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THE SOUND ENGINEERING MAGAZINE

December 1969 75c

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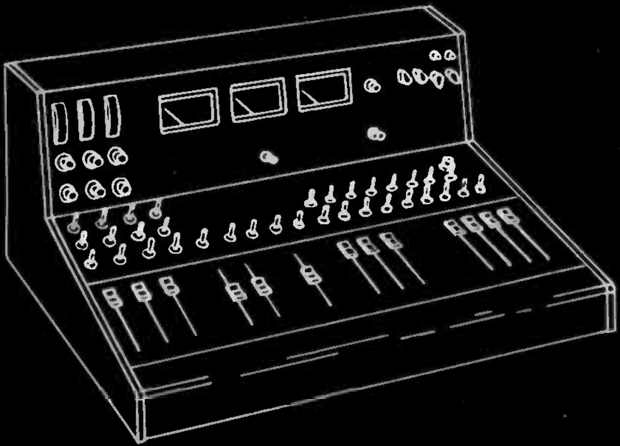
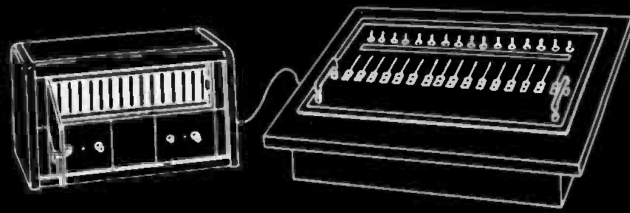


Approach I-Integrated



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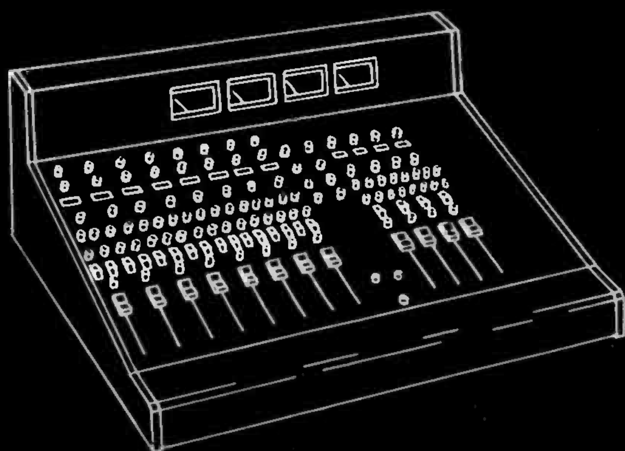
Approach III-Modular



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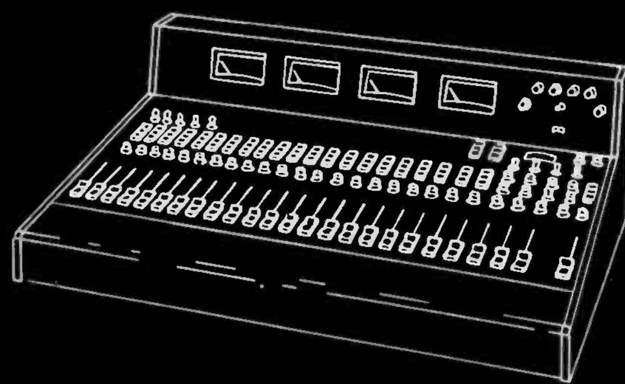

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Coming

● In January we will begin the new year with a multi-part article of paramount importance. Entitled A PRIMER ON METHODS AND SCALES OF NOISE MEASUREMENT, it will classify and identify those characteristics that must be known if noise is to be brought under control. The author is Wayne Rudmose and the information is based on paper that was given at the June 1968 Conference on Noise as a Public Health Hazard.

John Borwick will take us behind the scenes at (English) Decca's Vienna Venue. In picture and text we will see the facilities that have produced some of the finest classical records made.

A new column will make its bow. Titled THE SYNC TRACK, its author John Woram will investigate the methods and equipment necessary to the recording studio. The column will be responsive to reader request and inquiry. The first installment covers the human engineering aspects of studio equipment (and their all-too-common lack).

The postponed article A DIFFERENT VIEW OF SPEAKER COVERAGE by Elliott Full will appear. It raises the questions of phycho-acoustics in the selection of equipment for public-address systems.

And there will be our regular columnists, George Alexandrovich, Norman H. Crowhurst, Martin Dickstein, and Arnold Schwartz. Coming in **db**, The Sound Engineering Magazine.

About the Cover

● Scenes from the 37th AES Convention held this past October in New York City. On the left (top to bottom) are the booths of GOTHAM AUDIO, GATELY ELECTRONICS, and the 3M COMPANY. On the right is to be seen ELECTRO-VOICE, AUDIO DESIGNS, and B & K INSTRUMENTS. More booth scenes and specific products may be seen in our picture gallery beginning on page 30.

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DECEMBER 1969 • Volume 3, Number 12

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

BENDING THE BEAM

JOHN R. GILLIOM
Chief Engineer, Loudspeakers

Because paging and PA speakers can't always be placed exactly where needed for best sound distribution, it sometimes seems desirable to alter the polar pattern of the speaker to meet specific requirements. Observation of installations in the field discloses a wide variety of methods employed to achieve asymmetrical sound distribution.

These "accessories" vary from small flaps mounted on the horn to large panels. Even an existing wall or ceiling has been used to modify the polar characteristics. Not all of these devices are completely effective, and a brief discussion of why may aid you in making your own experiments.

When an object is placed in the beam of a speaker, the sound striking this beam may do several things, depending on the size of the object relative to the wavelength of the sound. If the object is large with respect to wavelength (say 5 times as large) sound will reflect, much as light reflects from a similar surface. But if the object is small (perhaps ½ to 1 wavelength in size) sound will diffract around the object.

Now let us consider the case of a typical paging speaker. With a frequency response range of 250 to 13,000 Kz, it will produce wavelengths varying from 4 feet to 1 inch in length. Our deflector must take into account the entire range of wavelengths if we are to affect the polar pattern over more than a small portion of the sound spectrum.

For instance, if we were to place a 6" square panel at an angle in front of the speaker, it would act effectively as a reflector only for the frequencies at or above 2 or 3kHz (and only if it were squarely in the center of the horn). Below this point, sound would begin to diffract around the panel. At some frequencies, sound intensities might well be higher *behind* the panel than at any other point due to this diffraction effect. At very low frequencies, the panel would have almost no measurable effect on the polar pattern.

The ability of sound to diffract or reflect—depending on the relative size of the surface with respect to wavelength—can be a useful tool in the design of sound equipment. But it can also be a trap for the unwary, leading to unexpected results if not completely understood.

For reprints of other discussions in this series, or technical data on any E-V product, write: ELECTRO-VOICE, INC., Dept. 1293BD 686 Cecil St., Buchanan, Michigan 49107

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Letters

The Editor:
We were surprised at the lack of mention of Electro-Voice in your historic microphone article in the November issue of **db**. At least one, and perhaps two, of the microphones shown on your cover and in the article were manufactured by Electro-Voice. The company was founded in 1927 by Al Kahn and the writer. After a short period of doing repair work on the then crude instruments, we started manufacturing microphones in the basement of a gas station in South Bend, Indiana.

Among the many product advancements in the late twenties and early thirties, was the development of a balanced coil device within the microphone which cancelled out hum. Hum pickup had been a major problem and this noise level necessitated a person shouting into the mic for any degree of intelligibility. Because of the Electro-Voice development speakers and singers could perform naturally, and be heard well at the receiving end.

Most of the companies mentioned in the article are no longer in the manufacturing business, but Electro-Voice was then and is still now, one of the few survivors due to its continuing technical achievements.

Louis Burroughs
Vice-President,
Professional Products
Electro-Voice
Buchanan, Michigan

The Editor:
In the article on the Bell & Howell Filmosound 8 system in your November issue there are two additions necessary.

In the playback function a special standby oscillator is keyed in to prevent the projector from jumping to its full speed during scene changes. The oscillator is preset to approximately 18 frames per second.

A service has been introduced which permits the conversion of the separate cassette and film format to magnetic sound stripe film. It is offered as a service to customers through the Service Department of Bell & Howell Company.

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The Audio Engineer's Handbook

GEORGE ALEXANDROVICH

DIRECT INTERSTAGE COUPLING IN TRANSISTOR AMPLIFIERS

● In our previous discussion on miniaturization of electronic equipment for audio use we did not mention what advances in circuit design made smaller packaging possible nor what effect this had on the performance of the circuit. We talked about the substitution of bulky components by smaller ones—of more expensive type. No manufacturer will miniaturize his equipment without attempting first to maintain its cost. Since miniaturization inevitably calls for more expensive parts, cost control is achieved through the simplification of the circuit. It has happened that simplification of transistor amplifiers in attempts to integrate the circuit on a single chip have resulted in an improvement of circuit performance. A description of these circuits is the subject of our discussion this month.

As you know, a transistor basically is a three-terminal device which, when connected into the circuit, must be properly biased in order to amplify. When the transistor was first invented the initial useful circuits resembled tube-type amplifiers—each stage was treated separately as a separate isolated amplifier. FIGURE 1 shows a typical class-A amplifier with two independent stages. Resistors R_1 and R_2 are bias resistors while R_3 is a load resistor. R_4 is an emitter and feedback resistor (since it is not bypassed with a capacitor).

The second stage is identical to the first except that it operates with higher level signals. Capacitors C_1, C_2 and C_3 a.c. couple the stages but isolate them to d.c.

This kind of circuit could be built by progressively adding stage by stage. A problem with this type of circuit is that, in order to extend frequency response to very low frequencies large

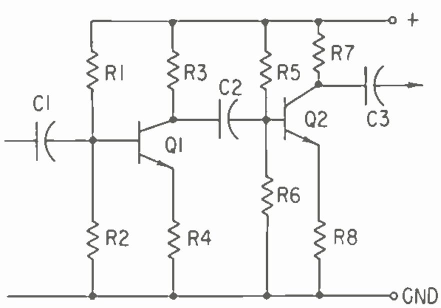

Figure 1. A typical class-A amplifier with two independent stages such as were first used with transistors.

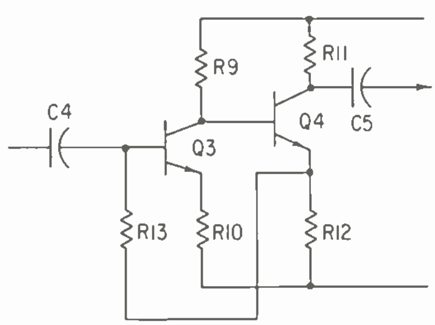

Figure 2. The invention of directly-coupled stages greatly simplified the circuit of Figure 1.

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says Jac Holzman, President of Elektra Records. *"Since early 1967, we have used Dolby units on most of our recordings of The Doors, Judy Collins, Tim Buckley, Tom Paxton, The Incredible String Band, Roxy, and many others. The New Music can have a surprising dynamic range, and we find that the Dolby System not only gives a really low-noise background during quiet passages, but it helps to preserve the clarity and definition of complex musical textures. A related advantage is that the mixdown is faster and less tedious. In working out the final mix, we no longer have to resort to intricate equalization schemes to retain crucial nuances and subtleties of the performance."*

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capacity electrolytics have to be used. When the circuit is energized it takes as much as a few seconds for the capacitors to acquire their charge. Until they do, transistors are not biased properly and there is no amplification. Also if a sudden overload of any one of the amplifier stages occurs, thereby charging the electrolytic with the transient peak, it produces a momentary shift in a bias—again blocking the amplifier and requiring seconds for the amplifier to recover from overload. This circuit requires four resistors for acceptable performance. With electrolytic capacitors it takes at least five components per amplification stage. For extra gain, emitter resistor R_4 is bypassed with a large capacitor. This increases the number of components to six. Piling up components around each transistor is not only costly, but decreases circuit reliablility.

