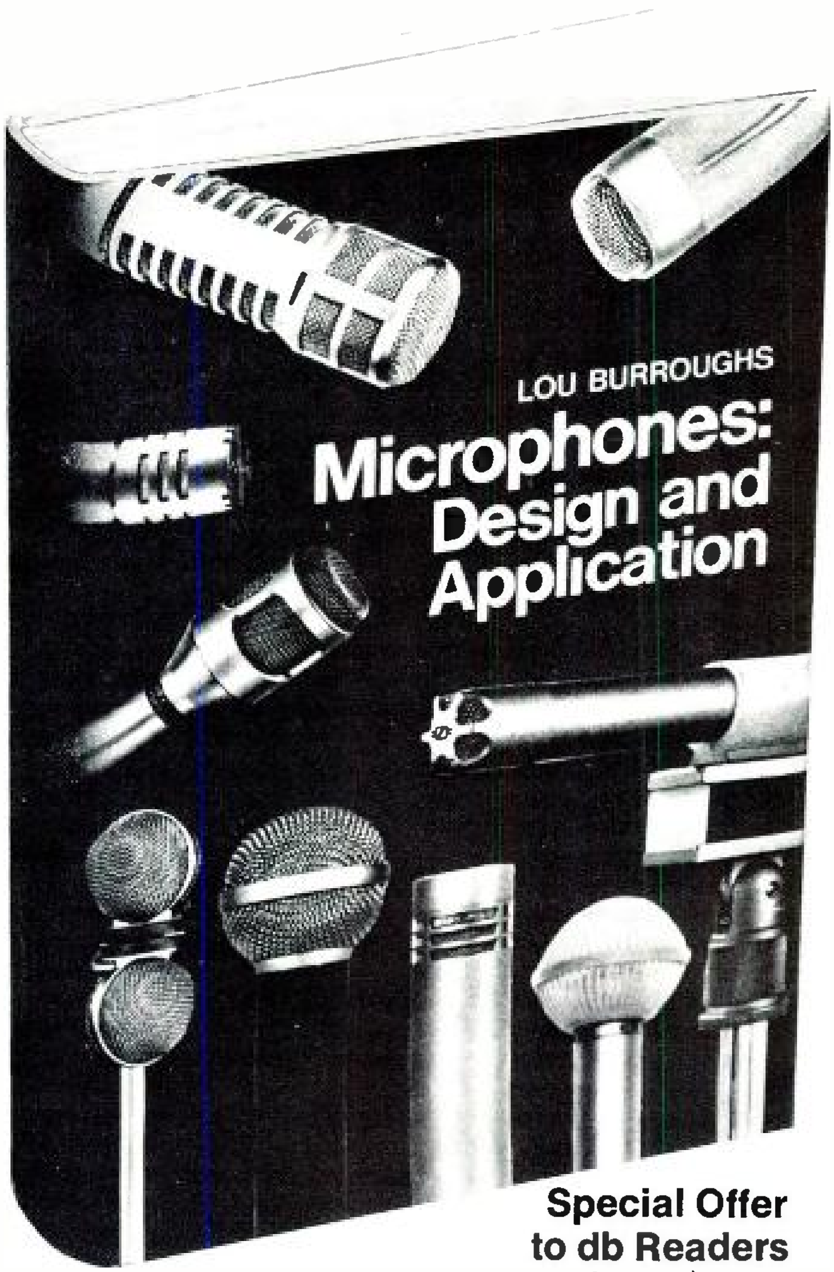

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- **How do you space your microphones to bring out the best in each performer?**

Author

Lou Burroughs is widely known for his pioneering work with Electro-Voice and is one of the universally recognized experts in the field. He helped design and develop many of the microphones which made modern broadcasting possible. In fact, he holds 23 patents on electro-acoustical products! Lou Burroughs knows microphones inside out. This book is based on his many years of research, field studies and lectures given throughout the world.

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John M. Woram

THE SYNC TRACK

• Last month's column went on about keeping the number of microphones used on a session down to some sort of sensible minimum. As noted, this requires more control in the studio. Groups of instruments are recorded in stereo, with the balancing chores being assumed more by the conductor than the engineer.

But, what about planning during a mixdown? How does one shift the apparent location of an instrument recorded in this manner?

At times, one doesn't. Even a single instrument recorded on a stereo pair of tracks cannot be re-located later without losing the effectiveness of this particular recording technique.

Consider for example, a solo french horn overdub. The musician sits in the middle of the room and is picked up by two microphones—each feeding a separate track. Later, the tracks are located left and right, so that the horn appears to be located in the center. But now, although everyone likes the stereo sound, the producer asks you to locate the horn on the extreme right. How can this be done? Of course, you can remove the track feeding the left speaker, or pan it over to the right along with the other track. Either way, the horn comes up on the right, but the stereo effect is lost.

In order to maintain a stereo effect, the horn would have to be recorded all over again, with the musician actually sitting off to the right. In stereo miking, directional information is a function of many variables; musician-to-microphone distance, space between microphones, angle of microphones, etc. The actual sound pressure level at each microphone might be about the same and yet the instrument would definitely appear to be located on the right.

This is quite different from panning a single track to produce the desired localization, because when a single track is panned to the extreme right, nothing comes out of the left speaker. In stereo miking, the left speaker is still active, as just noted.

So, why even bother with stereo miking when using a single track appears a lot simpler, and lets you easily relocate the instrument during mixdown? Obviously, you can't go back and re-record an instrument every time you wish to try a new location.

In a situation like this, the engineer must carefully consider the advantages of both techniques. Once again, a good understanding of the technology will help.

When a single track is to be located at a specific point between left and right, it is panned so that the proportion of left-versus-right signal gives the listener the desired impression. However, we are assuming the listener is located midway between the speakers. But, if the listener is sitting to the left of center, while the signal is panned to the right of center, the net effect may be that the signal appears to be coming from dead center. In other words, as the listener moves around, so does the apparent location of the sound source. If the signal is panned completely to one side, the sound may not shift as the listener moves, yet those sitting near the opposite side will hear a considerably unbalanced program.

With stereo miking, listener position is less critical. Although localization information may be a little more subtle, there will be less apparent shifting as the listener moves about. And, the instrument or instruments recorded in stereo will sound as though they are occupying space in a room, rather than as though they were point sources of sound.

Of course, the engineer must know where the instrument's sound is to come from *before* making the recording. In the case of an overdub, the eventual location of which is undecided at the time of recording, there may be no point to a stereo pickup. If it is known that the overdub will be on either the left or the right, then it might be recorded as a left-originating sound, and the tracks reversed later on to relocate on the right. However, shifts from either corner to the center, or *vice-versa,* could not be made.

On a multi-track tape with sixteen or more sources of sound, the sonic subtleties of a stereo overdub may be minimal at best. Yet, if the overdub is the featured soloist, as is usually the case on a pop session, stereo miking may be well worth considering.

Under this condition, it is usually certain that the soloist will be located in the center. If the orchestral background has been carefully recorded and mixed to present a wide program source, it may be difficult to blend in the soloist in the right proportion. At one extreme, the soloist may be buried in the accompaniment and at the other he (or she) will stick out like a sore thumb. On some recordings, it is all too obvious that the featured singer was added long after the band went home.

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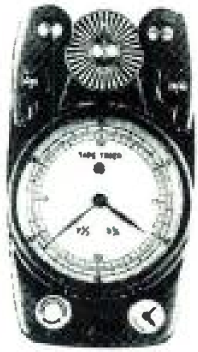

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Of course, stereo miking will not eliminate all the problems of the layered performance. But, if the singer is recorded in stereo, it wil be a lot easier to get a better vocal-orchestral blend. The stereo effect will create a feeling of some spaciousness, so that the singer will seem to be singing in a room rather than in a closet. Now, when the orchestra tracks are brought up, the vocal track(s) will fit more naturally.

Stereo miking does require some care, especially on vocal pickups. The distance between the microphones should be noted, and no one placed closer to the microphones than three times this distance to avoid cancellation effects.

Therefore, at the tight working distances preferred by many singers, the mics will have to be *extremely* close to each other. The charm of an "intimate" sound notwithstanding, the stereo effect will be minimal, or non-existant at super close range, so you may as well dispense with the stereo pickup in this case. However, if the orchestra is of any appreciable size, the vocal may sound a lot better with a little distance between tonsils and mic diaphragm. ■

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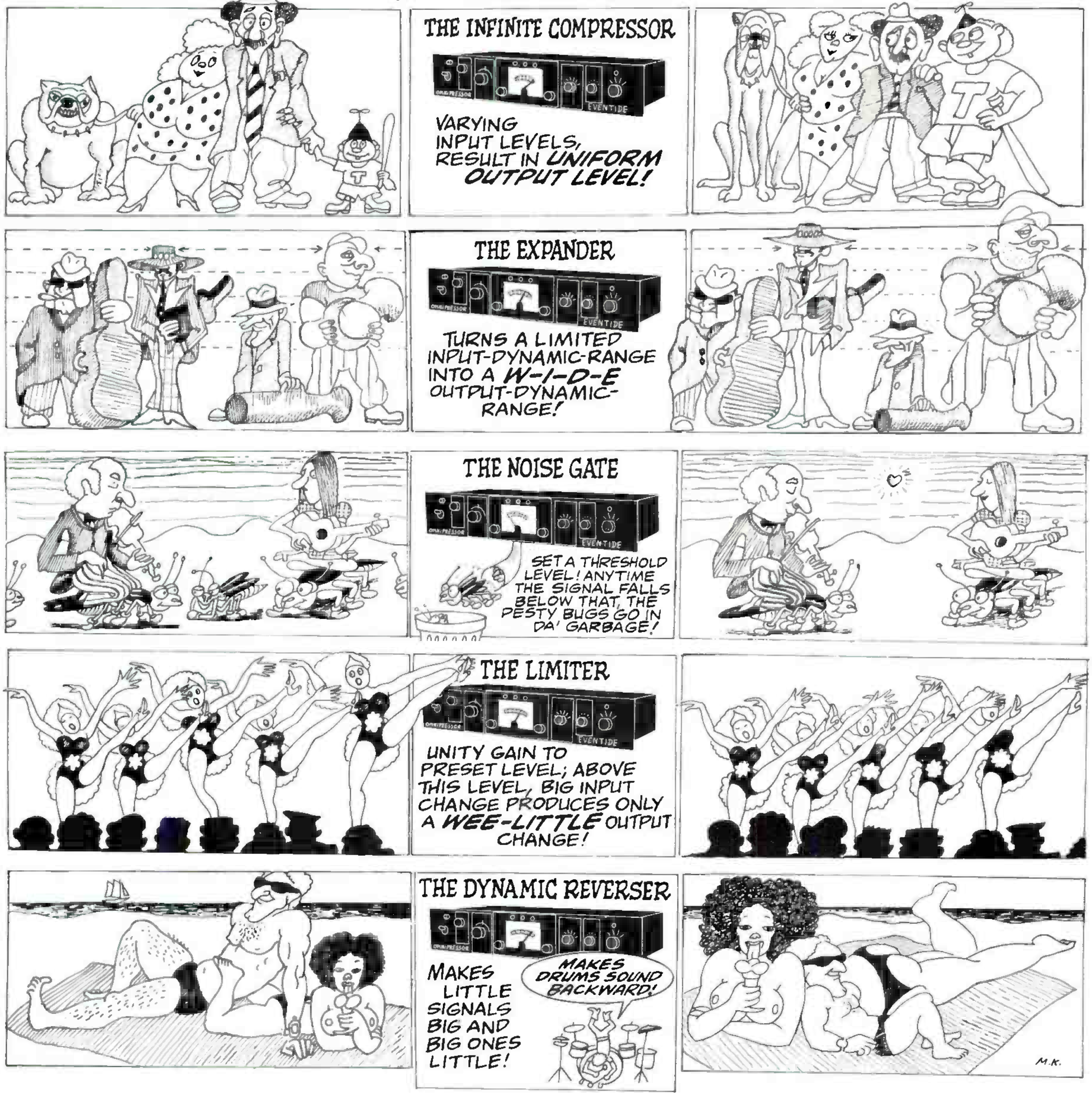

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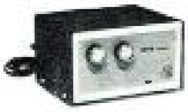

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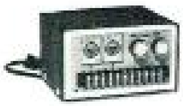

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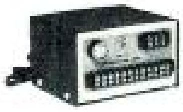

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Norman H. Crowhurst

THEORY AND PRACTICE

● Waveform analysis and synthesis is one of those theory-wrapped subjects that comes up from time to time, and has its quota of misconceptions. In the field of audio, because frequency content has been proven to be more important than phase relationships between the frequencies present, efforts to correlate content and waveforms have not been too frequent. They occur more frequently in other electronic applications.

But there is an important difference in ways that signals can be generated, that relates to the basic reference quantity used—frequency or time—and has also intruded much more upon the audio scene since the advent of synthesizers, and of function generators in particular.