Invention of directly-coupled transistor stages simplified the circuit, increased reliability and performance, and improved temperature stability. As seen in FIGURE 2, direct coupling of the two successive stages is more economical in terms of components. Additionally, there is a difference in the way the biasing is accomplished. Resistor R_{13} couples the base of the Q_3 to the emitter of the Q_4. Large resistance value of R_{13} produces little negative feedback, but supplies the d.c. current for the biasing of the base. The basic difference between the two circuits is that the biasing of the first stage in the directly-coupled amplifier is also affecting the biasing of the second stage. R_{14} is selected so that the output of the amplifier produces symmetrical clipping of the signal at the output, and this sets the operating point for the entire circuit. Since biasing is taken from the second stage, any change in current through the second stage due to change in temperature is reflected in a change of emitter potential. This increase in voltage due to change of conduction of Q_4 alters the bias of Q_3 through R_{13} in turn changing the bias of Q_4 and compensating for the initial drift.

The elimination of the bypass capacitors means that the small low-frequency rolloff caused by each of the bypass electrolytics is eliminated. Since this rolloff effect is additive, over-all response of the system is thereby greatly improved. If input and output capacitors are left out the amplifier is capable of amplifying d.c. The fact that there are no capacitors in the basic amplifier circuit makes this circuit ideal for miniaturization through the integration of the circuits on a silicon chip. Since capacitors can not be (as yet) included into the IC they have to be connected to the chip externally.

If more than two stages of amplification are involved, direct coupling saves

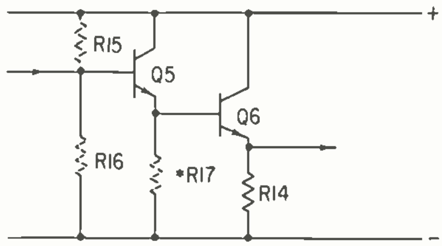

Figure 3. The Darlington circuit. R_{15} and R_{16} adjust the bias of the entire circuit. R_{17}* can be used for more stable biasing.

even more components. The only time capacitive decoupling using electrolytics (or other capacitor types) is needed is when it is required to isolate the load or the source from adversely affecting the d.c. parameters of the amplifier. For all practical purposes decoupling has to be in, except where the amplifier is working as a d.c. amplifier (power-supply voltage regulators or drivers for bulbs, meters, motors or relays).

Direct coupling in the amplifier reduces the phase shifts at low frequencies, increasing amplifier stability. This increase allows more negative feedback, producing lower distortion as an end result.

Directly-coupled circuits have reached a degree of high sophistication and are used extensively in the design of integrated circuits. The variety of approaches and circuits that have been invented includes circuits with dozens of transistors, with as many diodes, resistors and stages, comprizing complete power amplifiers, computer circuits, regulators, gates and myriad of other devices.

One of the very basic but useful circuits using direct coupling is the bootstrap or Darlington circuit. FIGURE 3 shows it. Q_6 is connected as an emitter follower. As shown, the amplifier is meant for d.c. amplification because input and output coupling capacitors are left out. Since the emitter-follower circuit is a current amplifier

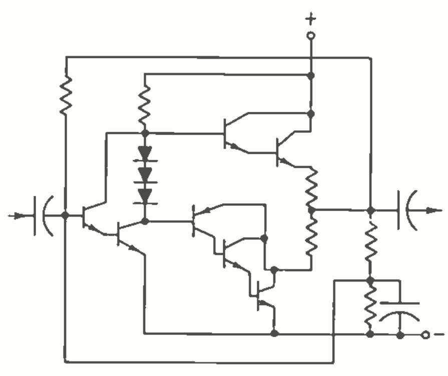

Figure 4. Most of the components shown appear on an integrated-circuit chip. This is a 1-watt power amplifier.

producing no voltage gain, signals applied to the base of Q_6 are appearing at the emitter of the stage, amplified according to the beta or amplification factor of the particular transistor. The higher the beta of the stage, the smaller the current needed to the base of the Q_6 to produce the same current amplification. By adding Q_5 to the base circuit of Q_6, betas of the two transistors multiply increasing the sensitivity of the circuit to the signals applied to the base of Q_5. Since Q_5 is also an emitter-follower circuit, it offers no voltage gain but has high current gain. This means that the current through R_{15} is larger than the current sent through the base of Q_5 by the product of Q_5 and Q_6 betas. Addition of resistors R_{15} and R_{16} adjusts the bias of the entire circuit and allows the use of coupling capacitors on the input and output. In practice, no more than three transistors are usually bootstrapped because leakages of the output stage is reflected back into the input, decreasing the input impedance to the point where all advantages gained by the use of Darlington connections could be negated.

From FIGURE 4, which shows a complete but comparatively simple amplifier using direct coupling techniques, you can see that circuits of the future will be relying on simplicity of design in terms of components required, yet will be reliable, and integrated with uncompromizing performance. The circuit shown happens to be an IC with a capability of 1 watt of power dissipation into a 16-ohm load. The size of the chip is hardly the size of the head of the small nail, yet it represents a circuit which, when built using separately biased stages, would require at least five times the number of resistors and capacitors. If there are seven transistors and we have determined that four resistors and one capacitor are needed for each stage, this implies the need for twenty-eight resistors and seven electrolytics.

The degree of miniaturization achieved through the use of direct coupling is estimated in this case to be at least fifty fold. There was no attempt to calculate the resultant degradation of performance without a direct-coupled circuit due to additional electrolytic phase shift or size. One more important fact about directly-coupled amplifiers; this technique is responsible for achieving extremely high impedances at the input, and low impedances at the output. This allows the construction of circuits using coupling capacitors of much smaller value, thereby further decreasing the size of the package. Low output impedance because of the large amount of negative feedback allows the use of long lines without appreciable loss, especially when feeding a high input impedance circuit.

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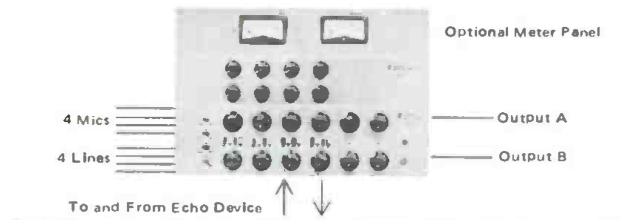

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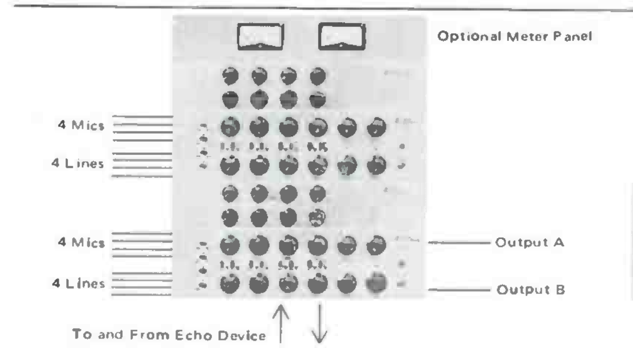

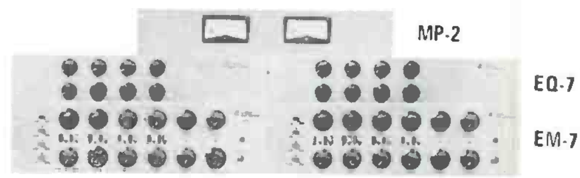

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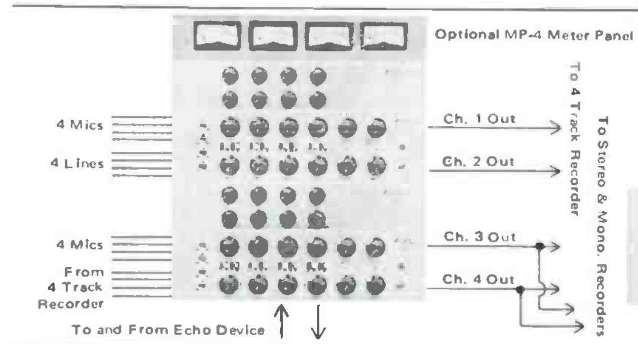

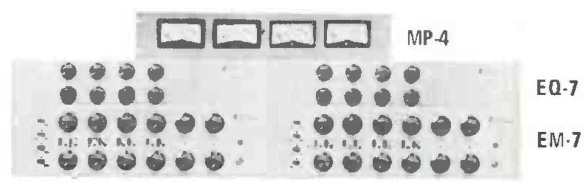

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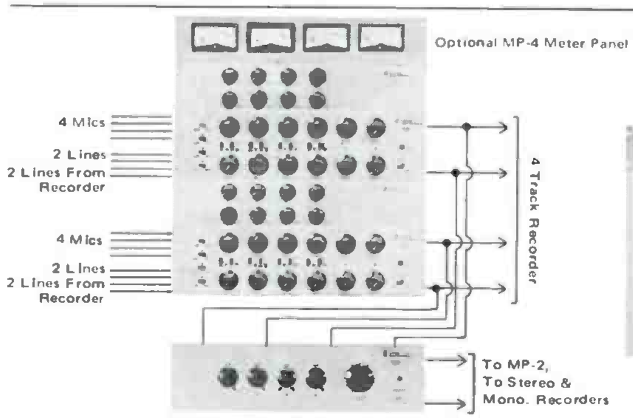

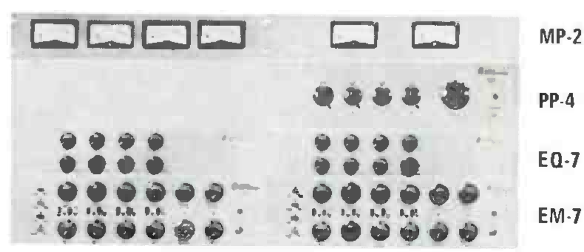

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The Feedback Loop

ARNOLD SCHWARTZ

• The Columbia Broadcasting System has proposed the creation of a privately operated system of domestic satellites to distribute television and radio programs across the nation. CBS president, Dr. Frank Stanton, announced the proposal at the Audio Engineering Society convention banquet held in New York City on October 15. The price of the satellite system is estimated at $100-million, but involves no cost to the taxpayer. Dr. Stanton explained that this system would bring some of the benefits of space-age technology to the American people by enlarging the capabilities of the television and radio networks. At present the long lines department of the American Telephone and Telegraph Company (AT&T) provides the service of nationwide radio program distribution. Interestingly enough, AT&T's announced position, following Dr. Stanton's statement, was that the wisest public policy" dictated that any group or organization be allowed to apply for operation of a domestic communication satellite system to be established.

The effects of the propossed satellite system, if it were to be realized, are difficult to predict. As far as radio program transmission is concerned, it would, in all likelihood, replace much of the long haul service now provided by AT&T. Local transmission lines, such as those going from radio studio to transmitter, would probably not be affected. A hybrid system would result with interface provided to interconnect existing local lines with the national distribution system provided by the proposed satellite system. In light of the CBS proposal, it would be interesting to look at the service now being provided by the long lines department of AT&T.

When I was with the American Broadcasting Company there was a particular jack located in network master control that always aroused my curiosity. This jack was labelled *NR*. If a handset was plugged in there was always a helpful voice at the other end to assist in correcting some line trouble or to verify an upcoming switching arrangement. I

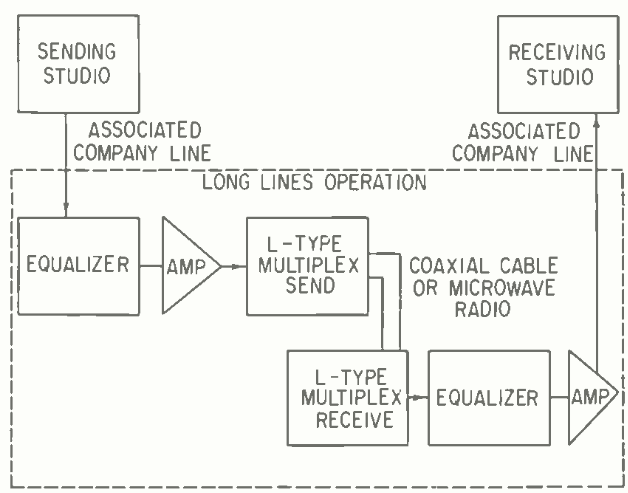

Figure 1. A block diagram of a long lines transmission path.

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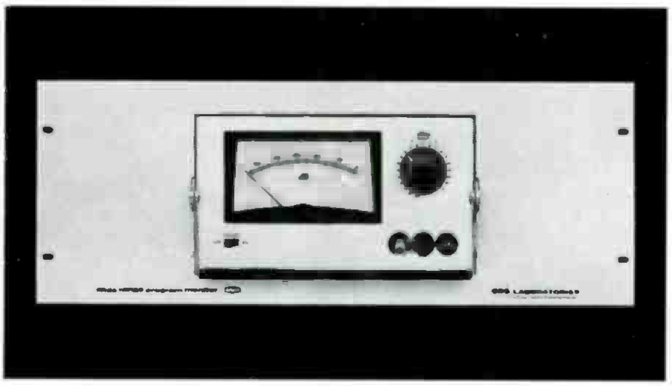

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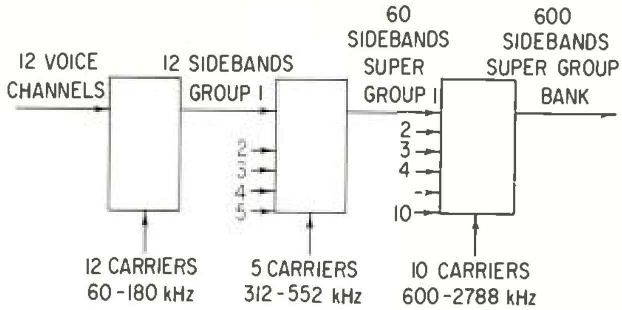

Figure 2. The AT&T L-Type multiplex system.

finally got to see where the *NR* (it means network radio) jack terminates. It is in an enormous master control room operated by the long lines department, and is located in the telephone company building at 32 Avenue of Americas in New York City. This area functions as a central switching and control facility for all long distance radio program lines in the New York area. Incoming signals destined for wide area distribution are amplified and equalized before being fed to the long-distance transmission system.

Transmission lines can be divided up into two groups: those operated by *Associated Companies*, and those operated by the long lines department of AT&T. The term *Associated Company* refers to an "Associated Bell System Company whose function is to conduct that part of the various services, including program transmission which, in general, do not extend outside the limits of its particular service area". Long lines refers to the long lines department of AT&T whose function is to conduct program transmission which interconnects the territories of the different Associated Bell System Companies.

A generalized block diagram of a typical long lines transmission path is shown in FIGURE 1. The program signal is fed from a studio or other source to the terminals of the transmission lines operated by the Associated Company. Program signals that are to be sent outside the local area terminate in the long lines central control area (NR). At this point amplifiers, equalizers and other equipment are employed so that signal-to-noise and frequency response specifications are maintained. The program signal is then ready to be fed to the carrier system.

Long-haul wire and radio systems employ what AT&T calls its L-Type multiplex terminals. This is a single side band suppressed-carrier system which translates "voice channels" into high-frequency sidebands. The high-frequency signal is then transmitted to remote points over cable or radio. A voice channel has a bandwidth of approximately 200-3,500 Hz. In the L600 multiplex system a composite signal is derived that contains 600 voice-channels. This composite signal is built up in three stages. The first step is formation of a ***group*** by modulating 12 carriers with 12 voice channels. The group frequency range is 60-108 kHz. Five such groups are then used to modulate five more carriers in the 312-552 kHz frequency range, and form a ***supergroup***. Finally, ten supergroups are used to modulate ten carriers in the 60-2788 kHz frequency range to form a mastergroup. FIGURE 2 summarizes this process. Cascading side bands in this way is more economical than modulating each voice channel with its own carrier. For example, the total number of carrier frequencies is reduced from a possible 600 to 25, and represents an efficiency at both sending and receiving terminals.

This composite signal, composed of 600 voice-channels, is transmitted by coaxial cable or microwave radio (see FIGURE 2). Suitable receiving and demodulating techniques are employed at the receiving terminals, including the insertion of a carefully controlled carrier frequency, to extract the original radio program signal. Associated Company lines are then employed to send the program to its final destination. At some receiving terminals a technique called branching is employed to avoid degrading the signal by successive modulation and demodulation. It is similar to the audio technique of bridging, and is used when the program channels are to be distributed in one area while at the same time it is required that the full group be transmitted to a more remote long lines office (see FIGURE 3).

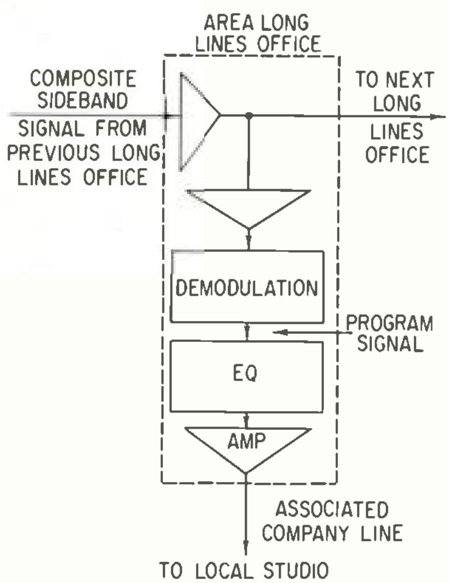

Figure 3. This is the AT&T branching technique.

AT&T offers program transmission facilities of various bandwidths. A widely used type of channel (Schedule A) has a range of 100-5,000 Hz. Extension of the bandwidth for Schedule A channels is accomplished by using two voice channels. In addition a Schedule A channel receives more careful supervision and has more extensive back-up facilities. In the case of Schedule AA channels, having 100-8,000 Hz range, three voice channels are used. For a Schedule AAA line, with a frequency range of 50-15,000 Hz, an entire group is used (12 voice channels). It is interesting to note the direct relationship between bandwidth and line cost. As bandwidth increases the channel utilization increases, and the rental cost rises proportionately.

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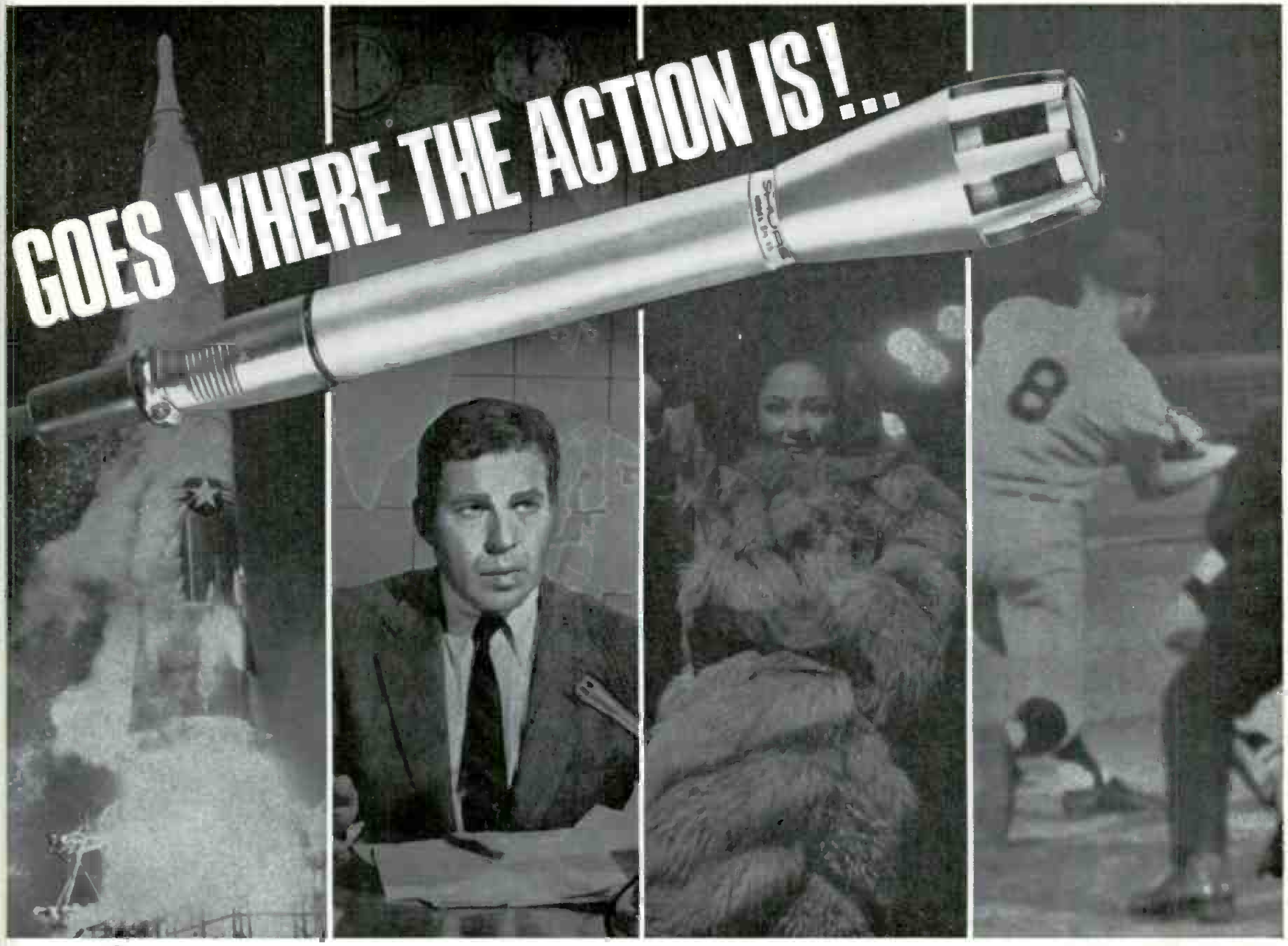

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Theory and Practice

NORMAN H. CROWHURST

● Building things that oscillate is an interesting, as well as occasionally useful pursuit. And it's also a wonderful area for putting theory and practice together. The theory suggests a circuit should work, but it doesn't, so you must revise the theory to find out why, and make something that will work. Or it works, but the waveform isn't what you expect, so again some back and forth between theory and practice is the best solution.

The mathematics for designing a phase-shift oscillator is not too difficult, provided you are conversant with the use of operator-J. And operator-J is perhaps a more practical mathematical tool than some other approaches, because it allows practical factors to be included. But for now we'll stick to the more over-all picture.

To oscillate, a phase-shift circuit (as opposed to the zero-phase, or half bridge circuit, which we'll come to later) needs at least three capacitors contributing to the same kind of phase shift, either advance or delay. Two such elements produce an ultimate phase shift of 180 degrees, which is reversal, but only when the gain has fallen to nothing. Using three elements allows a phase shift of 180 degrees to be achieved while there is still some signal being transmitted.

Now comes the question, whether to use delay or advance: shunt or series capacitor elements. As at least one series capacitor will be needed to provide d.c. blocking between signal and bias, this means two more will do it. But there is another reason for preferring the series configuration.

A series configuration is a sort of high-pass filter, while a shunt configuration is a sort of low-pass filter. But the feedback through the phase-shift network is negative in the absence of phase shift, of which 180 degrees converts it to positive at that one frequency.

If three R-C networks don't interact —that is, if they are separated by emitter followers or something that prevents the impedance of one from interacting with the next, each network will contribute 60 degrees phase shift when the series reactance is 1.732 times the resistance, and the output from each stage will be half its input (Figure 1).

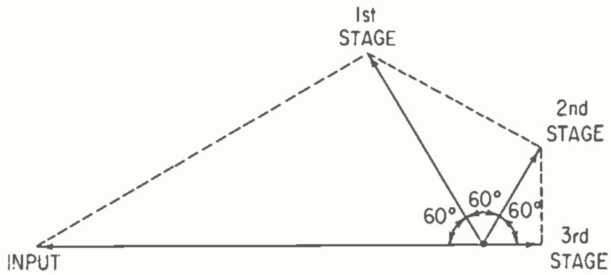

Figure 1. The successive phase shifts of three stages of R-C non-interacting, to produce phase reversal for oscillation.