In the old days, BFG (before function generators), all signal generators used one or other kind of oscillator in which various components of the circuit determined frequency, much like the pitch of a musical instrument is determined. In the case of a stringed instrument, the pitch is determined by the mass and length of the vibrating portion of the string, in conjunction with its tension.

In the old L-C oscillator circuit, this was almost a direct counterpart with the L and C of the tank circuit. The correspondency was a little less obvious in oscillators of the feedback or phase-shift variety, but the frequency of oscillation was still basically determined by various circuit components, as definitely as it depended on the L and C of its predecessor.

In those days there was another kind of oscillator, known as a "relaxation oscillator," of which the multivibrator was one. It was best known for producing a square wave, although with variations it also produced the sawtooth, which came into demand with the advent of the oscilloscope and, later, television.

This was really the beginning of waveform generators that were not frequency based, but time referenced. Intervals in the "action" were determined by circuit time constants, where all the earlier circuits, both L-C and phase shift, were dependent on the reactance of circuit components at specified frequencies.

In the L-C circuit, of whatever type, frequency was fixed where the reactance of L and C had identical value in the tank circuit, but opposite sign, of course. In a phase shift oscillator, usually three capacitors, in conjunction with resistors, each produced a phase shift, the total of which added up to 180 degrees at the operating frequency, which was thus fixed by the combination of three sets of R and C values.

In the feedback oscillator, usually two R's and C's were combined so that the net work produced zero phase shift at a particular frequency where their reactances and resistances produced the necessary symmetry. In another

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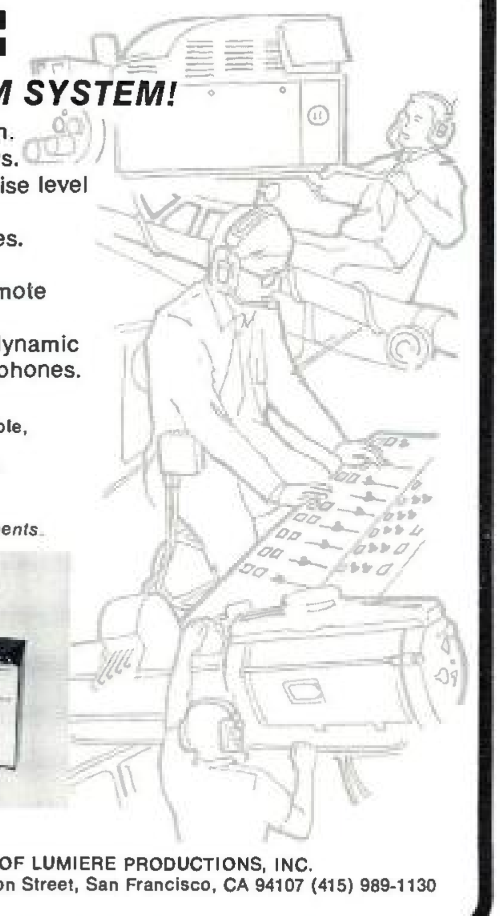

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variant, the network was a twin-T, with three R's and three C's in a network that either produced a null at the operating frequency, or else produced precise phase reversal (180 degrees) at that frequency.

In all those circuits, frequency was determined by the reactance of components in the circuit.

In the relaxation oscillator, an active device such as a tube—now replaced, usually far more effectively, by a transistor—alternated between two conditions, conducting and non-conducting. What controlled this change was the voltage in a resistor-capacitor combination. With the capacitor fully charged in one direction by the action of the circuit, the active device had its action suspended, until the voltage on the capacitor leaked away through the resistor, according to the circuit time constant, to a critical point.

At that point, the active device would trigger the next action of the circuit. This kind of circuit is time referenced. Where it generates a square wave, the length of the flat top and bottom of the square wave is determined by the time constants of the R and C components, and by certain voltage ratios set by the design of the circuit. Such a circuit can have its frequency controlled—really by controlling the period duration—by applying a variable voltage to that part of the circuit where the R-C time constant sets the interval.

A frequency referenced square wave could be made—and some early circuits generated them this way—by starting with a sine wave oscillator, which was the basic shape generated by all frequency referenced oscillators, even if it was often not a very good sine wave, and then clipping its tops and bottoms off.

The first such clipping would make a trapezoidal wave, one with horizontal top and bottom, but sloping sides, because the sides of a sine wave slope. By amplifying and clipping again, the sides could be steepened as much as you want. It was never a perfect square wave—but then, if you want to be particular, a perfect square wave has never been generated. Its frequency, of course, was always that of the sine wave from which it started.

The relaxation oscillator almost inevitably had steeper sides than this fabricated, wave-shaped variety. The circuit produced a trigger action which very rapidly flipped the circuit from one bistable condition to the other. Usually one of a pair of active devices is always non-conducting, while the other is conducting. Come trigger time, both of them amplify for a split second, and the situation is reversed.

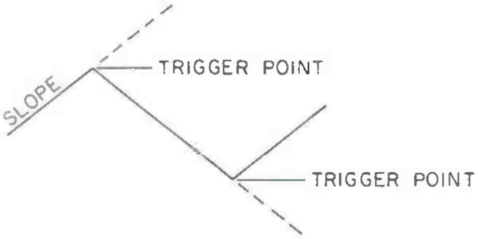


Fig. 1 How a triangular wave is built.

The function generator, in a way, provides the link that brings us back to where we started. We were able to generate either a sine wave, with a machine that is frequency referenced, or a square wave (or other shape) with a machine that is time referenced, and we could convert a sine wave into a square wave. Now the function generator gives us a means of making a sine wave that is time referenced.

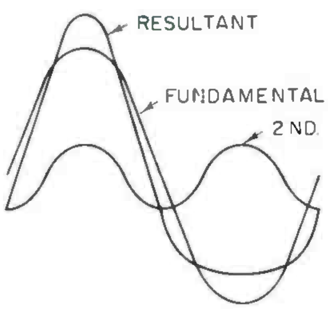
The basic function used in such a generator is similar to that described for the relaxation oscillator, but the function generator does it with more precision. Instead of a simple R-C charge circuit, the function generator has a constant current circuit that can alternately charge a capacitor in opposite directions.

During each such charging action, the voltage on the capacitor is a linear slope, producing one of the slopes of a triangular wave (FIGURE 1). This charge goes on till the voltage reaches a preset trigger point in that direction, when the charge direction is reversed, and the slope goes the other way. When the voltage gets to the other trigger point, then it is turned back on its first slope course.

The shape of such a wave is determined by the voltage distance between the trigger points, and the slopes of the lines going back and forth between them—again, this is a time referenced operation.

Having generated a perfectly controlled triangular wave, it can now be shaped into virtually any symmetrical waveform. Shaping it into a near perfect sine wave is a cinch. Using diodes appropriately biased to change the slope at successive intervals of voltage change, a sine wave with low fractional percent distortion is easily and consistently produced.

Fig. 2. Two-frequency synthesis of a single-ended pulse



Such a circuit can have tremendous advantages in producing very low frequency sine waves, of equally perfect form, that would be impossible with any of the older type circuits. If you want a sine wave that completes its cycle once every ten minutes, no problem!

As readers are undoubtedly aware, music synthesizers use generators capable of producing any of these waveforms, using voltage control for both frequency and amplitude. Actually, to be academically correct, such generators do not control frequency; they control periodicity. Where the old frequency referenced oscillators worked because certain reactances took effect at so many hertz (usually called cps in those days) the new ones set the individual period length in microseconds.

Academic, admittedly, but it helps understand the differences in how they work. There is another difference. A frequency referenced oscillator has to "get going." If it produces a good sinusoidal waveform, it usually takes

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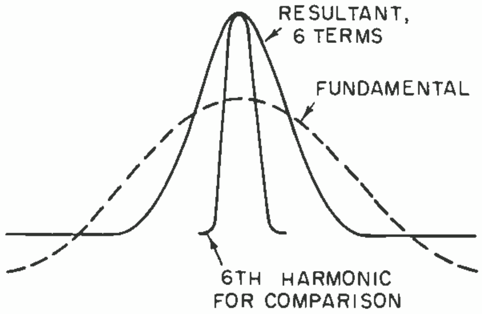

Fig. 3. Synthesis of the same pulse, using 6 frequencies. The successive series are:

f
$f + 1/4\text{-}2f$
$f + 2/5\text{-}2f + 1/15\text{-}3f$
$f + 1/2\text{-}2f + 1/7\text{-}3f + 1/56\text{-}4f$
$f + 4/7\text{-}2f + 3/14\text{-}3f + 1/21\text{-}4f + 1/210\text{-}5f$
$f + 5/8\text{-}2f + 5/18\text{-}3f + 1/12\text{-}4f + 1/66\text{-}5f + 1/792\text{-}6f$

a good many cycles of any particular frequency to reach a stable level. The function generator, on the other hand, produces its first cycle perfectly, at the same level as all subsequent cycles, unless the voltage operated amplitude control is used deliberately to change amplitude.

There are other differences between frequency and time referenced circuitry and operation. And this was what started me off at the beginning, although I have digressed by showing the practical significance first, in the way different generators operate. This distinction can be demonstrated by considering pulses from two viewpoints: frequency synthesis and time analysis.

Frequency synthesis would use either a Fourier series—which must be taken to infinity before you see the result—or a successive finite series, to approach the ultimate, ideal waveform. Time analysis considers only its shape through time—how the voltage rises and falls within the duration of the pulse.

Using the successive finite series, a fundamental with 1/4 amplitude second harmonic makes a first approximation to a pulse (FIGURE 2). If you add some third of 1/15 amplitude, you can raise second to 2/5. As you add successive harmonics, you can raise the value of earlier ones, slowly getting something that looks more like a pulse. FIGURE 3 shows the form produced with harmonics up to sixth.

For comparison, we show a pulse produced by drawing one cycle, from bottom peak to bottom peak, of just the 6th harmonic. That is more like what a pulse generating circuit that is time controlled would produce, if it had a switching time equal to half a period of the 6th harmonic.

The reason for the radical difference is that the frequency synthesis route is analogous to a balancing act. All those diminishing magnitudes of harmonics are devoted to ensuring that no ripples occur in the interval between pulses. The sharpness of the pulse is limited by the larger magnitude, fundamental and lower harmonics, combining, and thus is much broader than just a cycle of the 6th by itself.

Space has just about run out on me for this time. I had wanted to compare the Fourier analysis of various waves of straight line form with that produced by successive finite series approach. This is quite instructive, but will have to wait for another time. As you may probably know, wherever you cut off the Fourier synthesis, you are left with a wave that has ripples on it. And since you cannot get frequencies up to infinity, even with modern technology, how can one have the good-looking square waves, sawteeth (sawtooths?) that we have seen displayed on CR tubes? The successive finite approach shows how, as well as helping to understand the difference between synthesis and analysis, as being not merely the inverse of one another. ■

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Martin Dickstein

SOUND WITH IMAGES

Projector Care and Maintenance

• Last time, several ideas concerning the care-taking of tape recorders, both audio and video, were discussed. Certainly, there are many more tricks and techniques that are known by those who work with these devices in all circumstances of operation, such as the type of cleaning liquid most satisfactory, head demagnetization suggestions, and so on. Similarly, there are some simple ways to keep projectors working satisfactorily with a minimum of down-time.

Film projectors have a few more moving parts accessible to the operator than does a tape recorder; each of these parts should be checked very often to make sure they are clean and in good shape to protect the film and to offer a smooth and clean presentation. In most industrial audio/visual installations, the most-used projectors are those for 16mm film and 35mm slides. Others in lesser use are for 35mm film, slide projectors for different size slides, strip projectors, etc. In general, film projectors are similar within any one class, and in this discussion, certain units will come to mind immediately; others will be able to be handled in a similar manner although type, location of parts, and other dissimilarities may exist.

In the 16mm film class there are generally two types—the kind that will thread automatically and the type that requires manual threading. The film path is the same in both—past a series of rollers, around motor driven gears, around a sound drum, past idlers, and up to a takeup reel. These all make sure the film moves smoothly. One essential segment of the film path was omitted—the small section where the film goes through a gate, past an aperture, in front of a source of light, and is pulled through by a toothed mechanism at the proper speed to provide smooth flow of motion on the screen. It is this film path and projection system that we'll discuss, first.

Starting with the source of light, the projection lamp is housed in a protective enclosure to keep the light output from straying out of the film illumination path and into the room, projections booth or the eyes of the projectionist. (This housing gets quite hot and care should be taken when working around the area during use.) Some of the light does escape through the top of the projector through the vented area over the housing. This opening is actually provided for the escape of the heat from the lamp. A fan in the projector operates normally as long as the motor power is supplied. This means, therefore, that as soon as the projector is stopped, the fan also goes off. In a great many presentations, the film showing is done in start/stop fashion, and this process can go on for some time. Heat is not usually carried away sufficiently during actual operation, so that when the projector motor is off, the heat in and around the lamp housing escapes only by the air convection in the room. The longer the start/stop process, the greater the heat accumulation. The housing and any controls in the immediate vicinity of the lamp remain hot and can possibly cause injury.

There are, therefore, several obvious conclusions to be drawn, suggestions to be made, and some questions. Under all circumstances, care must be taken while working at or near a projector during a showing. The projection room should be well ventilated, not only for the good of the projector, but also for the well-being of the projectionist. For ease (not always speed) of rewinding the film after a presentation, the projector is turned on. This provides fan circulation to the lamp and housing and will prolong the life of the lamp. For cooling efficiency, it's obvious that the area through which the circulating air must move should be clean and clear of obstruction. Enough room must be left around the projector, if the unit is installed in an enclosed area, to permit the air to move freely. Nothing should be

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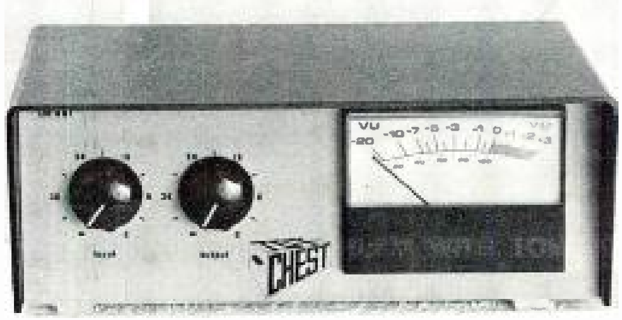

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placed on the projector where the hot air emerges, and the area in which the unit is placed should be kept clean of dust, cigarette ashes, and any dirt particles which can be drawn up or into the projector. (In the event the lamp blows during a showing, extreme caution must be exercised to avoid injury during replacement.)

The difficulty and danger of a sudden lamp failure, as well as the delay that causes during the presentation, can be forestalled by changing the lamp when it starts to turn dark or gray and when the slightest sign of a blister in the glass of the lamp starts to show up. If precautions are taken and the lamp replaced before the expected life of the lamp runs out, downtime of the projector will be reduced sufficiently to make the trouble of the precaution worth while.

To keep the lamp output at specified level, it also helps to maintain the rest of the illumination components in the best operating conditions. The brightness and sharpness of the image in presentations are maintained at peak level when the lenses and heat filter are kept clean. Depending on the type of projector, the lenses may or may not be readily accessible, but in most cases, with care, they can be taken out of the projector with only a minimum of effort. These lenses should be checked regularly and cleaned carefully with lintless lens paper or lens cleaner. Finger prints should be removed completely without scratching the glass before the lenses, either front or rear, are replaced into proper position. In most instances, the lenses are keyed in their individual mounts and the glass should not be removed from the frames. The mounts are usually also keyed so that each unit can only fit into one place in only one way. This assures proper replacement after cleaning.

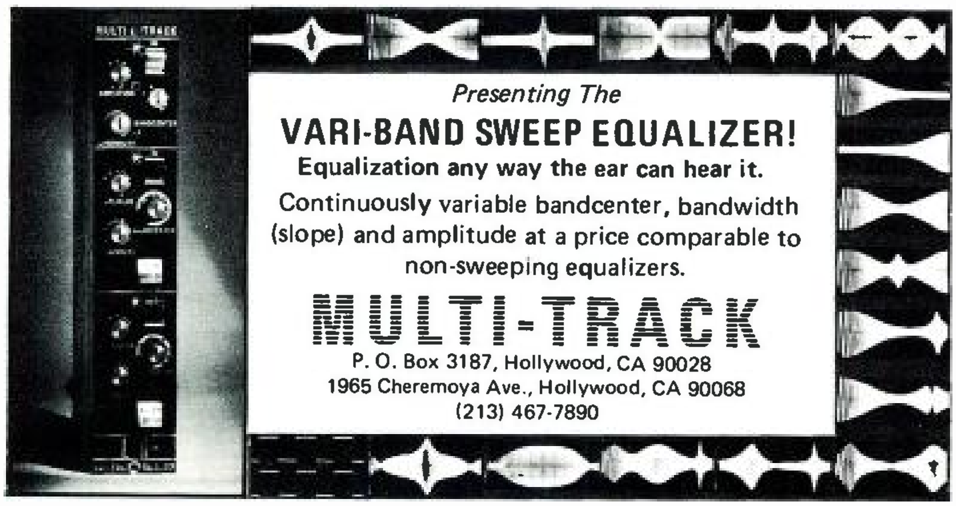
In some projector units, the heat filter is not removable but can be reached with the lenses removed. This glass also needs cleaning periodically with lintless lens paper or cleaner. (If the heat filter cracks or breaks, it should be replaced as soon as possible. The projector should not be used without the filter or the film will burn.) If the lenses crack, this sometimes will not be noticed just by watching the image, since only a small amount of light might be lost and not noticed. If the picture will not come up at all on the screen, it will be possible that a broken condenser lens might be the answer.

The reflector in the lamp system is located behind the lamp and directs the light that is thrown toward the rear of the projector back toward the film illumination path. This reflector is usually factory installed and adjusted. It rarely requires continual attention, but should be inspected and cleaned occasionally to assure proper image brightness. Care should be taken to avoid damaging or scratching the reflector surface. It should be cleaned with lens cleaner or lens paper, taking care not to leave fingerprints or lint.

The film path must also be clean. In the type of projector which has a lens which only moves forward and back (usually in the manual-load type), there is also a removable gate shoe that can collect lint and dirt which will show up on the screen. It not only looks bad but some of this debris could possibly scratch the film. Directly behind the shoe is the aperture through which the lamp beam reaches the film. The rollers, idlers, toothed gears and pulldown mechanism are also part of the film path. All of these locations, the space around the aperture, and the sound drum must also be kept clean with a cleaning fluid and clean, lintless cloth or brush. In the model which permits swing-away lens holder movement, the path around the aperture can be reached easily. Otherwise, as in the manual load projector, it is necessary to insert a probe such as a pipe cleaner to cleanse the aperture and path. Caution must be observed to prevent damage to the lamp and other items in the path, and especially, no cleaning should be performed while the machine is in operation, for the sake of the projector and the operator.

One other place to look for trouble before it starts is in the spring action of the gate shoe or pressure plate depending on the projector. The tiny springs that provide the pressure on the film during its motion past the aperture are held in place by tiny screws. The screws should be checked for tightness and the spring for ease of movement. If one of the springs gives way, or if one of the screws loosens or goes through the plate a bit too far, the film can be badly torn or scratched—ruined, possibly.

Also in the line of preserving the life of the film, it would be wise to clean the film periodically to prevent dust or oil from collecting on it and damaging the image. The dust could also come off in the projector and introduce the possibility of future trouble. There is a film cleaning solution which is recommended. A piece of soft velvet can be used to apply it



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during a normal rewind process. One-and-only or special copies of films might also be handled with white gloves, just to make sure they stay clean and in good shape.

Another thought on handling film—when attaching the film on the projector to the take up reel, an adhesive tape should *not* be used, especially if the projector is of the auto-load type. If, when the tape is rewound, it is run back through the normal film path, the adhesive material could possibly catch in the gear or gate mechanism and remain to cause trouble on the next loading. At least with a manual load unit, if the adhesive sticks somewhere, removal of the film is quicker and easier than with the auto-load units. Of course, on either projector, if the film path at the aperture is opened up by movement of the lens and the pressure plate or shoe, the sticky stuff may not stick at the aperture, but it can foul gears or the sound drum. (And, speaking of film, if any film develops broken sprocket holes or a bad splice where either the loop is lost or the film parts, the film should not be used again until the damage is repaired properly.)

Much of the care that goes into maintaining a film projector can also be applied to a slide projector. There's no path of movement past an aperture, but there is movement of parts; there is a lamp/lens/heat filter system for projecting an image onto a screen and care of these parts is the same as for a film unit. The same technique is used to clean these parts with the same materials as in the movie projector. Care of slides is similar to that of film. Ventilation for the lamp is the same as in the film projector except that in some projectors the fan can be turned on without the lamp, while in others this is not possible. Replacement of lamps, lenses, etc. should be done with the same care as in the film projector. In some of the slide projectors, the fan can be left on after a presentation to cool the lamp. This can come in handy to change the lamp during a presentation (if this does become necessary). It would be wise to replace the lamp before its life is completely gone—as in the film projector. Here again, the same precautions must be taken in positioning the slide projector. Air must flow cleanly around and through the unit to help cool the lamp. Although normal operation of the fan usually does not keep the lamp cool enough to handle, it does keep it from breaking. The air passing through the projector should be cool, clean, and the air vents should be left unblocked. In those units in which the cooling air is brought into the projector from the bottom, the projector should not be placed on a soft surface (like a chair or sofa) to permit easy flow of air.

You will recall that this whole discussion of care of equipment started (in the last column) with a voicing of opinions by industrial users of such equipment and the dissatisfaction they expressed with the lack of helpful hints passed on by the equipment salesmen (aside from the equipment manuals that come with the units). Other questions that came up were concerned with whether it mattered if the projection lamp was handled carefully or not (prints, etc.), whether the fan on a slide projector could be left on too long so that the lamp could possibly reach a temperature below the room ambience and then blow if it were turned on suddenly, whether it was really necessary to cool the lamp with the fan at all or if this cooled the lamp too fast for its own good and if the lamp were safer with just turning off the projector. Any ideas by our readers on these or any other points would be appreciated. ■

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Picture Gallery—45th AES Convention

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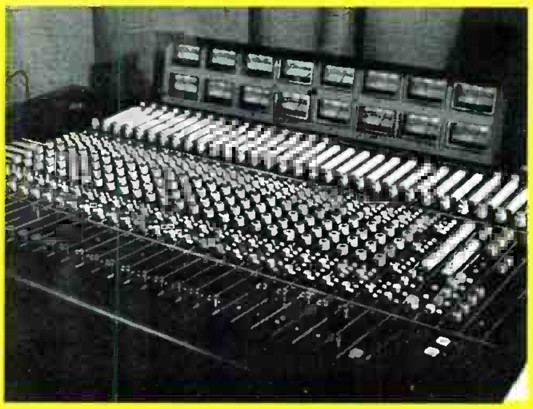
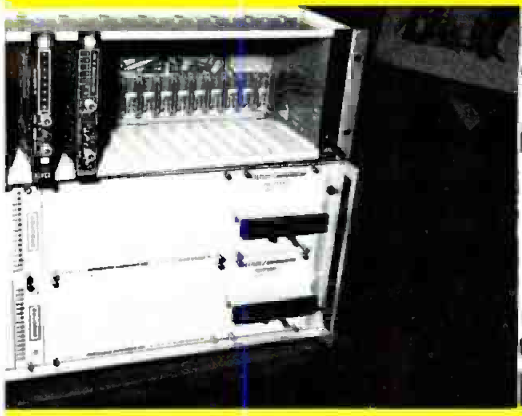


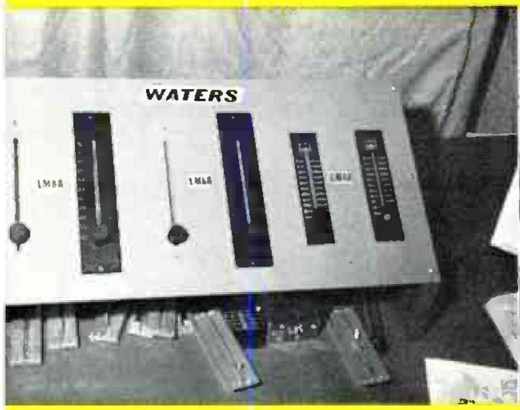
As many as 26 in and 16 out on the Son of 36 Grand by Auditronics also had quad/stereo/mono mixdown. Circle 94 on Reader Service Card.

Mark Levinson, a west coast distributor, showed their own compact stereo mixing board. Circle 49 on Reader Service Card.

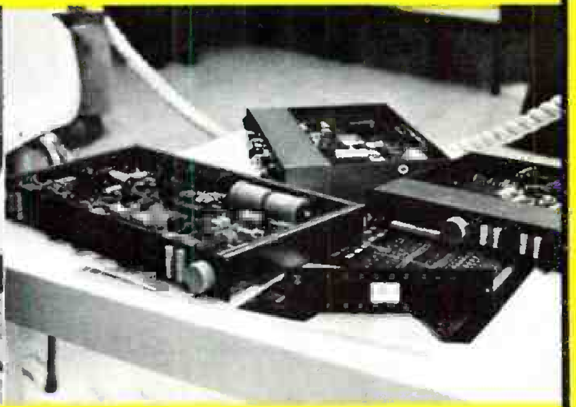


Allison and API have cooperated in the design of a mixing console computer memory system. Circle 72 on Reader Service Card.

Cetec is the new name, but Electrodyne is the maker of this model 2000 board with quad mixdown. Circle 70 on Reader Service Card.



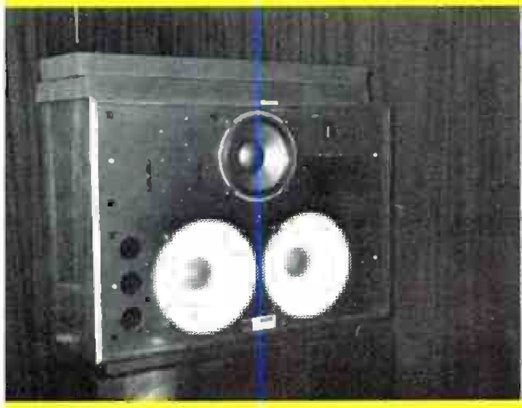
This demonstration board showed only a part of the Waters fader line that is available. Circle 60 on Reader Service Card.