Thus three stages will reduce the input to 1/8th with 180 degrees phase shift. Such an arrangement could be made into a fairly stable oscillator (Figure. 2), by inserting a stage that produces very slightly more than 8:1 voltage gain, to offset this loss. With the values chosen, each capacitor feeds into 500-ohms resistance, so the frequency is set by where the reactance is 866 ohms, which would make 0.1 mFd oscillate at about 1,850 Hz.

The advantage of this method (series capacitor elements), as well as making coupling easier, is that any harmonics generated by the gain transistor (Q3) are fed back as negative feedback, and thus reduced by the feedback, while the fundamental is fed back precisely positive.

But that's a lot of parts to make an oscillator, and if its frequency needs to be varied, or even adjusted, at least three capacitors need changing. For many purposes, it would be an advantage to have a circuit that doesn't require so many parts, and that could be adjusted more easily.

While using operator-J to do the calculations makes the theory of any network relatively easy to handle, a particularly simple one to use as a

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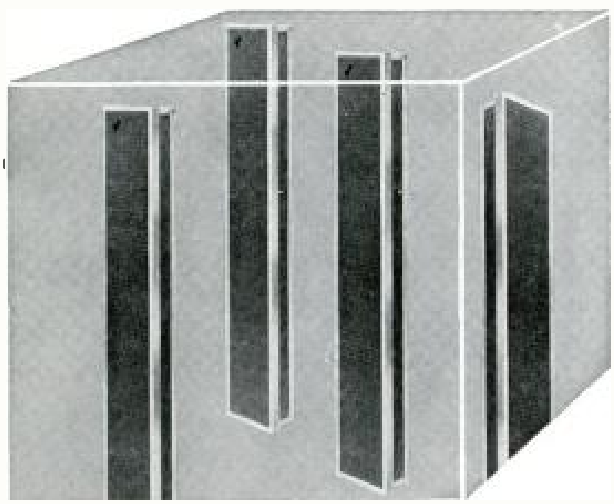

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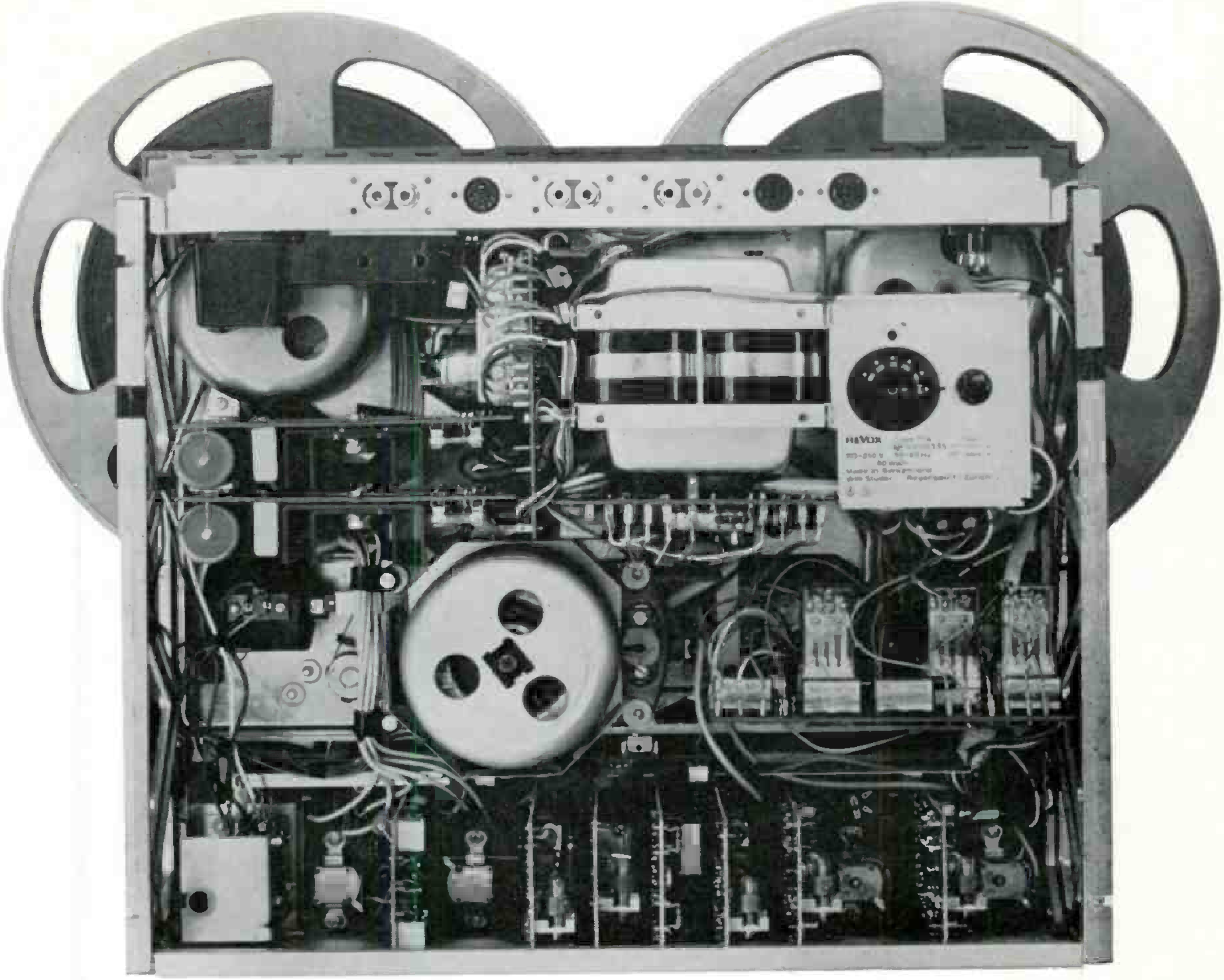

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To know the detailed inside story on Willi Studer's Revox A77 read the fully descriptive story from REVOX CORPORATION 212 Mineola Avenue, Roslyn Heights, N.Y. 11577
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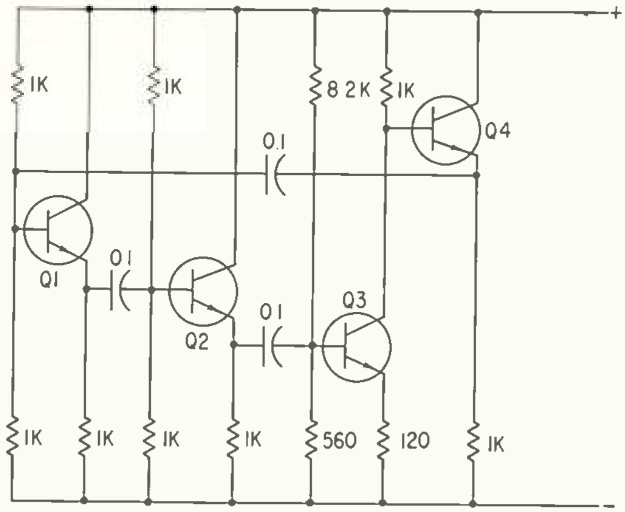

Figure 2. One way of embodying (as the patent specs say) the phase shifts of Figure 1 into a transistorized oscillator.

starting point is the combination of identical successive elements, in this case, three identical Cs and three identical Rs (FIGURE 3).

Theory tells that with this combination, the attenuation at the 180 degree phase shift frequency is 29:1, and that the frequency is one where each capacitor has a reactance root−6 (approx. 2.45) times the resistance values. This means a gain of just under 30 needs to be provided.

But how do you apply this to a transistor circuit? The network postulated works from zero source into an open-circuit load. The open-circuit load can only be approximated by feeding into an emitter follower, although as the terminating shunt value is a resistance, it can be arranged as the input impedance of the gain stage, as was done in FIGURE 2). But the only way to get something approaching zero source is to use an emitter follower to feed the network (FIGURE 4).

The values there are worked out to provide a workable oscillator. We have cut the number of transistors from 4 to 2. But isn't there a way of making a circuit oscillate reliably with only one transistor?

The theory used to calculate the facts relative to the network of FIGURE 3 was based on voltage attenuation, or division. An input voltage source is used to deliver an output voltage at the other end. But a transistor is basically a current-amplifying device, so it would be easier, in this case at least (it isn't always true), to regard the transistor as a current source at the beginning of the network, delivering a current at the end of the network.

In terms of impedance, this means that the first impedance source is high (theoretically infinite) while the last is low (theoretically zero).

As we've shown in earlier discussions about operation of transistors, their bias can be more readily stabilized with a substantial resistor in the emitter, or by taking the bias resistor from the collector rather than the collector voltage supply point. But using either of these methods of stabilization to hold gain within close margin will make it difficult to get a gain of 30 (more precisely 29) from a single transistor.

There's one simple trick, which isn't capable of exact prediction by theory: that's to put one of the capacitors in the emitter circuit, bypassing the emitter resistor (FIGURE 5). This produces the same effect, in the collector circuit, as inserting a series capacitor between the collector and the collector load, except that it doesn't block d.c., as making that connection would.

Also this means that a slight reflection occurs into the base circuit, that

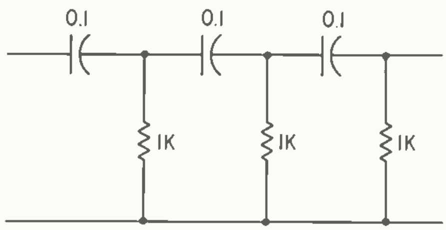

Figure 3. The basic identical successive-element network that can be used. It forms a good starting point for other variations.

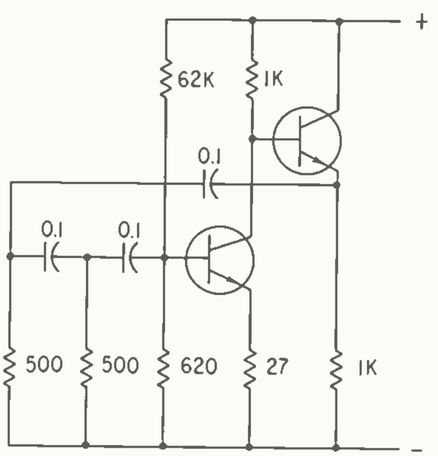

Figure 4. A circuit using the basic network of Figure 3, again with an emitter follower to provide essentially zero source impedance for the feedback network.

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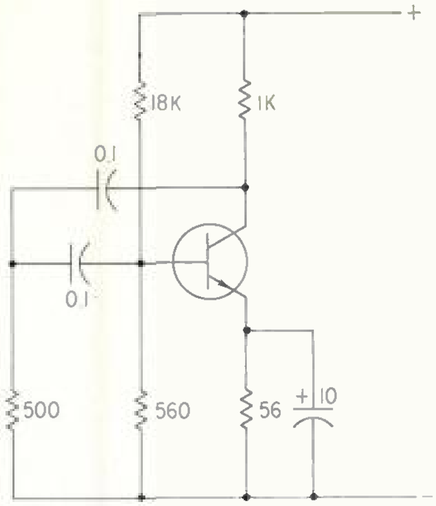

Figure 5. Another variation that can be made to work puts one of the phase-shift capacitors across the emitter resistor.

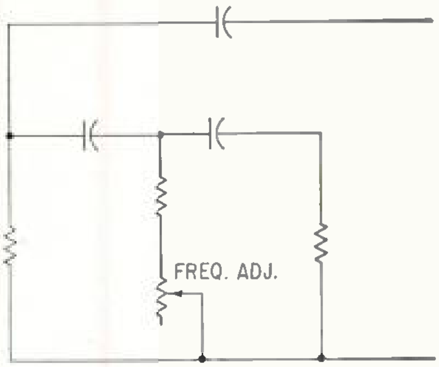

Figure 6. Making frequency adjustable is best achieved by putting a variable resistor in the middle phase-shift stage. Using a combination of fixed and variable resistance limits variation of oscillation condition within a practical range.

looks like a shunt capacitor. But this effect is much smaller (approximately by the current gain of the transistor) and thus the predominant effect is the phase shift at the collector.