The English firm of Trident manufactures consoles and components distributed by Audiotechniques. Circle 82 on Reader Service Card.

Bushnell offers this compact console for a variety of recording uses. Circle 62 on Reader Service Card.

Multiple woofers and wide dispersion high end drivers are used in United Sound Systems speakers. Circle 63 on Reader Service Card.



James B. Lansing Sound showed covered and uncovered versions of this 4350 model studio monitor. Circle 43 on Reader Service Card.

Among the studio monitor speaker line of Altec's are these model 9846 and 9848 models. Circle 42 on Reader Service Card.

Be sure to attend . . .

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Successor to the Crown DC-300 is the improved 300A. It has twice the output devices. Circle 96 on Reader Service Card.

Bose, long known for speaker systems ins now into electronics with the 1800 800 watt stereo amplifier. Circle 80 on Reader Service Card.

Strom Communications makes a broard line of amplifiers and speakers. This is one of their huge horns. Circle 46 on Reader Service Card.

This demonstration of the Systron-Donner tone generators and spectrum analyzer was effective. Circle 93 on Reader Service Card.

BGW's massive power amplifier has 275 watts across 8 ohms, 550 across 4 ohms, 1500 across 1 ohm. Circle 85 on Reader Service Cards.

These components comprise the DuKane line of equipment for audio spectrum control. Circle 44 on Reader Service Card.

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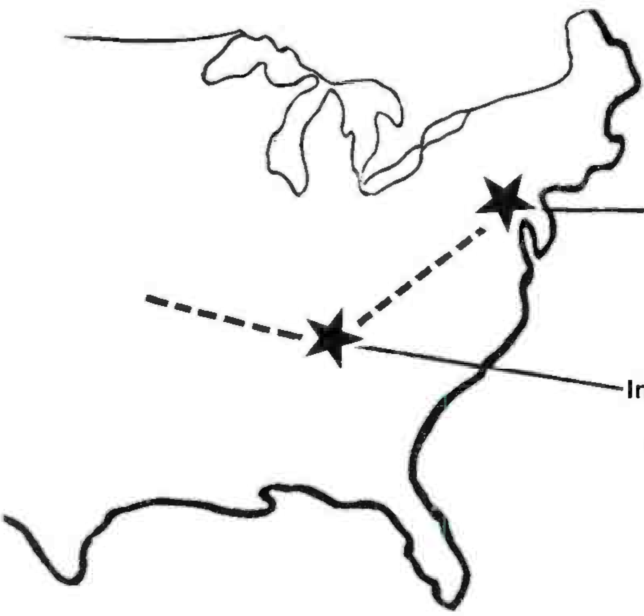

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Circle 24 on Reader Service Card

JOHN WORAM and LARRY ZIDE

db VISITS—Sound 80

RECENTLY, **db** packed its cameras and boarded a Minneapolis-bound plane to pay a call on Sound 80, one of the midwest's most impressive contributions to the world of recording studios.

Sound 80 began in 1969, when Herb Pilhofer, the music director of the Minnesota Theatre Company, joined forces with engineers Tom Jung, Scott Rivard and Gary Erickson. In 1971, they moved into their present specially designed building.

Sound 80 is a recording studio (*five* studios as a matter of fact) with its own audio systems division and creative services department. Old timers who still insist that all recording sessions must be done within walking distance of an ocean are advised to stay away from the twin cities area.

Sound 80 boasts two 16 track studios, a quad mixdown room, and 35 or 16mm film facilities. They've also installed a complete tape-to-disc transfer system. And in downtown Minneapolis, on the 40th floor of the new I.D.S. Center, they've just opened an elegant announcer studio as a service to the local ad agency business. Since many of the office buildings in this area are linked by pedestrian passageways, the harried ad man need not even stop for his coat when the inspiration for another brilliant recorded announcement hits him.

All studios have their unique tales of construction problems and the I.D.S. installation is no exception. Located in the next room is a psychiatrist's office. Now, although many studios could really use a staff shrink on the premises, the analyst didn't think it would do much for his patients' psyches if through the walls they heard the advantages of this or that detergent.

So, acoustical consultant Robert Hansen specified 500 square feet of lead shielding, weighing in at 7000 pounds, for the wall separating the couch from the console.

Sound 80 Vice President and Chief Engineer Tom Jung supervises the I.D.S. studio as well as the main studio complex at 2709 East 25th Street. Also at this location is the systems division, with design engineer Gary Erickson in charge. Among other projects, the division designed the Auto-Cue-2 system for the Stratford Theatre. (**db**, December, 1972).

And, the ZPE (Zero Position Error) Sync System is also a product of the Systems Division. The device permits two transports to be interlocked for 30 track recording sessions or for video-audio work. Although not as complex as other interlock systems, Sound 80 feels that its modest price tag of about $2,000 may encourage smaller studios to progress beyond 16 track with minimum expense. The unit should be ready for marketing in the not-too-distant future.

Creative Services is another facet of the complete Sound 80 concept. President and Director of Creative Services Herb Pilhofer—who claims he would rather be on a house boat on the St. Croix—may often be found in his office working out an electronic music score on his ARP and Moog synthesizers. Some time ago, Herb produced a five (5?) channel presentation for Pan AM. He also composed the musical score for the Guthrie presentation of *Julius Caesar* as well as countless arrangements for everything from commercials to classics.

Following, are photos taken at the Sound 80 studios. Each has a self-explaining caption.

Sound 80's modern studio-headquarters building.

This capacious lobby greets the visitor to Sound 80 studios.

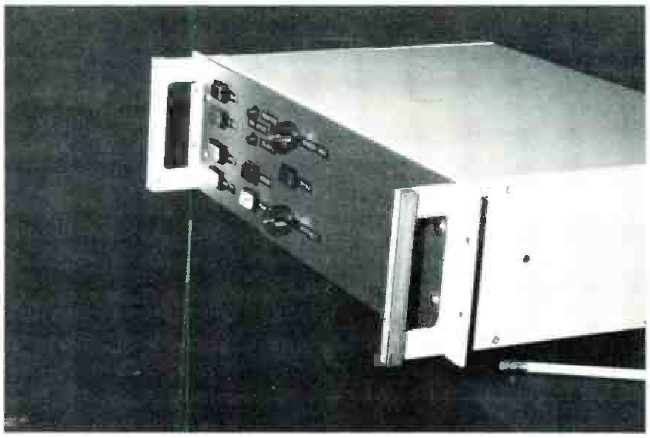
Tom Jung at the board and Herb Pilofer pondering during a mixdown session.

Special effects for a t.v. commercial are created by Herb Pilofer on one of the synthesizers at Sound 80.

The view into the studio over the console. This picture was taken as Canadian producer Bob Burns recorded the film score to Race Home to Die. *A soundtrack album is scheduled for release on A & M records.*

The small announce studio in the I.D.S. building in downtown Minneapolis. Engineer Bob Schultz assisted by Jackie Maron are at work recording a reading.

Two sixteen-track machines are interlocked during a 30 track session. The ZPE syncronization system of Sound 80's is used.



The ZPE "black" box. This synchroniser is expected to sell in a commercial version for around $2000.

Record mastering is done on a computer controlled Neumann lathe. Robert Berglund is in charge.

W. A. RHEINFELDER

New Approaches to Improved Tonal Reproduction, Part 1

The author has spent at least fifteen years of experimentation and research in audio circuit design aiming at better tonal quality. This series is a product of that work.

WHEN SITTING DOWN to listen to a recording, most of us are annoyed to varying degrees by imperfections of one sort or the other and, depending on the degree of annoyance and our technical skill and knowledge, we do something or little about it. When there is too much noise, we might reach automatically for the treble control and turn down the noise (and the treble content of the music) and arrive at a different, not necessarily satisfying, condition which might be more satisfying for the moment. The same kind of action is often taken for excessive distortion, with similar semi-satisfactory results; if the bass appears weak, we use the conveniently provided bass control, and although it may not accomplish what we were after musically, it does change the sound character at the low frequencies, and what else can be done anyway?

To a person with a keen ear, experiences like these are exceedingly frustrating. If he becomes utterly distressed at a harmonic distortion of 0.8 per cent, he obviously has a harder time in achieving satisfactory reproduced sound quality than the average listener, who will be quite happy with ten to fifteen per cent distortion. Similarly, a musician familiar with the tonal character of an instrument tends to be less satisfied with reproduced sound than a person who has never heard or played a live instrument.

The deficiencies common in a sound system are *distortion*, (harmonic and intermodulation), *noise* (wide band hiss and pop, extraneous tones, 60, 120 Hz and higher harmonic hum, rumble, beats and interference, such as the 15.75 kHz t.v. horizontal oscillator, the 9 kHz a.m. station beat, etc.), and lastly, *poor tonal balance*, which is a most common problem, but is tolerated amazingly well by many people.

PROBLEMS WITH DISTORTION AND NOISE

It appears reasonable first to remove, as much as possible, the cause for the deficiency. For example, in the case of distortion, the amplifier and speaker system should be checked out, using measurement techniques and critical listening tests. If the problem is not there, the source needs to be worked on. With records, the stylus is often at fault, and with a critical ear, it is easily found that unless both angles of the stylus to the record surface are correct (and in most practical cases they are not), the distortion will be excessive even in an otherwise excellent system. As a general rule, if you are distortion conscious and you have a problem, it is most likely a stylus or tracking problem, particularly if the system was good to begin with. Stylus angles don't stay put! Other sources of distortion include tracing distortion, pinch effect, tracking angle error, etc. For the purist, stereo records produce less distortion if they are played monophonically so that the high-distortion vertical component is cancelled (which is often no loss unless the stereo effect was pronounced and must be retained at all costs). Theoretically, the difference between channels A and B is less than the sum if they are equal and in phase, which is practically not the case, and this difference is recorded vertically in stereo records to achieve less distortion because of the supposedly smaller amplitude, while the sum is recorded horizontally as usual. Listening to one channel only on stereo does not reduce the distortion; it is necessary to use both cartridge outputs and phase them to cancel the vertical component.

Removing the cause of a deficiency first is also practiced with noise. Records can be kept clean, the stylus force can be optimized, and hum can be removed. Thereafter, it appears that the rest of the problems can be controlled by the judicious use of filter, limiters, tone controls and equalizers; this approach has led to some truly astounding results.

THE PROBLEM WITH TONE CONTROLS

The problem of equalization and tonal balance had been with the author for years until some rather drastic measures were taken. It is easy to demonstrate the problem in listening tests. But it is difficult to correlate the effect one is

W. H. Rheinfelder is an engineering consultant, as well as a musician.

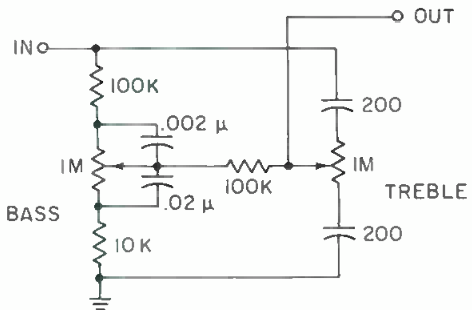


Figure 1. A loss-type tone control.

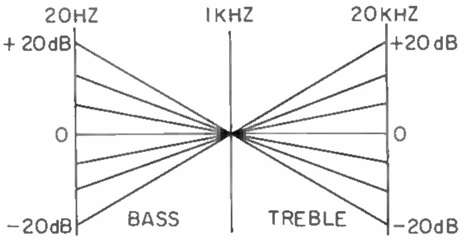


Figure 2. The typical response of the circuit of Figure 1.

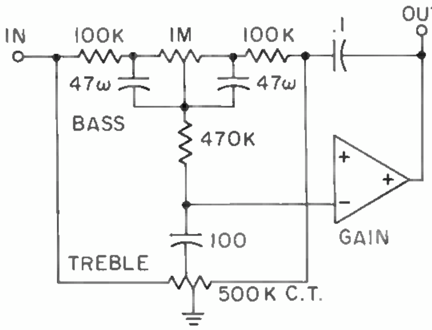


Figure 3. The circuit of a Baxendall control.

hearing to frequency response measurements until one goes to a very elaborate set-up described below.

A normal bass-treble control of the loss type is shown in schematic form in FIGURE 1 and by action in FIGURE 2. As can be seen, in boosting or cutting treble or bass, the maximum action is achieved at the extremes in frequency which is certainly undesirable. For example, for several reasons which we shall discuss in more detail below, bass frequencies of musical instruments are generally in the region of 80 to 130 Hz. If we want to boost frequencies in this region, for example by 10dB, we find that we are boosting 20 Hz by 16 dB and we are boosting the whole region below 80 Hz unduly. The same is true for the region above 130 Hz, which causes a muddy juke-box type of bass and all clarity is lost. Any boost in gain at frequencies where there is no music can only increase extraneous sounds, such as rumble, i/f noise, etc. Such a type of control has no musical value, although it is the most common type of control in use. The high end function is not much better and everybody knows how much music is lost and how little is gained in noise improvement as the treble is turned down.