Adjusting the frequency of this kind of oscillator can be achieved by making the resistance of the middle stage of R-C coupling variable. This is the change that has least effect on over-all attenuation of the network, as frequency setting is changed. It also does not affect the collector and base circuit impedances as much as changing any other component in the network would.

It is best to limit the variation that can be achieved to that over which waveform is not seriously impaired (FIGURE 6).

With tube circuits, a more popular form of oscillator circuit used the so-called *half-bridge* or Wein bridge, which uses a combination of series R and C with parallel R and C to produce feedback which is positive and in-phase at just one frequency. Converting this variety for use with transistors encounters certain problems which we will take up next month.

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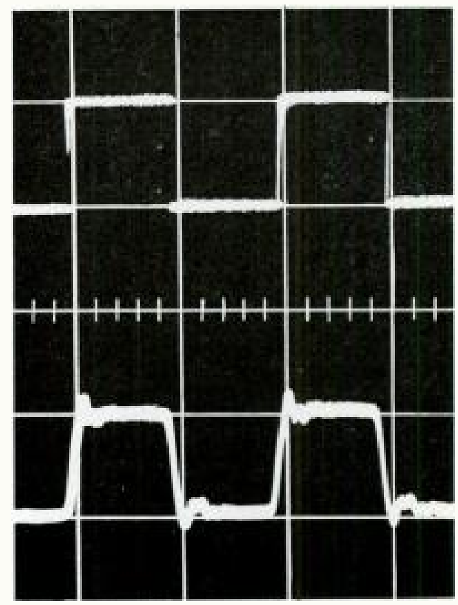

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MARTIN DICKSTEIN

HOLOGRAPHY FOR THE HOME

• Now that the World Series is over, you might want to take another look at the fantastic catches made in the outfield or you might wish to look at the last time Ted Williams stepped up to the plate (and hit a home run), or the 61st home run Roger Maris hit, or any other similar historic moment in sports. Perhaps there are events in theater or art that you would want to see. . .and on your television set at home, whenever you wished.

Toward this end, a new device was presented to the press about two months ago, and although the final product is not yet ready for the public, the idea has been developed to the point where the softwear is already under preparation and the hardware will be available for purchase in the early 1970's.

The SelectaVision^{tm} unit, developed by RCA, is envisioned as a small cartridge player, not much larger than a hi-fi phonograph, hooked up to the antenna leads of the t.v. set and capable of playing back in full color (on a color set) or in compatible black-and-white. To accomplish this feat, the capabilities of holography are used and the advantages derived therefrom offer a low-cost unit, inexpensive tape cartridges containing almost indestructible tape and nearly unlimited library from which to cull material for playback in the home. Most recently, the literature available on the applications of holography seems to indicate that the final image will appear in 3D, taking advantage of the peculiar characteristic of lensless photography to provide the observer with a completely realistic image of the process or object under scrutiny. However, this method (FIGURE 1) is only one method of producing holograms.

In the Fresnel method (FIGURE 2) the hologram is formed with the object in the near field while in the Fraunhofer process, the object is in the focal plane of a lens (as is the reference laser beam's source). The resolution of the latter process is much higher than that of the other method. In the third method, the off-axis beam is used to produce images that do not line up. This provides two images each of which can be recorded without interference from the other, a marked improvement over the shortcomings of the Fresnel method, especially, with the two images on the same axis—each interfering with the sharpness of the other. In the Fourier method, the hologram can be produced either with or without a lens (A) and (B) as the reproduction is accomplished with a lens to effect the transform (C). In any event, the hologram contains only waveform patterns (FIGURE 3) not images.

While it seems as though most holography applications are in the military (low-flying planes scanning the terrain directly underneath, or searching the ocean depths) or in industry (quality

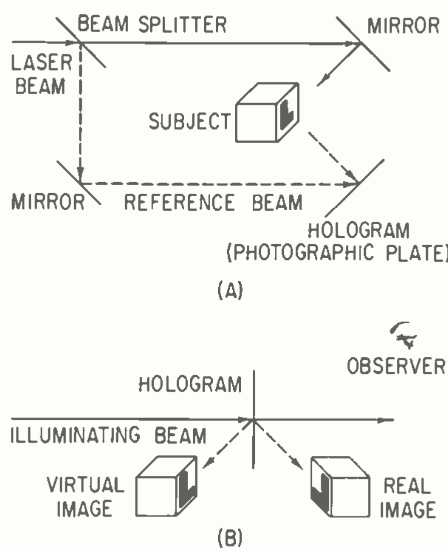

Figure 1. The usual method for producing and illuminating a 3D hologram.

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control on semiconductors or welded materials, in tires or in molds), the everyday consumer will soon be able to purchase a home application of laser/holography technology. This is expected to be the first consumer product utilizing lasers.

At present, the process will consist of producing holograms from ordinary film (FIGURE 4), which in itself means that there already exists an almost unlimited source of material which can be processed for home use in this device. Simplified, the recording will be made on a material which will be coated with *photoresist* (FIGURE 5). (If the original source is to be a color t.v. camera or videotape, the recording will be made on regular film using an electron-beam recorder with the color encoded on the film in vertical stripes with a total frequency range for black-and-white, red,

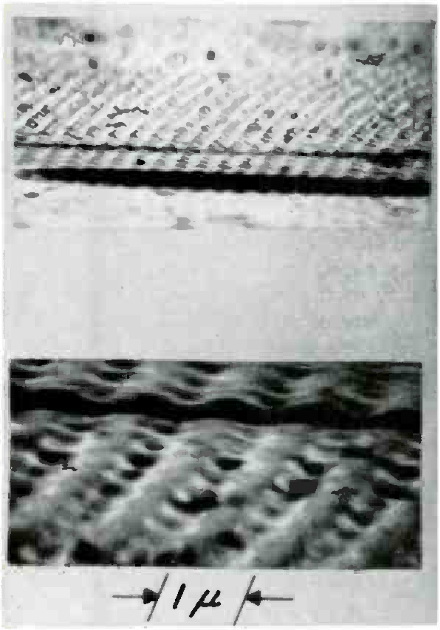

Figure 3. The appearance of a hologram with the indication of 1 micron as the distance between the adjacent ridges.

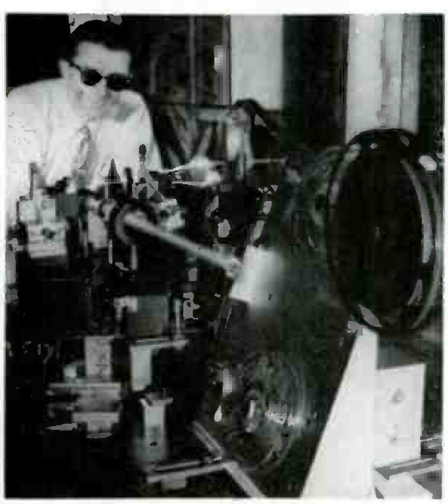
Figure 4. RCA scientist Robert A. Bartolini looks at equipment developed for making master holographic tapes for RCA's SelectaVision process.

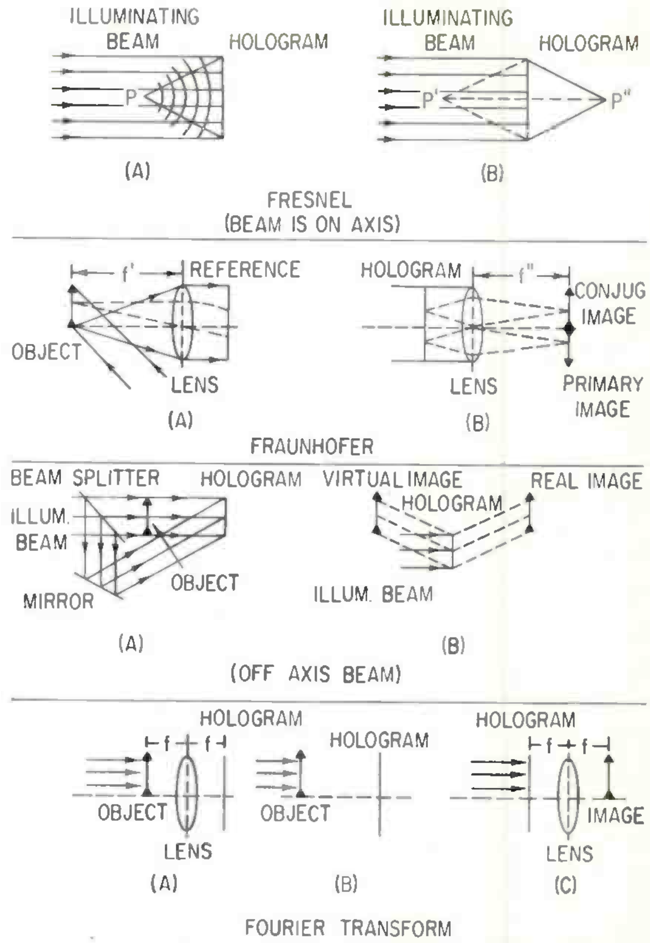

Figure 2. The various methods of producing holograms.

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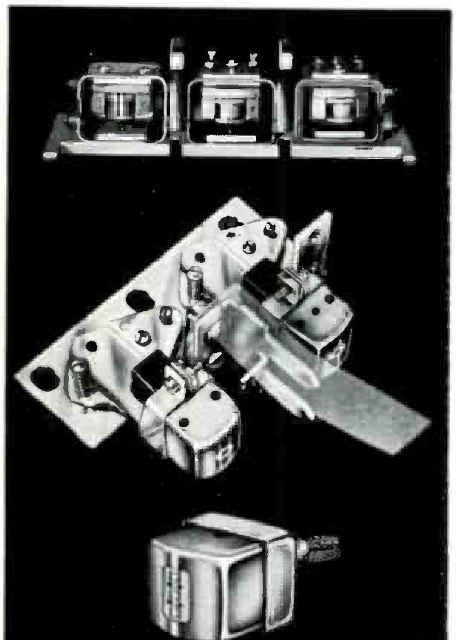

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and blue of 5 MHz.)

This film is then known as the color encoded master. Using a laser beam, this is then converted to holograms on a plastic tape coated with the photoresist, a substance which hardens depending on the intensity of the incident light. This tape is then processed in a chemical solvent leaving only the interference pattern ridges, and valleys. The processed tape, the hologram master, is plated with a coating of nickle which, when removed from the master, contains a duplicate impression of the holograms but with valleys where the ridges were and vice versa.

This nickle master is then pressed through pressure rollers onto a transparent vinyl tape. This final tape now contains impressions identical to the hologram master and can be rolled onto reels for packaging and sale to the consumer. The nickle master can make thousands of final tapes with no loss of quality. (FIGURE 6 illustrates the total process from the original film on the left to the color-encoded master, then the hologram master, the nickel master and finally, on the right, the vinyl hologram tape used at home.) The tape will be ½ inch wide and 2-mm thick and will run at 7½ in./sec.

The reconstruction of the viewable image will consist of the hologram tape moving in front of a low-powered laser with the image (FIGURE 7) being picked up by an inexpensive t.v. camera (FIGURE 8). The single vidicon sees only encoded messages produced from the film by the laser beam and thus does not have to be a color unit. However, to reproduce the color, the encoding of the vertical lines on the film is read by special circuitry following the camera and this image information is then sent on to the color t.v. set antenna leads through a modulator to be reproduced on the screen as either black-and-white or color images.

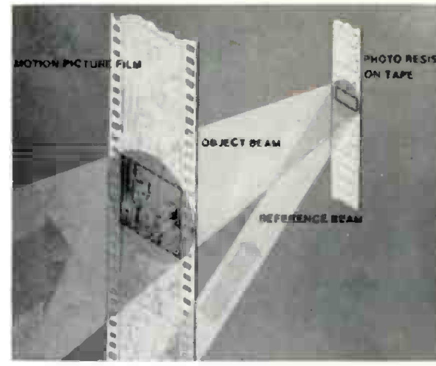

Figure 5. Production of a holograph from film, depicted in simplified form.