An improvement was made years ago by a British engineer named Baxendall.[2] This control uses feedback for tone control (FIGURE 3) with two important results: reduction in distortion and variable inflection points (FIGURE 4). Inflection points are the points where the curve starts to rise or fall. In FIGURE 2, all curves hinge around 1 kHz. By contrast, in FIGURE 4, the hinge point wanders in from the outside. It is possible to boost frequencies below 100 Hz, for example, while leaving frequencies above 100 Hz unchanged. This cannot be done with the older type of control. The Baxendall tone control is functionally much better, costs no more, and is used in the better type of equipment; however, it still leaves much to be desired. In the maximum boost or loss position, it is identical to the old style controls, and again it has maximum action at the frequency extremes, where there is little or no music.

In the process of trying to find out what is the real cause for such poorly balanced sound, the author tried the circuit of FIGURE 5[3] with rather pleasant results. The response of the circuit of FIGURE 5 is compared with conventional bass control in FIGURE 6. By some chance the bass boost happened to be close to the actual musical bass frequencies and the Q was about right. At this point it was decided to develop a set of tone filters to expedite future research and to really find out what was happening musically.

HIGH AND LOW PASS FILTERS

A survey of the literature showed quickly that it was easy and relatively inexpensive to construct filters of 12, 18, and 24 dB/octave slope. (The normal tone controls might be called 6 dB/octave filters). In all these circuits feedback is used to sharpen the knee to make for a sharper cut-off, instead of the round knee obtained by cascading r-c sections. An 18 dB/octave filter requires three r-c sections and a typical example is shown in FIGURE 7, which is a high pass filter with a cutoff below 20 Hz for the values given. A typical filter of this type is shown in FIGURE 8 with details in the references[4,5,6]. Although these filters have practical value, for experimental purposes a somewhat sharper cutoff is desirable. Investigation disclosed a little known simple approach already given by Williamson,[7] which is capable of giving a slope in excess of 40 dB/octave. The principle of these types of filters is shown in FIGURES 9 to 12. Basically, a twin-T network is used in conjunction with a feedback amplifier and a two section r-c-network. Taking the output after the twin-T produces a null and the extremely sharp cutoff (FIGURES 10 and 12). Taking the output before the twin-T (FIGURES 9, 11), results in a peak at the twin-T frequency which is rolled off by the r-c sections and produces a very good dB/octave filter. Based on the principle of FIGURES 10 and 12, a high-low filter was constructed with the following logarithmically spaced cut-off frequencies: 22, 30, 40, 55, 75, 100 Hz and 4, 5.5, 7.5, 10, 13.5 and 18 kHz, all selectable by rotary switches. By careful trimming, the peak before cut-off was kept to about 0.3 dB and the second peak in the cut-off region was 28 or more dB down. The circuit for this combination filter is given in FIGURE 13. This combination circuit is harder to trim because only one feedback stage is used for both filters. Cascading of individual high and low pass filters as shown in FIGURE 14, allows somewhat easier design and accomplishes the same purpose. Frequency response of these filters is shown in FIGURES 15 and 16. Incidentally, in all practical filter circuits of this type, vacuum tubes or high voltage fets are preferable to bipolar transistors. High input impedance and low capacitance together with high gain, low noise, and good output capability are very desirable. High voltage

Figure 4. Idealized response of the Baxendall control of Figure 3.

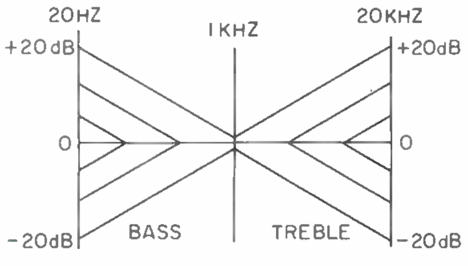


Figure 5. A special bass control (reference 3).

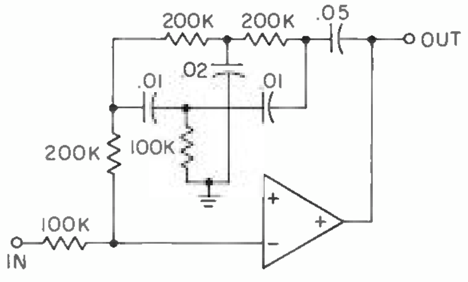
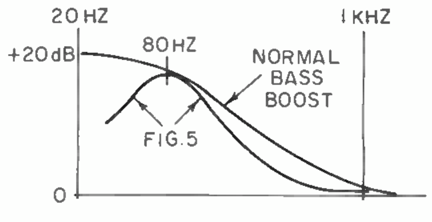


Figure 6. A comparison of the circuit of Figure 5 to normal bass boost.



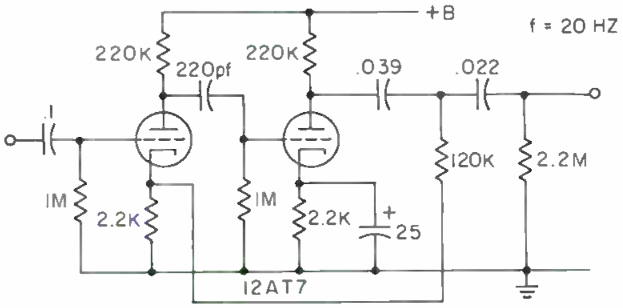


Figure 7. A rumble filter with an 18 dB/octave rolloff. Feedback produces a peak, rolled off by the r-c sections.

fets are reasonably priced and have all desirable features such as 25 volts or more output at 0.1 per cent distortion, less noise and better stability than bipolar transistors, together with input impedance and capacitance better than the best vacuum tubes[8,9,10]. One single fet of this type* will do what would take many bipolars and much complexity of circuit design. The only drawback is that the bias resistor in the source must be individually determined since manufacturers presently do not furnish values at the

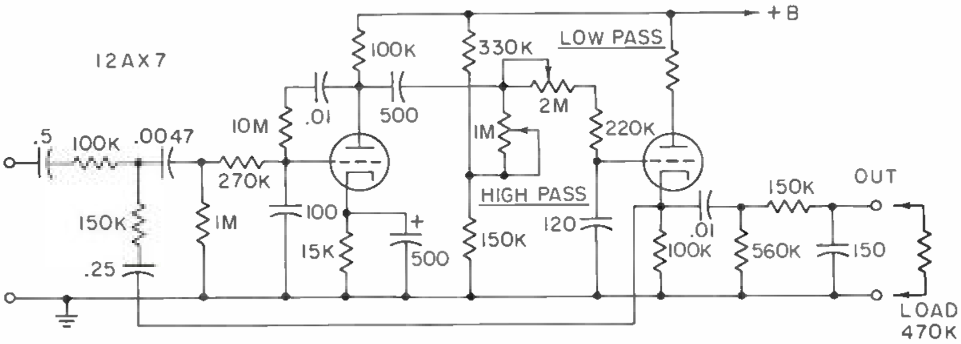


Figure 8. A variable 18 db/octave filter (ref. 4)—35 to 100 Hz and 5 kHz to 14 kHz.

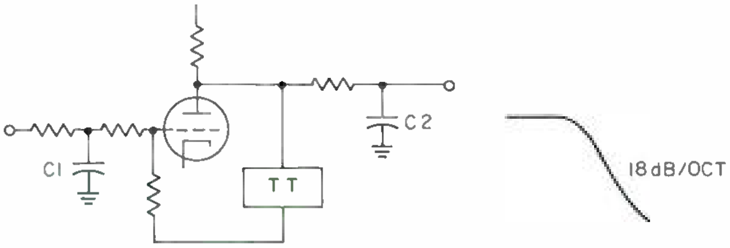


Figure 9. A twin-T low pass peaking filter and response.

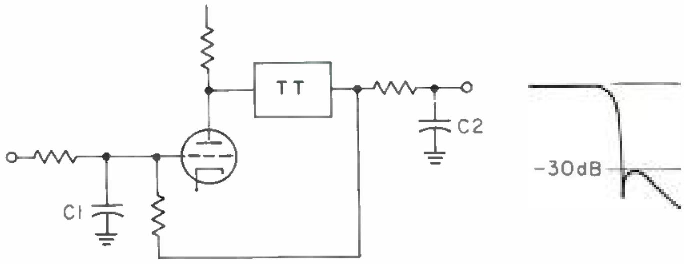


Figure 10. A twin-T low pass dipping filter and response.

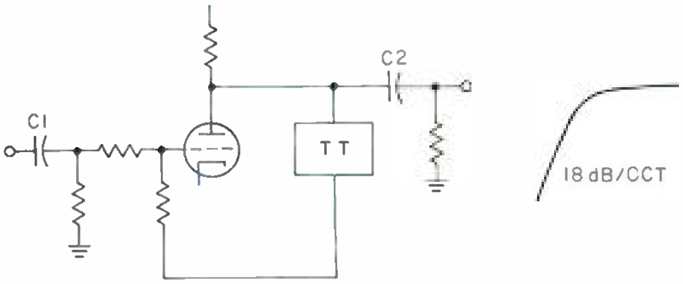


Figure 11. A twin-T high pass peaking filter and response.

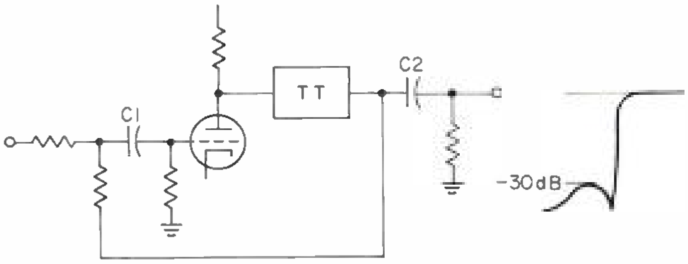


Figure 12. A twin-T high pass dipping filter and response.

operating point. Finding the right bias resistor is a small job, since maximum gain and least distortion coincide with fets and the gain maximum is readily found.

A TUNABLE TONE FILTER

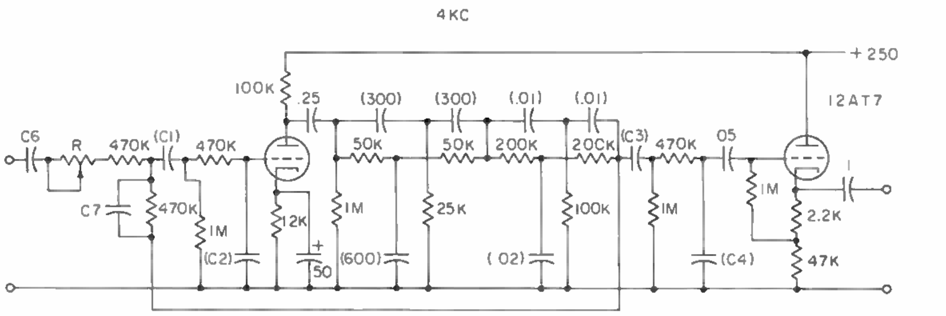
In addition to this cut-off filter, a very flexible tone filter was designed. The idea was to be able to accentuate or eliminate individual frequencies to different amounts and with different Q. Such a filter should be tunable from 20 to 20,000 Hz, permit a boost up to 30 dB, reject a frequency to 60 dB. both with a variable Q from zero to 30. At the same time, all other frequencies were to be constant while the processing of the signal was taking place, with an option of allowing the rejection of everything but the desired tone. Such a filter was designed[11] and the schematic is given in FIGURE 17 with the performance in FIGURE 18. It is interesting to note that the requirement of 30 dB boost and 60 dB rejection calls for a device in the bridge section having a distortion of 90 dB down. A 12 BY7A tube, of many devices tried, made the grade, when connected as a triode and fine trimmed, and achieved a distortion of less than 0.003 per cent. In the practical construction, replacement parts for a popular kit for a distortion analyzer were used and balanced sufficiently well in the Wien-bridge section. Work done with this unit disclosed the need for yet another piece of equipment for the analysis of music.

*For example: T.I.2N5544, TIS79, TIS78, 2N5543; Teledyne 2N4883, 2N4886, etc.

MULTIPLE FREQUENCY EQUALIZER

For the ultimate in a tone control, it would be desirable to be able to control many overlapping frequency bands separately. Before coming up with a suitable circuit, much research was done on selective feedback amplifiers. I had once designed a graphic equalizer for use in motion picture recording. While it was a good circuit for its purpose, it used many iron-cored inductors which were not only expensive, but hard to tune and the Q was not easily controlled. A simpler, more flexible feedback circuit was desired and finally a bridged-T was used, together with a phase shift network, to arrive at the desired response. The final circuit is shown in FIGURE 19, together with the re-

Figure 13. A combination hi-lo filter based on Figures 10 and 12. Twin-t's are shown at 4 kHz and 100 Hz. Capacities in parenthesis must be switched for different cutoff frequencies. Design points: 1. Twin-T null frequency fo=1.7 fc loss pass cutoff, fo=fc/1.7 high pass cutoff; C1 and C2 for maximum at 2 fo and fo/2 respectively; 3. C3, C9 for 0.2 dB rise at 2 fo and fo/2 respectively; 4. R is a fine adjustment for unity gain; 5. C6, C7 are optional for sharper response.



fc	fo	fo/2=fi	C
18 kHz	30.6 kHz	15.3 kHz	50 p
13.5	23.0	11.5	68
10.0	17.0	8.5	90
7.5	12.75	6.375	120
5.5	9.35	4.675	170
4.0	6.8	3.4	220

1. Select C2 for max. gain at fo/2
2. Select C1 for + 0.3 dB at fo/2
3. Select R1 for 0 dB at fo/10
(Includes source resistance)
Values given for CI and C2 are approximately .7.

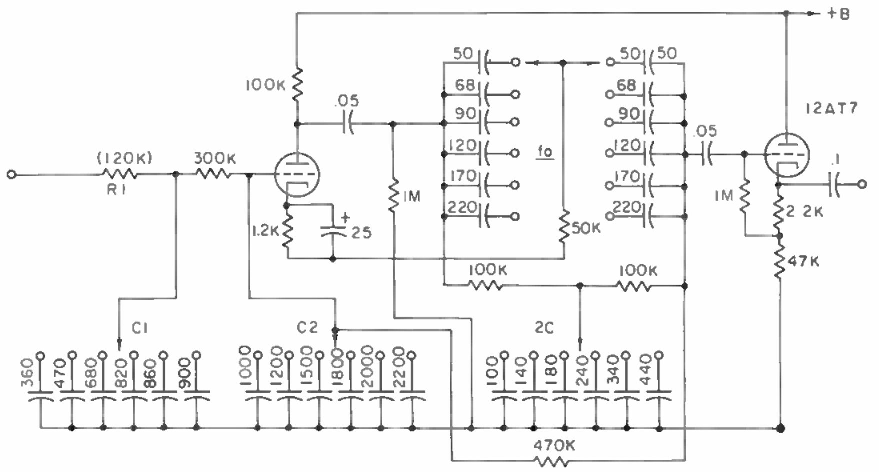
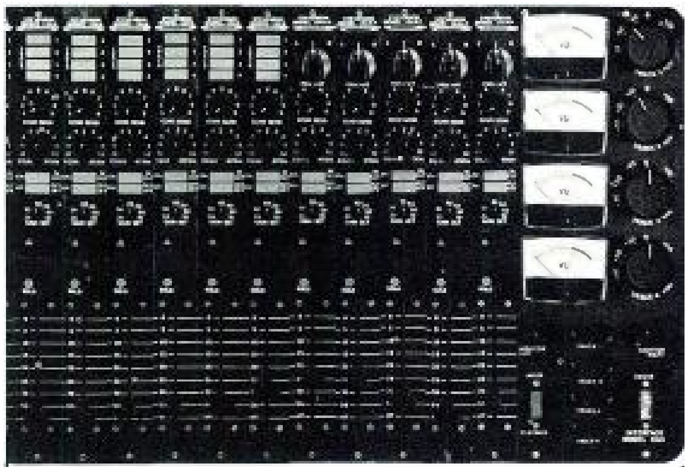


Figure 14. A practical low pass filter.

sponses in FIGURE 20. This feedback circuit proved advantageous for its low distortion and stability. Center frequencies arrived at in the end were 40, 80, 160, 320, 640, 1280, 2560, 5120, and 10240 Hz. A similar piece of equipment was available at one time commercially*, however, with a totally different circuit. In the design of this unit experimentation was carried out with different circuit Q's which is readily done by changing a few resistors to alter the feedback factor. With a Q=2, there was distinctive ringing; in fact, it had to be judged worthless from a musical viewpoint. A Q=1 proved ineffective to emphasize musically important ranges and was also judged useless. The circuit was then set in the middle at a Q of 1.41 and listening tests showed very nice action. With a Q of 1.41= 2, the frequency spacing must then be made on an octave basis if the ranges are to overlap properly. It is wise to

*Blonder-Tongue "Audio-Baton."



SERIES 100 MIXERS

Series 100 mixers are available in the Model 16X4 prewired frame shown above which accomodates up to 16 modules, and in the popular portable Model 8X4, which takes up to eight modules.

The standard model 8X4-100-2C is a professional quality portable mixer measuring 15x18x5" and weighing 18 lbs., has eight plug-in modules switchable to 200 ohm XLR-type mike inputs or line inputs, each providing push-button track selection, echo send, equalizing, solo button, slider attenuators; two with compressors. Integrated circuits throughout, four track outputs, max. 20 dbm to 600 ohms with masters, VU meters, XLR output connectors, two monitor mixdowns; other models with optional internal reverb. Price $2012.00 FOB Houston.

Series 100 mixers may be had with any combination of seven modules:
Model 100A standard equalizing
Model 100AP panpot equalizing
Model 100AQ quad equalizing
Model 100B multifrequency equalizing
Model 100C compressor equalizing
Model 100CP compressor/panpot
Model 100CQ compressor/quad.

Other options include built-in reverb and the C-1 Cover for the 8X4. Call or write for further details, prices, and address of nearest dealer. Dealer inquiries invited.

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Circle 20 on Reader Service Card

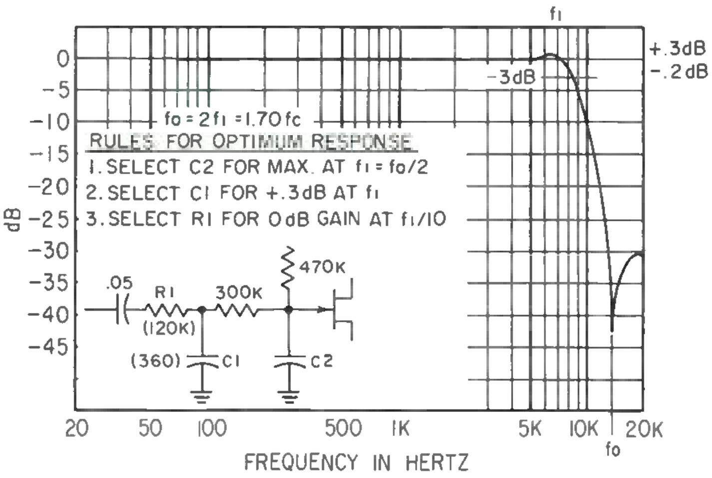
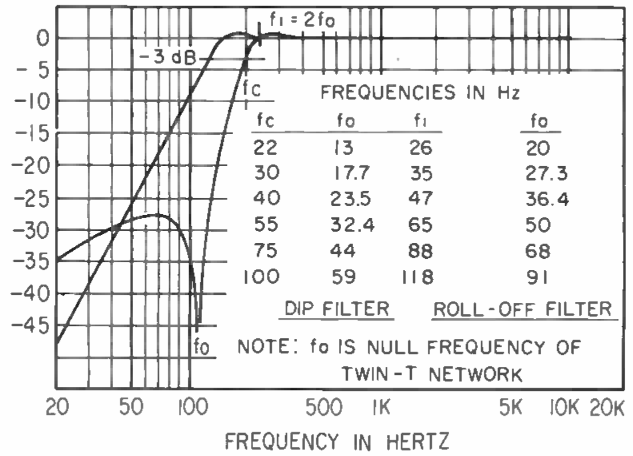


Figure 15. Typical low pass response.

Figure 16. A high pass dip and rolloff filter.



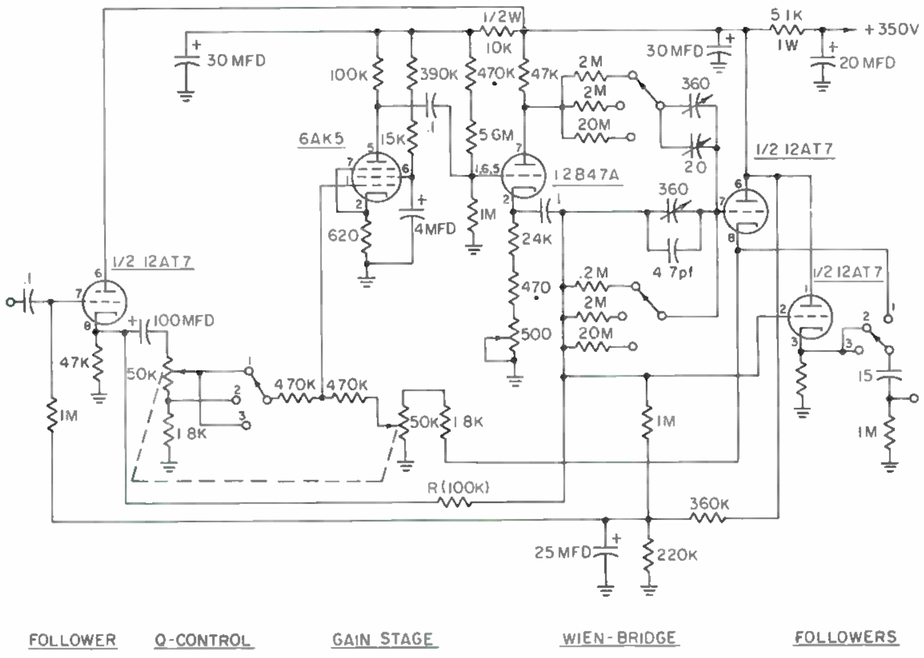
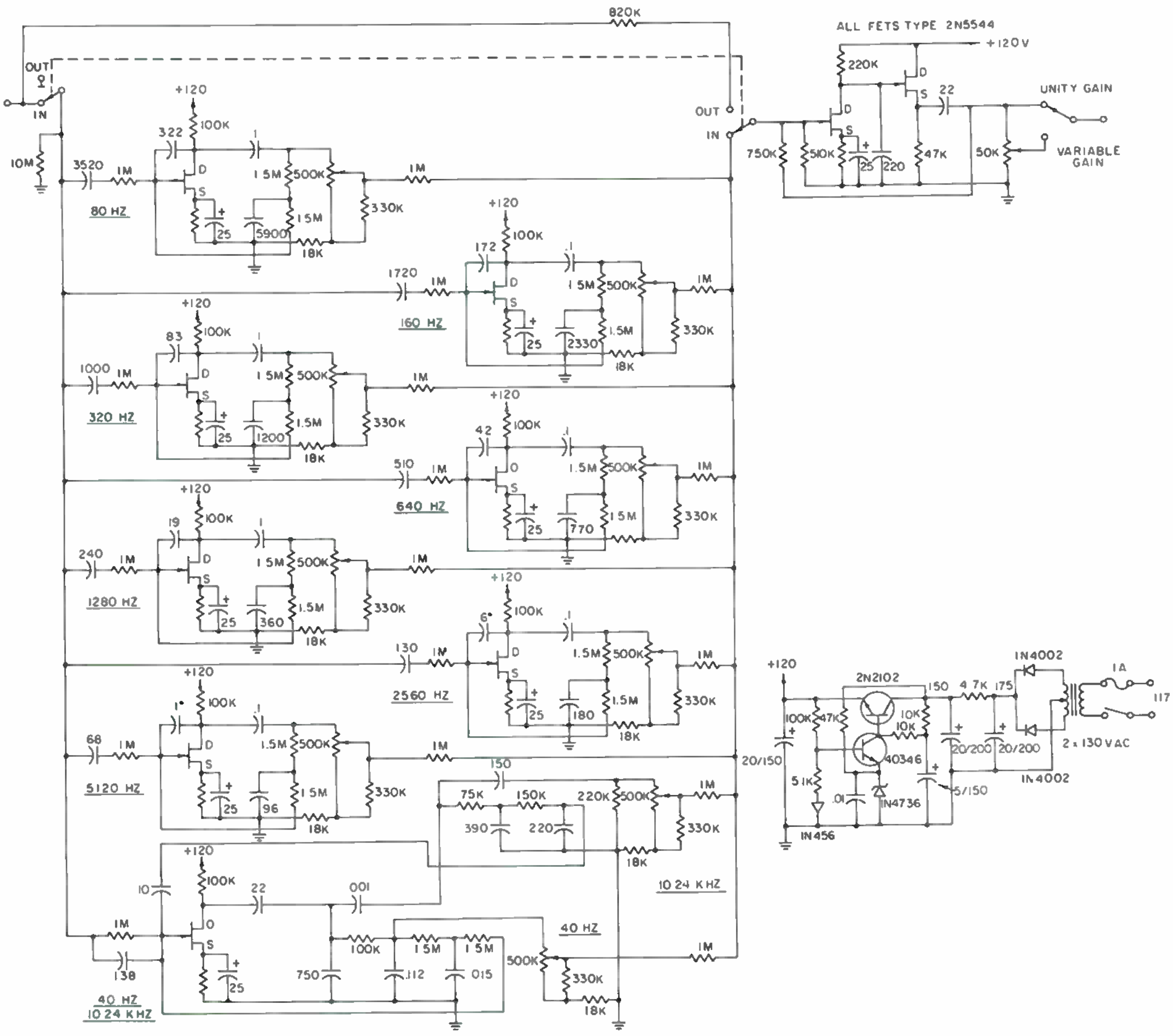


*Figure 17. A filter with adjustable Q from 0 to 30 and tunable 20-20,000 Hz. Switch positions: 1. frequency elimination; 2. frequency peaking, gain at peak changes with Q; 3. Frequency peaking, gain at peak constant. Note that d.c. filaments were used. The resistors marked * used for fine trimming. Resistor R may be used to suppress skirts of response to equal tuned circuit.*

put a frequency between the two hum frequencies of 60 and 120 Hz, not to unduly emphasize hum and harmonics. The other frequencies are then automatically obtained.