The present estimate for the unit is a consumer cost of about $400.00 with the tapes at about $10.00 for a half-hour program.

At present, the sources will consist of film, slides, videotapes or photographs. Sound has not yet been put on the tape but it is thought that an optical track may be used.

The advantages of the over-all system lie in the cartridge tape (permitting easy storage and loading into the machine), inexpensive tape (the vinyl will be similar to that used to package meat and other products found in market display cases) and the almost indestructibility of the tape (holograms have the property of producing complete images even though a part of the film is physically cut out, unlike a photograph, and the only loss is in resolution).

It might be interesting to note that the hologram tape does not have sprocket holes as does ordinary movie film nor does it have frame divisions even though the holograms are in the same aspect ratio as the original film. The tape will be drawn through the machine by a mechanism similar to an audio or video tape machine. The fact that frame divisions are missing means that a shutter mechanism as in a film

Figure 6. The five steps that convert broadcast-type film (at left) to the plastic tape used in Selecta Vision are checked by RCA's William Hannan. Left to right the steps are: broadcast film, color encoded master, hologram master, nickel master, plastic tape.

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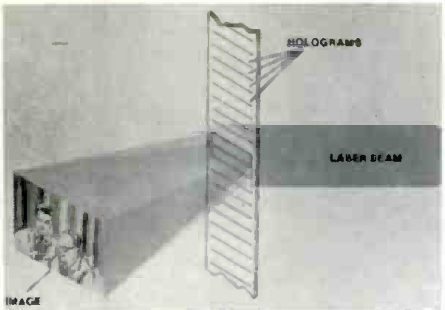

Figure 7. A simplified reconstruction of an image from the hologram tape.

projector is not needed but the pictures will still move smoothly from one "frame" image to the next without flutter. The hologram images actually blend or dissolve into the succeeding one to present a smooth flow of action. This process, therefore, allows the tape to be run at any speed (slow or fast motion) that is available on the machine or even to stop the tape at any instant for a study of one frame at a time.

It does not seem that comparison to the CBS EVR unit, at the present state, is possible as the RCA unit will have color capability while the CBS unit does not (yet) and also the CBS unit seems destined for the university or industry application while RCA's is for the home.

Thus, within the next two years or so, the consumer will have a home laser/hologram device, so soon after the discovery of lasers, with which to catch up on history or art or sports or space films of the past while the t.v. brings him more current events on the same tube.

Figure 8. The basic elements of RCA's SelectaVision are demonstrated with lab elements by Charles Carroll. Directly in front of him is a low-power gas laser, sending a beam at the tape of a simple tape-transport mechanism (left). As the laser passes through the tape holograms, it bends part of it into the camera where it is deciphered into the final images.

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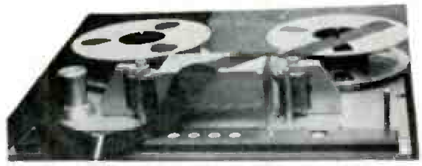

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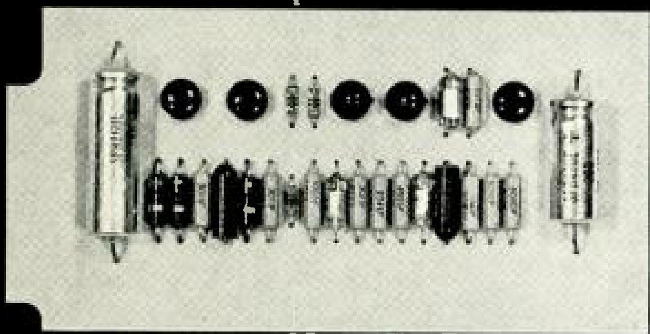

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Tetraphonic Sound

JAMES CUNNINGHAM

Four-channel stereo is now being promoted to the consumer, and it may very well catch on, supplanting two-channel stereo. This article sets you thinking about the right and wrong ways to approach the problems of recording to provide a proper listener perspective.

ANECDOTES from the late, great Sir Thomas Beecham have always had an arresting effect on musicians. There is one that also should have a similar effect on engineers. The story goes that on the event of a dinner given in his honor and celebrating ten years of recording for a certain record company, Sir Thomas announced to the assembled executives that they had been engaged in a "fantastic public swindle" for the past decade and only recently did their records even crudely resemble what took place in the concert hall.

If Sir Thomas were alive today and could hear one of our modern stereo recordings through today's finest components he would, no doubt, say the same thing. Of course everyone in the audio profession knows that perfect reproduced sound in the home is unattainable.[1] A photographer cannot hope to exactly reproduce a scenic sunset in all its surrounding glory on an 8 x 10 picture, so he resorts to various techniques to capture a feeling of the sunset, similarly the audio engineer must use analogous techniques to *represent* the original as he hears it. This is why audio mixing is an art, a personal interpretation of reality. Still, an occasional reminder of how far we are from reality is helpful. so that we can continue to improve our techniques.

For more than a decade now, two-channel stereo has been with us and extolled as the ultimate in sound reproduction. Behind the scenes, however, many engineers have for years tried various combinations of multichannel techniques, and yet only in recent months has a multi-channel product been marketed. There can be no doubt that the audio world desperately needs an infusion of excitement such as it had in the 1950's, so let us explore the logic and economics of expanding the number of channels in a high-fidelity system.

Why should we need more than two channels when we only have two ears? This simple question can perhaps best be answered by reviving the old "hole-in-the-wall" theory or explanation of sound reproduction. Suppose we erect a typical living room in the center of a large concert hall with four sound-proof walls and a ceiling. If we now cut two holes in the wall nearest the stage (FIGURE 1) we will have, at first glance, an approximation of today's stereo system. The sound emanating from an orchestra on stage will, however, never be truly the same inside the living room until we have literally removed the walls and ceiling. Since this is

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James Cunningham is director of research for the 8 Track Recording Company located in Chicago, Illinois. As such he has been experimenting with four-channel stereo recording for some time.

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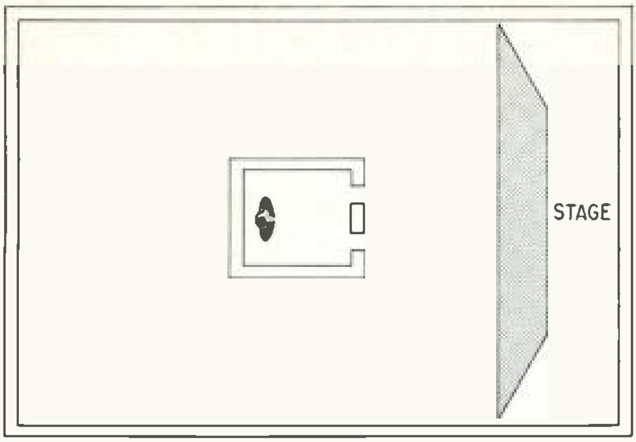

Figure 1. Here is a concert hall with a conventional stereo two-hole living room in it.

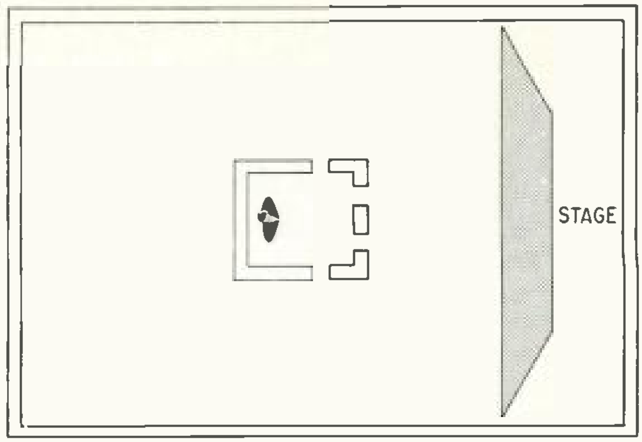

Figure 2. The same set-up as in Figure 1, only now the living room has four holes.

obviously impossible, what is the smallest number of holes we can cut—and where should they be?

First, let us examine what is happening to the sound inside the living room. The binaural hearing sense is unable to operate properly because the direct sound from the orchestra and all of the thousands of reflections from the walls do not *each* come from a different direction as they do in the hall—thus not giving our brain the information it needs to sort them. Instead all these sounds are more or less mixed up and funneled through those two holes in the wall. This effect would be obvious if you were to make a recording with the microphone where you are now (no anechoic chambers, please) of someone talking on the other side of the room. On playback the recording will sound hollow or boxy and the ambient noise in the room will seem to smother some of the words. Yet, as you listen to the person talking in the room with you none of these things are apparent because your binaural hearing sense is operating properly.

Meanwhile back in our mythical living room there are other deleterious conditions. The sound emitted from those two holes is bouncing from wall to wall creating a new set of reflective patterns and standing waves which interfere with what we are trying to hear through the holes. The standing waves or room modes tend to upset the directional intensity clues from the holes and the reflections tend to mask the critical spatial information. In other words, we do not want the listening room to have any characteristics of its own or contribute anything to the sound, we only want to reproduce what is happening out there in the hall. One only has to experience the startling effect of stereo outdoors to verify this.

Since there is no known method of making the walls and ceiling of our living room acoustically transparent, we must try to improve things by cutting more holes in the walls. If we take the stand that the directional information from those two holes is adequate but the spatial information is poor, then the logical place for two more holes is one in each side wall as shown in FIGURE 2. To test this theory we can make an experimental recording by placing microphones at the exact spots in the hall where our mythical holes are: then in the listening room set up speakers at these locations. Anyone naive enough to try this will meet with complete failure because the forward microphones are simply too far from the orchestra to hear the correct ratio of direct-to-reflected sound. This failure does not, however, invalidate the theory, it merely illustrates that cutting four holes in the walls is not equivalent to removing the walls and ceiling.

How about eight or even sixteen holes? At the present state of technology this would limit the market to eccentric millionaires with a penchant for high fidelity, and even then the sound would be poor because we still have not overcome all the deleterious effects noted above.

To return to what was said at the outset, a recording is a representation of the original. Now, however, perhaps we better know what is needed to represent the original. Suppose, for example, we record two-channel stereo in the usual way and simultaneously record two more channels of information which will give the ears reflected sound in such a manner that our binaural hearing sense can better function in the normal way—to be able to separate the direct and reflected sounds which come from different directions. If we place the loudspeakers as shown in FIGURE 3 and supply them with the proper information, the results are beyond all expectation. The sound is open, the definition is incredible, every instrument seems to have "room to breath," and each instrumental timbre is so much more faithfully reproduced that a switch back to two-channel stereo is a shock, as if one's ears suddenly stopped up.

It is evident from the foregoing, that a two-channel stereo recording, no matter how excellently it is done, simply cannot supply the listeners' ears with enough information to recreate a convincing replica of the original. A time lapse study of what happens in a concert hall will explain this. FIGURE 4 shows the paths taken by the direct and the first four reflected sounds. FIGURE 5 shows the time distribution of the first-order reflections, six from the six surfaces. If the hall is 40 x 60 x 100 feet the sixth reflection will arrive at the listeners' ears about 68 milliseconds after the direct sound. The second order reflections, 18 in number, will have arrived by 102 milliseconds, etc. The 10th order reflections, 402 in number, will have arrived by 376 milliseconds.- If we add up all the reflections to the 10th order we have over 1,000 reflections in the first third of a second! Of course, the intensity of these reflections will depend on the absorptivity of the boundary surfaces, and if the sound source is periodic we cannot neglect the phase relationships. Nevertheless, the complexity of the sound field is staggering even for a single sound source, not to mention a hundred-piece orchestra. Although the mechanism of the human binaural hearing sense is not known exactly, the *cocktail-party* effect has been noted by many observers (this is the facility to supress unwanted sounds—for example separating one voice from the din of a cocktail party). A person with hearing in only one ear has great difficulty hearing in such an environment and yet his hearing appears normal in a quiet environment.