With all this machinery, it was now possible to carry out considerable music research, and some very interesting and unexpected results were obtained. This research led to a different, musician's type sound control, which will be discussed next month.

Figure 19. A selective tone equalizer. Note that bias resistors in source of fets are selected for maximum gain in the range 1 to 10 kohms.



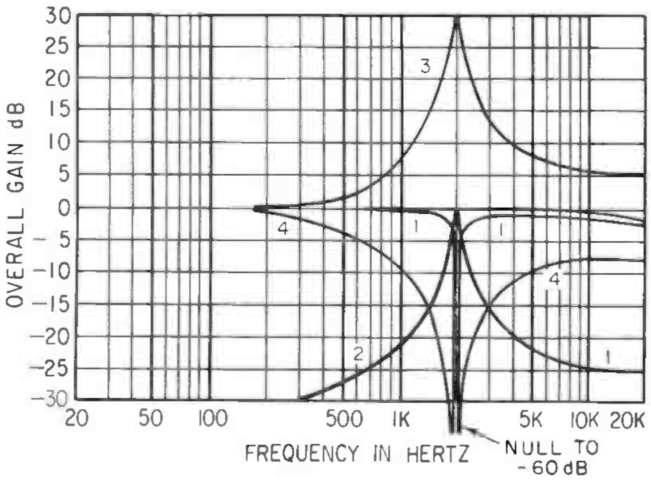


Figure 18. Responses of circuit of Figure 17. At position marked 1. reject; 2. select; 3. boost; 4. as in 1 with lower Q.

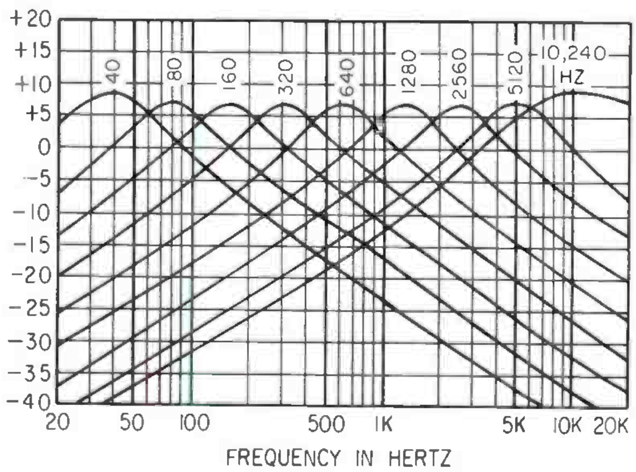


Figure 20. The responses of the circuit of Figure 19.

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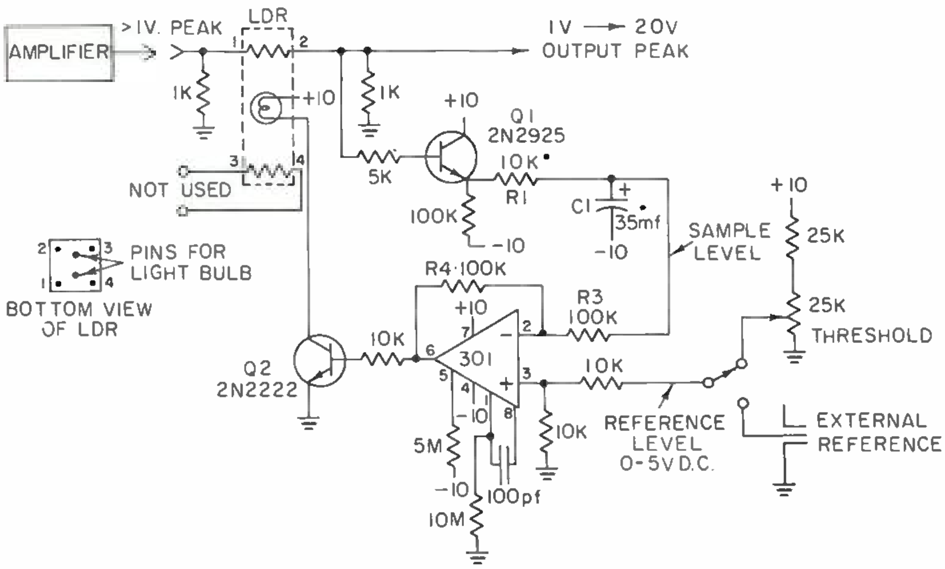

Figure 1. The schematic of the limiter circuit for audio signals at about 1 V nominal.

WHAT? Another design for a limiter? I suppose each of us has dabbled in electronics deep enough and long enough to realize that designing a limiter is no easy task. The audio man wants a box that will accept as much as +40 dBm of signal dynamic range, will put out the input signal with constant +0 dBm level, will not make the signal breathe, grunt, or pop, has near zero distortion and noise, will work with any signal from d.c. to light, and can be wired to limit in a lot of ways (fast or slow attack and decay).

Big order, isn't it? Some fellows would be willing to pay anything for this box. Well, this article will show you just such a box. It'll cost you less than $15 plus a ± 10 V.d.c. power supply. There's nothing critical about construction. It can be built in one evening, but you'll probably play with it for weeks.

Last summer I was doing consulting work for KBVL, an f.m. radio station that wanted to go automated. I concluded that the best investment for them was in a system sold by Broadcast Products, Inc., a relatively new company. When the equipment arrived, I was intrigued by the audio mixer. It was a 24-channel mixer which was completely voltage-controlled by another box, the computer. Each channel was tied to the common programs bus through a light-dependent resistor, or ldr. The ldr was in a small sealed box with a 12-volt incandescent light bulb. Nothing fancy, just a pilot light. Increasing the light intensity lowered the ldr's resistance. Full range of the ldr was roughly 100 k ohms to 20 ohms.

Here was a voltage-controlled attenuator with virtually perfect signal transfer characteristics. The gears in my head started turning. The ldr was a device around which one could design mixers, oscillators, and equalizers, all voltage dependent with wide dynamic range. The cost for the ldr is a mere $3.86 from Broadcast Products, Inc. And there's a second photo-resistive element added in the little sealed container if you want to control two circuits at a time.

David A. Howe operates Howe Audio Recording in Boulder, Colorado.

The schematic of the ldr limiter is shown in FIGURE 1. The component types and values aren't critical. They were picked for what I consider to be a limiter applicable to most audio purposes.

Attack time is about 0.3 second. Release is about three seconds. Increasing the value for R1 decreases the attack time, and the release time can be changed by changing C1. R1 multiplied by C1 equals the time-constant of the feedback loop which is equivalent to the attack time. Since R4 divided by R3 is equal to one, the gain of the operational amplified LM301 is unity. Any op amp you choose should be wired for unity gain and should have all the extra components needed to cause attenuation at frequencies much higher than the natural resonant frequency of the loop. Here it's roughly three hertz. By the way, if you make the gain of the op amp greater than unity, the whole works will go into oscillation, and you'll add a brisk vibrato on a constant signal passing through the ldr.

The power supply should be able to furnish ± 10 V.d.c. The +10 V supply has to drive the light in the ldr container, so it should be able to deliver about 200 mA or more. Just a few milliamps is all that's needed for the —10 V supply.

There's nothing fancy about the resistive network where the ldr is used. The input and output impedance of the network will wander between 500 ohms and 1000 ohms as the ldr changes resistance. For most of my applications, this is tolerable since I usually derive a signal from a low impedance emitter-follower and feed a relatively high impedance load. In many applications, a constant input-output impedance is necessary. I suggest a bridged-T network such as the one shown in FIGURE 2. You'll need two ldr's and another driver transistor. A bridged-T attenuator is well suited because the bridge and shunt resistances change linearly but in opposite directions.

Remember that the limiter uses a voltage-controlled attenuator. Gain through the attenuator is always equal to or less than unity. The amplifier feeding the limiter should have a gain of two or more in order to put the limiter in a working mode. In most cases, you can just increase the amplification of a stage before the limiter. Usually amplifiers have some amount of headroom. The purpose of a limiter is to cut the amplitude down to size before going

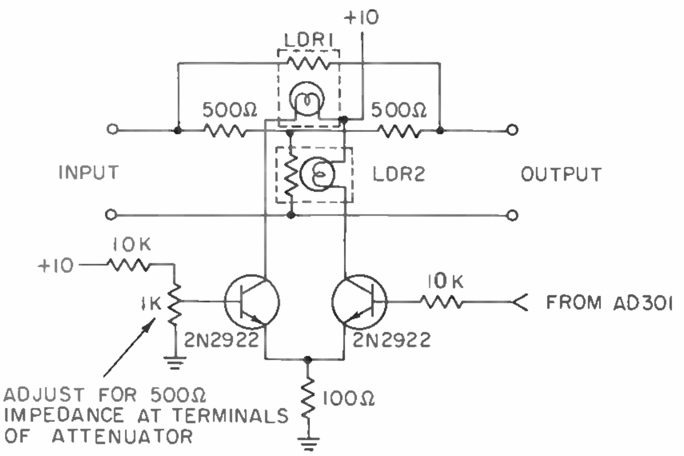

Figure 2. A voltage-controlled pad used in a bridged-T configuration. Two ldr's are used.

to the input of another device. The peak level going through the attenuator should be a volt or more.

My target was to come up with a limiter with excellent specifications and a minimum number of parts. To change this poor man's limiter into a rich man's, you can go for a higher priced ldr. Some are sold with led's and come up to full brilliance in less than a millisecond. Furthermore, an led light source glows with intensities more linearly proportional to the current flow through them. You may like to build a single stage amplifier preceding the attenuator since power supply voltages are available and you'll probably have room for it. To make two or more limiters track together as in the treatment of stereo signals, connect each limiter's sample level lines together. You'll have to balance each op amp using an external trimmer so that the limiters are acting with similar amounts of attenuation. You should refer to the op amp application sheet to determine where to add the trimmer.

My experience with the design of this limiter can be simply stated: I was satisfied with it in every application. And for the price, it's unbeatable.

HOW IT WORKS

With no audio signal applied through the ldr, the light source is at full brilliance. There is very little attenuation through the ldr and its resistive element will be less than 20 ohms. An audio signal passing through the ldr drives emitter-follower Q1 whose output is fed to an integrator, R1 and C1. Attack time is fast by virtue of the low impedance through Q1 to +10 volts; release time is slower through the 100 k resistor to —10. The d.c. level out of the integrator (sample level) will roughly equal the peak voltage of the audio signal passing through the ldr.

Differential amplifier LM301 compares the sample level with a reference level. The reference may be manually adjusted or can be derived from any external source. The amplifier has unity gain. A difference voltage between the sample and reference shows up at the base of Q2. Since Q2 drives the light in the ldr, a change in the light's brilliance will occur which tries to correct the error; that is, the difference between the sample and reference. R1 and C1 determine the time-constant for the loop, or how fast the loop responds. R1 can range from just a few ohms to as high as several hundred thousand ohms. R3 and R4 determine the loop gain. A gain of near unity carries the risk of having the limiter act too "violently." Program material will be "hard-limited" and loud excursions may cause overshoot. However, this circuit contains enough losses in the loop, such as through Q1 and the integrator, that the total gain is less than unity by a comfortable amount. Increasing R3 will lower the feedback loop's gain still further, making the limiting "softer." ■

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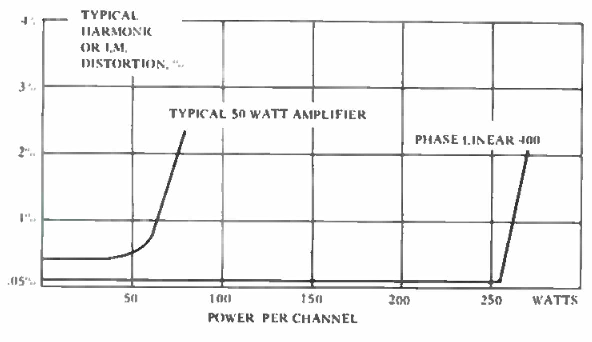

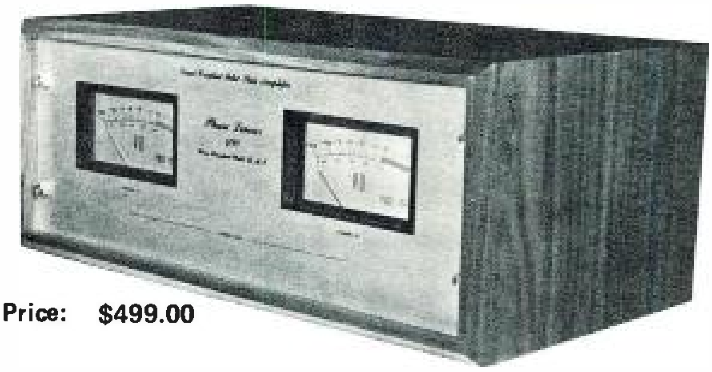

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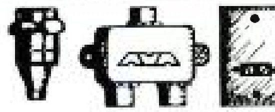

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*Do you know the sound of a hit? Do you want to cut hits? Do you want success badly enough to eat every top selling single and LP you're not on?
*In short, are you a born winner?