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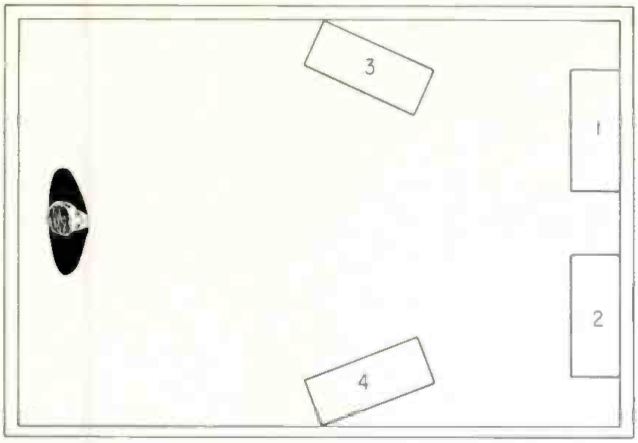

Figure 3. This is a listening set-up showing speaker placement for listening to four-channel stereo.

This situation is analogous to the concert hall; in any reproduction system *we must preserve the directionality of the reflected sound* as well as the direct sound, so that the ear can use its faculty to suppress unwanted sounds.

The theory of microphone placement up to this day has been simply to move the microphones to a location where the unwanted sounds are supressed by the nature of the pattern and position of the microphone relative to the sound source. This monaural technique was transferred to stereo and although it has been developed to a considerable degree of excellence, it involves a number of compromises, and has severe limitations. As we expand the number of channels in a stereo system to supply directional clues to the reflected sound we can begin to desert the old techniques of mono sound.

What we are suggesting here then, is a new method of microphone placement together with loudspeaker placement which will come closer than any system heretofore in use to achieving the original sound field. Although a forthcoming paper will give the details of microphone placement, it is not difficult to surmise what configurations are possible from FIGURE 3. Just as two-channel stereo microphones are placed to give virtual images between channels, thus creating a *wall-of-sound*, microphones are placed so channels 1 and 3, and 2 and 4 will operate as pairs to give three walls of sound thus supplying the needed directionality to the reflected sound. In addition, channels 3 and 4 operate as a stereo pair to sharpen the directionality of the reflected sound. An analysis of the sounds reaching the listeners' ears after the direct sound reveals 3 high-fidelity reflections picked up by the

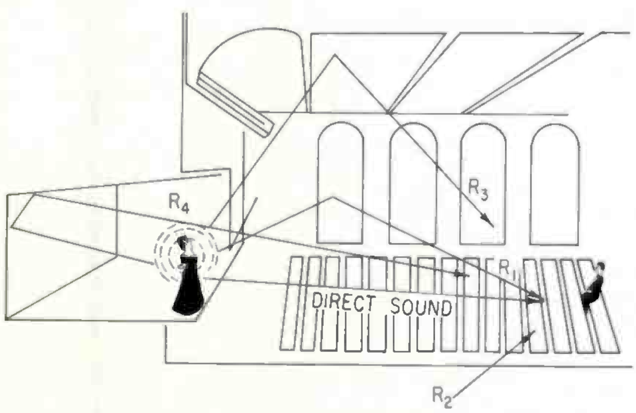

Figure 4. The paths of direct and several reflected sounds (not all first order) are shown.

other three microphones which would correspond to R_1, R_2, and R_3 in FIGURE 5.

This fact, together with the necessity of having a built in delay for channels 3 and 4 (due to the Haas effect all the sound seems to emerge from channels one and two, the normal stereo speakers) determines the initial microphone placement. Many other factors, such as the characteristics of the hall itself, the size of the orchestra, the type of music, etc., will influence the final placement.

The speaker locations shown in FIGURE 3 were arrived at after tests in many typical living rooms, and do not represent the ideal location in every room. The speakers could be placed in the four corners of the room, for example, but the seating arrangement in the vast majority of listening rooms probably favor something close to FIGURE 3.

When we discovered this phenomenon some eight years ago, we called it *Tetraphonic Sound* and set about to market it. A demonstration tape was played for an audience including professional audio people, recording company executives, musicians, and laymen. The reaction was without exception

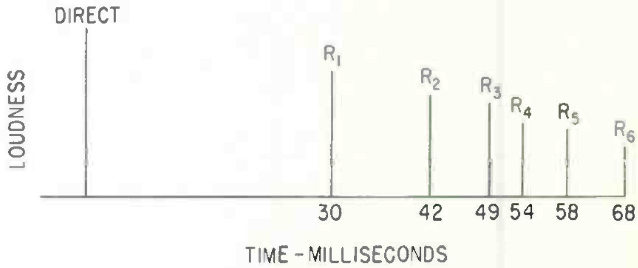

Figure 5. The time distribution of direct and first-order reflections.

one of great enthusiasm, much more rewarding than in the early days of stereo when we used to have to hit people on the head with ping-pong balls to keep their attention. Difficulties arose, however, which proved insurmountable. There was no moderately-priced equipment available on which all four tracks of a tape could be played simultaneously. This rather reduced the chances of anyone marketing the tape recorded in *Tetraphonic Sound* since no one would buy it. This in turn discouraged manufacturers from marketing the equipment. Another small deterent was the fact that *Tetraphonic Sound* could only be recorded in certain concert halls, thus outmoding all the recording studios in the world. This method, of course, can *not* be electronically simulated any more than can stereo be made from mono. Methods of supplying auxillary speakers with sound derived from various kinds of reverberation chambers have been attempted for years with very little success. There is, of course, a virgin field here for electronic gimickery in the field of pop music, which has, in stereo, created its own reality. One hopes, however, the principles outlined in this article will not be too flagrently violated. This situation is somewhat analagous to that of stereo in the early 1950's; so just as stereo made its way, slowly and haltingly, perhaps four-channel sound will catch the interest of the public giving the audio world a much-needed breath of spring.

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A Phono Reproduction Preamplifier

ALLAN P. SMITH

The author describes two new phono preamp cards that have recently been marketed as an attempt to achieve the state of the art in recovering the information on a disc.

THE TRANSITION FROM VACUUM-TUBE to solid-state amplifiers has brought about a significant improvement in the performance of recording and reproducing equipment. Vacuum tubes are high-impedance devices, and as such, require particular attention to impedance matching for optimum performance. The development of transistor amplifiers, which are basically low-im-

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pedance devices, has often indicated that design techniques that were valid for vacuum tube circuits are being applied to the design of transistor amplifiers. The result has been the failure to take advantage of the improvements offered by low-impedance transistor design techniques. In particular, the design of modern magnetic phono-cartridge preamplifiers is a typical example of vacuum-tube design techniques.

The majority of magnetic phono-cartridge manufacturers recommend that the input impedance of a magnetic phono-cartridge preamplifier be 47,000 ohms. In vacuum-tube technology, a 47k ohm input impedance was a good match for preamplifier inputs. Why is 47k ohms the recommended load impedance for a magnetic phono cartridge? Moving-magnet phono-cartridge manufacturers usually design their cartridges with as high an impedance as possible, somewhere around 3k ohms, in order to get greater output voltage than with a low-impedance design. This impedance, combined with the capacitance of the cable connecting the cartridge to the preamplifier and the resonant frequency of the cartridge, have led to the selection of 47k ohms as the recommended load for a magnetic phono cartridge. If the resonant frequency of a magnetic cartridge is 15 kHz and a long connecting cable is used to the preamplifier, the resulting resonant frequency may be reduced to 8 kHz or so unless the resonant frequency is damped by the high impedance of the phono preamp input.

The use of high-impedance coils within the magnetic cartridge or in some cases where a step-up transformer is used to achieve the high impedance, cartridge performance is significantly reduced by the frequency discrimination, phase shift, ambient pick-up, and impedance limitations of the coil configuration. Also the signal-to-noise ratio of the input stage of the preamplifier is a contributing factor to the final performance of the cartridge-preamplifier combination. The effective impedance of the cartridge at a specific frequency and the input impedance of the preamplifier in parallel combine to produce a theoretical limitation on signal-to-noise performance of the preamplifier. The thermal noise produced by a resistor which is equal to the parallel combination of the cartridge impedance and the preampifiler input impedance indicates the maximum theoretical signal-to-noise ratio that the preamplifier is capable of producing. For this initial consideration, we shall neglect the effect of the RIAA equalization network on preamplifier noise. The low frequency boost of the equalization network will influence the final signal-to-noise performance of the preamplifier, but for the purpose of discussing the effect of input impedance on noise, we can neglect it. The following equation is generally used for the computation of thermal noise:[1]

$E^2 = 4kTBR$

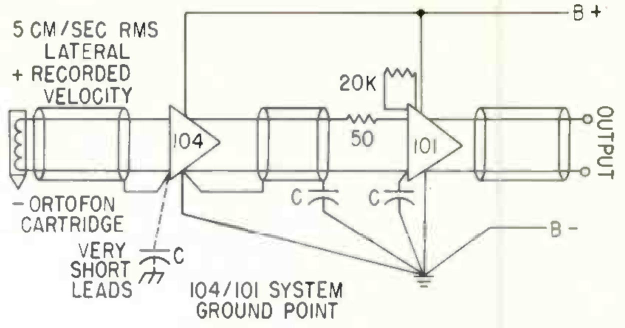
where k = Boltzman's constant = 1.374×10^{-23} joules per °K
T = Absolute Temperature in °K
B = −3 dB. bandwidth
R = Equivalent resistance

If we substitute the value for k in the equation, substitute 290° for K and use a bandwidth of 20 kHz, we arrive at the following form:

$E^2 = 3.188 \times 10^{-16} \times R$

If we insert the value of 3,000 ohms for the equivalent impedance of the cartridge, we arrive at the following:

$E^2 = 9.564 \times 10^{-13}$



SMITH FIG. I

Figure 1. The preamplifier wiring diagram for a two-conductor wiring configuration.

Taking the square root of this value, we arrive at the theoretical thermal noise voltage for an impedance of 3,000 ohms which is:

E = 0.98 microvolts

Now let us consider the theoretical thermal noise voltage developed across a 2-ohm resistor.

Again we use the formula

$E^2 = 3.188 \times 10^{-16} \times R$

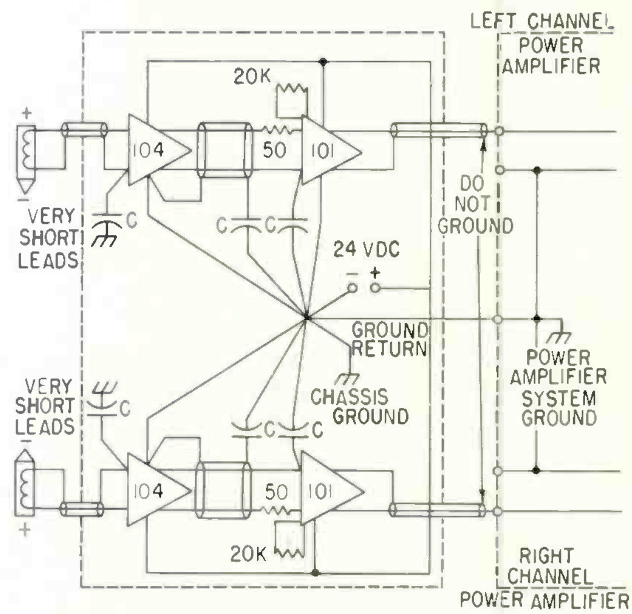
Inserting the value of 2 ohms for R, we get

$E^2 = 6.376 \times 10^{-16}$

Taking the square root of this value, we arrive at the theoretical thermal noise voltage for an impedance of 2 ohms, which is:

E = 0.02 microvolts

The Ortofon SL-15 magnetic phono cartridge, a moving-coil cartridge, has an impedance of 2 ohms and is supplied with an external step-up transformer with a 15 k-ohm output impedance. The phono preamplifier described in this article was designed to take advantage of the performance improvements offered by a magnetic cartridge with a 2-ohm impedance. This combination of a 2-ohm cartridge impedance plus low preamplifier impedance (3 ohms) will reduce the



SMITH FIG.2

Figure 2. Stereo preamplifier wiring for a single-conductor wiring configuration.

ambient hum pickup and capacitive high-frequency attenuation found in normal high-impedance shielded cable connections by more than two orders of magnitude, or greater than 20 dB!