If you can honestly answer "yes" to all the above, we want you to join us and we'll pay whatever's fair. Track Recorders has had eight national chart records in the last year. Washington, D.C. is the last major music frontier and we're the leaders. Our studio has all the standard quality equipment — 3M 16-track, 25-in/16-out custom console, EMT reverb, JBL 4320 monitors, Dolby, Kepex, varispeed, grand piano, Hammond B3 organ, amps, drums, excellent test gear and maintenance. Your weekends will generally be free. The Washington area offers great entertainment plus Blue Ridge Mountains, Shenandoah Valley, Chesapeake Bay, Atlantic Ocean.

Call or write to: **TRACK RECORDS, INC., 8226 Georgia Ave. #11-2, Silver Spring, Md. 20910. (301) 589-4349.**

PEOPLE, PLACES, HAPPENINGS

• **Arthur A. Shubert, Jr.** has been appointed chief development engineer for **Neve Electronic Laboratories, Ltd.,** Melbourn, England. Mr. Schubert, who was formerly chief engineer for **Rupert Neve, Inc.** in Connecticut, will be responsible for the development of new techniques and new products for the Neve line of professional sound control consoles. Another Neve appointment is that of **Barry J. Roche,** who joins Rupert Neve, Inc. in the senior engineering position. Mr. Roche was formerly manager of technical services and responsible for post-installation customer liaison for Neve in Great Britain and Europe.

IMPORTANT ANNOUNCEMENT TO MANUFACTURERS OF PROFESSIONAL AUDIO EQUIPMENT

Sagamore Publishing Co., Inc. publishers of **db**—is planning to publish a *Directory of Professional Audio Products.* A questionnaire requesting company and product information has been sent to all manufacturers asking that they respond by the deadline indicated to assure their free listing in this important directory.

If for any reason you are a manufacturer of professional audio equipment and have not received your questionnaire, or have misplaced or misfiled your copy, please write immediately for another copy. Complete instructions are included for your listing.

If you wish any further details please write Larry Zide, editor, at Sagamore Publishing Co. Inc., 980 Old Country Rd., Plainview, N.Y. 11803. Information concerning advertising may be obtained from H. Krantz at the same address. Phone (516) 433-6530.

The Second Annual Nashville Recording Arts Seminar takes place August 22nd through the 26th. The place is the Sheraton Motor Inn, 920 Broadway, Nashville, Tennessee. The purpose of the seminar is to help everybody share new and old ideas and learn more about the recording industry. Sponsors of the seminar are *Nashville Record Productions* and *Fanta Sound.* Cost for the programs is $35, not including motel and food. Some of the important topics to be covered include Ins and Outs of Monitor Speakers, A to Z on Equalization, Financing the Studio, Power Amplifiers, Use of Test Equipment, and Basic Acoustics. There will be speeches and demonstrations by a number of manufacturers, question and answer sessions with some of the top mixers in Nashville, and there will be a Flea Market permitting the sale (or purchase) of items brought by participants.

Call **Johnny Rosen** at **Fanta Sound** for further information. He can be reached at (615) 327-3768.

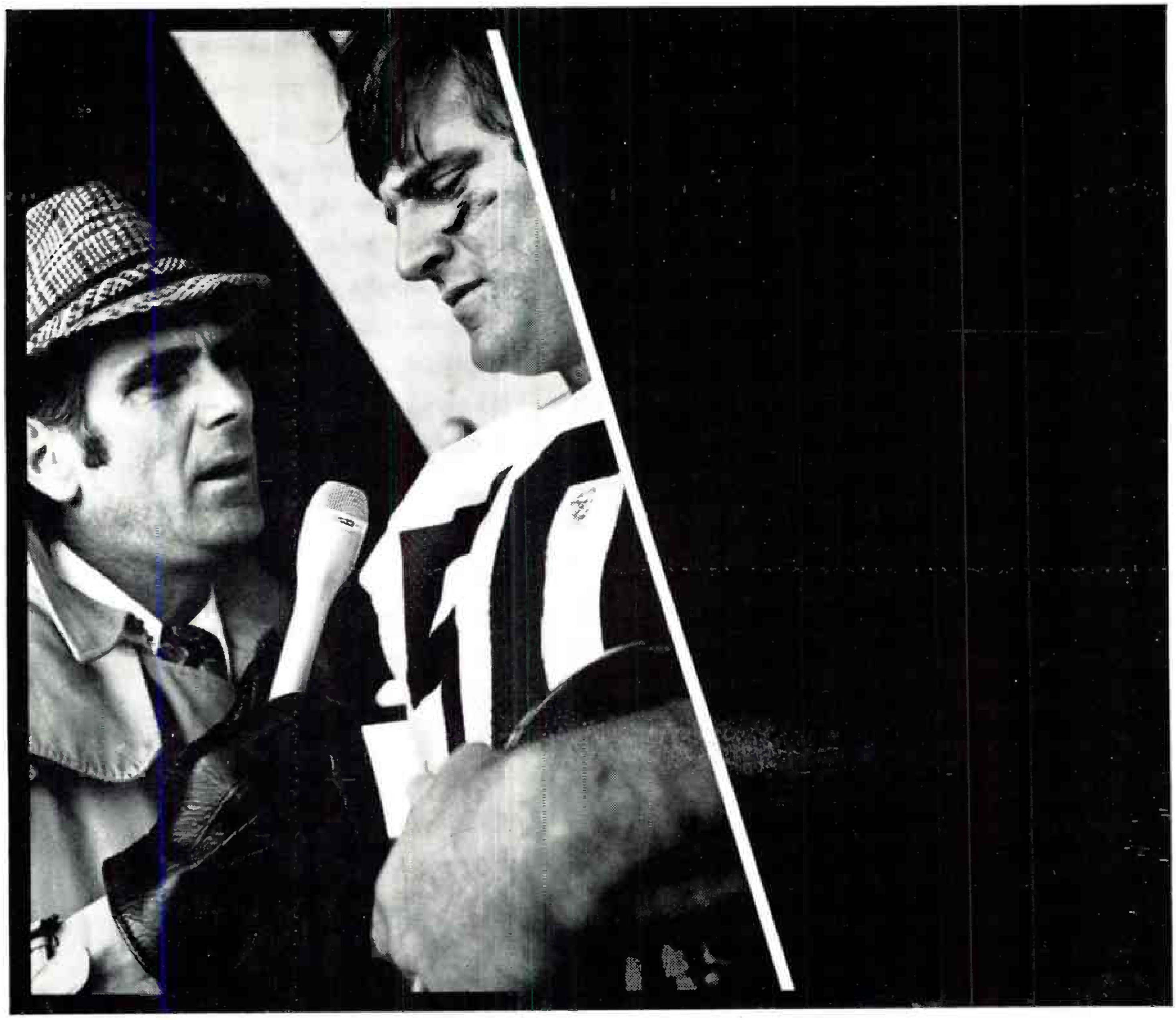
• **Quad/Eight Electronics** has formed a new sales subsidiary to service overseas customers, including Canada and Mexico. The new division, known as **Quad/Eight International,** will be located at the parent company in North Hollywood, California under the direction of Quad/Eight marketing director, **Ron Neilson.**

• A new studio, offering 8- and 16-track recording, has been opened by **Clear Light Studios,** in Bayside, Queens, N.Y. The new studio is equipped with the latest MCI mixing console, Scully and Ampex tape decks, dbx noise reduction, and auxiliary equipment. Operated by **Louis Duka** and **Joel Schwartz,** Clear Light has, for the past two years, cut demos for some prominent performers, including Miles Davis, Benny Goodman, and Aretha Franklin.

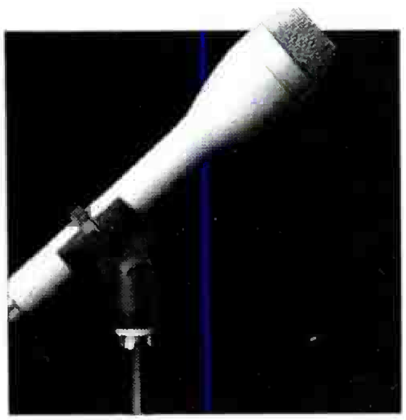
• A book on guiding those interested in audio engineering as a career is bing prepared by **Paul S. Moverman.** The author has requested that those institutions dealing with education in the audio industry send him full information regarding the courses they offer. The book will attempt to explore all courses in the audio engineering field, covering the syllabus of each course and the credentials of the instructors. U.S., Canadian, and European schools will be included. Please send information to Mr. Moverman, c/o **db, 980 Old Country Rd., Plainview, N.Y., 11803.**

• **Daniel E. Denham** has been appointed vice-president of the newly formed recording materials group of the **3M Company.** Denham's new group, the result of a reorganization of the magnetic products aspect of the firm's business, will comprise the magnetic audio video products, data recording products, Mincom, and film and allied products divisions. Other appointments effectuated by the reorganization include **Dr. M. R. Hatfield,** a chemist, named vice president of the Mincom division, **Robert Herr** as vice president of the data recording products division, and **John E. Povolny,** named general manager of the magnetic audio products division. **William A. Aitken** continues as general manager of the film and allied products division.

• **Altec Corporation,** of Anaheim, California, has announced the formation of a subsidiary corporation, **Altec International (U.K.) Ltd.,** at Stevenage, Hertfordshire, England, to develop the European market for products manufactured by its Sound Products Division. The new branch will be headed by **J. P. (Ben) Hogan.**



The Quiet One...



Time was when hand-held microphones could mean a handful of problems. Now, the Shure SM61 professional omnidirectional dynamic microphone combines sleek good looks with *extraordinary* reduction in cable and handling noises. The SM61 is built around a shock mount that *effectively reduces cable, handling and mechanical noises to insignificant levels.* A super-efficient "Blast Barrier" cuts wind and breath noise to a negligible minimum. Smooth, wide-range response produces an extremely natural, coloration-free sound that does great things for speech, vocal music and instrumental pickup. The SM61 is beautiful to look at, a delight to work, a pleasure to hear. Write for a complete data sheet to:

Shure Brothers Inc.
222 Hartrey Ave., Evanston, Ill. 60204
In Canada: A. C. Simmonds & Sons Ltd.

SHURE

Circle 11 on Reader Service Card

Please don't dance on your tape recorder!

We've seriously gone about the business of designing the best possible loudspeaker for monitor use. With computers, and anechoic chambers, and all the rest. And, having gained a monster new insight into bass speaker performance, we've come up with what looks like a winner. The Sentry III.

We've run all the curves that prove, in a most scientific, sober fashion, that the system is really quite good. We've got polar graphs, and frequency response curves, distortion measurements, total power output curves, power handling test results, and SPL data galore.

But what happens when we demonstrate the Sentry III? Leading engineers (whose names we hesitate to divulge—but you know them) leap about in their control rooms DANCING for heaven's sake! Snapping their fingers and feeling the sound, and reveling in the sensory pleasure of a clean first octave. And last octave too, for that matter.

And they run from one side of the studio to the other trying to find holes in the distribution of the highs . . . and they can't . . . and they LAUGH! It's very unseemly (but secretly quite gratifying). So we try to thrust our good numbers and graphs at these serious engineers, but they'd rather listen and compare and switch speakers. And make rude remarks about their old monitors.

Who will stand still long enough to heed our technical story? Perhaps you're the serious-minded, sober-sided engineer we're looking for. If so, by all means write us. We've got quite a stack of strait-laced, objective literature describing the new Sentry III monitor loudspeaker just waiting to be seen and appreciated.

And after you've read our story, perhaps we can arrange a demonstration of this new speaker for you. The Sentry III. Bring your tap shoes.

New SENTRY™ III Monitor Loudspeaker

a Gulton COMPANY

Electro-Voice®

SENTRY III Frequency Response 40-18,000 Hz ± 3 dB; Sound Pressure on Axis at 4' with 50 watt input 113 dB; Dispersion 120° horizontal, 60° vertical; Size 28½W x 20½D x 34½H; Weight 156 lbs. $600.00 suggested professional net. SEQ active equalizer extends response to 28 Hz, $60.00.

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ELECTRO-VOICE, INC., Dept. 831BD, 686 Cecil St., Buchanan, Michigan 49107