Typical common-emitter amplifier input circuits exhibit lowest noise at an input impedance of between 10k and 15k ohms. The design of the amplifier discussed here exhibits lowest noise at a 0-ohm input impedance. Without equalization, the preamplifier is capable of a frequency response within 0.1 dB, 10 Hz to 300 kHz and distortion below most test oscillators.

The SL-15 cartridge with its 2-ohm output produces an output level on the order of −80 dBm for a cartridge input of 5 cm./sec. lateral recorded velocity. The low output impedance of the cartridge assures that long shielded cable lengths to connecting equipment may be used without the ambient hum pickup or high-frequency capacitive attenuation associated with high-impedance cartridges. (However, normal precautions of keeping the cartridge and wiring out of hum fields produced by power transformers and motors must still be observed for proper operation.)

Because of the extremely wide bandwidth of the preamplifier, proper attention to the elimination of ground loops in the interconnection of the preamplifier with associated equipment will assure optimum operation. The creation of ground loops in either the input or the output circuits of the preamplifier will cause transients and/or oscillation that may damage other equipment such as high frequency loudspeakers. FIGURE 1 shows the wiring diagram for a single-channel preamplifier for the two-conductor wiring configuration. The Spectra-Sonics model 104 phono preamplifier card provides 40 dB. of gain in addition to the required RIAA phono equalization. The model 101 preamplifier card, which is similar to the model 104 card, except that it does not provide equalization, is normally supplied with a 10.7 k-ohm resistor for 40 dB of gain. Replacing the 10.7k-ohm resistor with a 20k-ohm low-noise resistor raises the gain of the Model 101 preamp card to 45 dB. The combination of one model 104 preamp card and one model 101 preamp card provide a combined system output of +5 dBm for a cartridge input of 5 cm./sec. lateral recorded velocity.

The printed-circuit card connector for the model 104 preamp card must be of the bifurcated contact type (Viking 2VK10S/2-2, or equivalent). Bifurcated contact edge connectors must be used for positive dry-circuit contact because of the extremely wide bandwidth and low-level signals being amplified, high-frequency grounding at the signal input

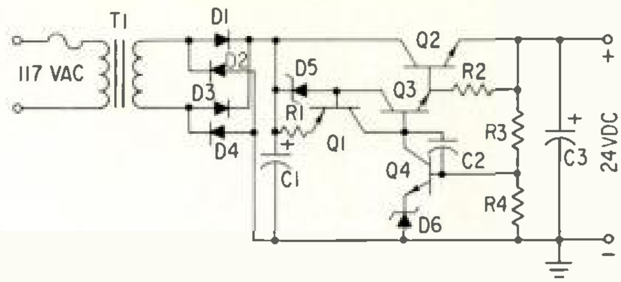


Figure 3. A power supply for the preamps described. The components are listed in Table 1.

negative terminal must be effective. The input capacitor shown in FIGURE 1 should be a 0.47 mFd, 10-V ceramic capacitor with very short leads to the closest chassis ground for effective high-frequency grounding.

When a dual-channel power amplifier is to be used with this preamplifier, the single-conductor shielded-cable configuration as shown in FIGURE 2 is recommended. This configuration is used when the preamplifier is connected directly to the power amplifier without a transformer coupled input. The shield must not be grounded at the power amplifier and must be disconnected when standard prewired phono jacks are used. The complete wiring configuration for a stereo playback system is shown in this figure. The capacitors (0.47 mFd, 10-V ceramic) are required for high-frequency grounding. Whenever there are two separate power amplifiers not electrically connected, each power-amplifier system ground must be connected by a separate ground return to the preamplifier ground plane. If two separate power amplifiers are mounted in the same equipment rack or if the separate power amplifiers have three-wire power cords and are connected to the same power-line circuit, there will be a ground loop and care must be exercised against the development of ground loops in this manner.

If the SL-15 cartridge is to be mounted in a record changer, an inspection of the changer's muting switch should be made. The shorting of the cartridge leads by the muting switch during the change cycle of the record changer will cause severe transients to be developed. Thus, the muting switch must be bypassed.

Power for the phono-preamplifier system is supplied by the power supply shown in FIGURE 3. This power supply is extremely well regulated and provides the filtering and regulation required for the preamplifiers. The parts list for the

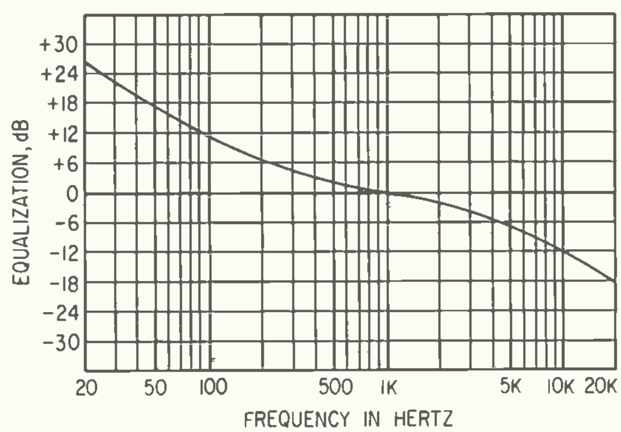


Figure 4. Equalization of the Model 104 phono amplifier.

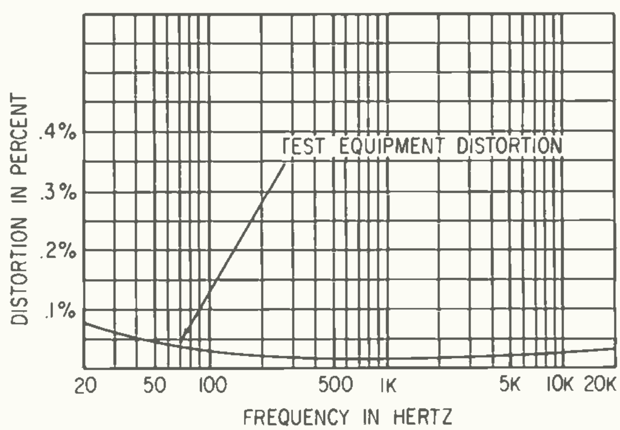


Figure 5. Combined t.h.d. and noise of the preamplifier without feedback.

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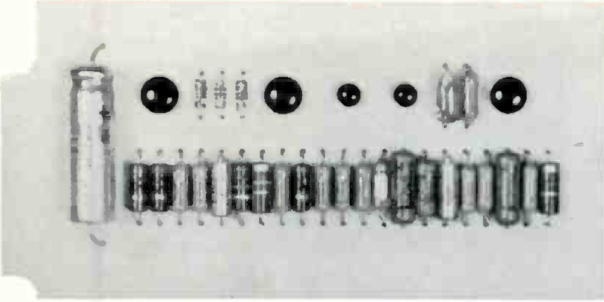

Figure 6. The Model 104 phono preamplifier card.

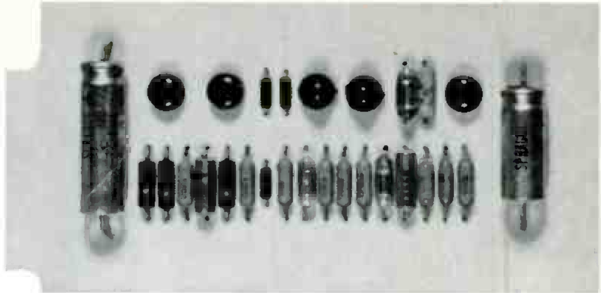

Figure 7. The Model 101 phono preamplifier card.

power supply is shown in TABLE 1.

The phono preamplifier described in this article sounds impressively good. First demonstrated at the spring Audio Engineering Society Convention held in Hollywood, California in May 1969, this preamplifier system, when used with power amplifiers and loudspeaker systems of the finest quality, demonstrates that there is musical information on phonograph records which has not been heard before. The frequency response of the preamplifier system is shown in FIGURE 4. Unlike other preamplifiers, the low-frequency response of the preamplifier extends down below 10 Hz. When used with quality turntables with low-rumble characteristics and wide-range loudspeaker systems, this system brings out low-frequency program material with clarity and definition that is missing in other reproduction systems.

Because of the RIAA equalization characteristic which provides considerable low-frequency boost, conventional signal-to-noise measurements are meaningless. As demonstrated at the AES convention, the true test of low-noise performance is to play a recording of mint condition with known low surface noise and listen to the surface noise between selections on the record. Then place the stylus of the cartridge on the record label and one will find that the noise of the preamplifier system is significantly below the surface noise on the finest quality disc recordings.

PARTS LIST FOR POWER SUPPLY

C_1 = 1000 MFD, 50 V Electrolytic Capacitor
C_2 = .001 MFD, 50 V Mylar Capacitor
C_3 = .05 MFD, 50 V Mylar Capacitor
D_1-D_4 = International Rectifier 10D2 or Equivalent Silicon Diode ¼ Ampere, 100 V.
D_5,D_6 = 6.2 V Zener Diode, ¼ W. 10%, IR 1N709 or Equivalent
Q_1 = 2N4248 Transistor
Q_2 = 40389 Transistor (RCA) or 2N3053 Transistor with Heat Sink
Q_3 = 2N3566 Transistor, Fairchild, CDC or Equivalent
Q_4 = 2N3566 Transistor or 2N1711
R_1 = 1 k ohms, ½ w. 5% composition resistor
R_2 = 510 ohms, ½ w. 5% composition resistor
R_3 — 13k ohms, ½ w. 1% low noise metal film resistor
R_4 = 5.1k ohms, ½ w., 1% low noise metal film resistor
T_1 = 26.8 VCT secondary @ 1 Amp., Triad F40X or Equivalent

Table 1. The components used in the schematic shown in Figure 3.

Distortion measurements on the preamplifier are likewise complicated by the equalization curve with its high-frequency roll-off and low-frequency boost. Since the equalization network is used as the feedback element in the model 104 preamplifier, removal of the network will render the preamplifier without any feedback indicating the worst-case condition for measurements. With the feedback network connected, even at the lowest frequency of bass boost where feedback is at its minimum value, there will be less distortion than with the feedback network disconnected. Total harmonic distortion measurements of the preamplifier were made with the feedback network disconnected and the results are shown in FIGURE 5. At maximum output before clipping (+18 dBm) the total harmonic distortion produced by the model 104 phono preamplifier card is less than the residual test equipment distortion. Considering that in typical operation the typical output level of the model 104 card is approximately −40 dBm, the preamplifier has 58 dB of overload margin before distortion occurs. The model 101 preamplifier card is identical in performance to the model 104 phono preamplifier card though it lacks the Model 104 card's network for RIAA equalization and input filter to minimize radio-frequency interference pickup. The intermodulation distortion of the model 104 phono preamplifier card is also less than test-equipment distortion or under 0.02 per cent.

The preamplifier cards used in this article are available from the manufacturer, Spectra Sonics, 770 Wall Avenue, Ogden, Utah 84404. The model 104 phono preamplifier card is shown in FIGURE 6 and currently lists for $72.00. The model 101 preamplifier card is shown in FIGURE 7 and currently lists for $69.00. The Viking printed-circuit card connectors are available as the model 230 and list for $2.14 each. The preamplifier cards measure 2½ in. x 5 in. x ½ in. and weigh 2 ounces each.

The complete preamplifier system described in this article is soon to be released as a stereo phono preamplifier with self-contained power supply and using the single-conductor wiring configuration. It will be designated as the model 105.

REFERENCE

[1]M. C. Sprinkle, THE ULTIMATE NOISE, db Magazine, Vol. 3, No. 6, pp. 23-27.

ACKNOWLEDGEMENT

The writer wishes to acknowledge the photographs used in FIGURES 6 and 7 as supplied by Mr. William G. Dilley, Spectra Sonics, Ogden, Utah.

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Illumination Noise Control

MICHAEL RETTINGER

Now that consoles and recorders are approaching theoretical limits of signal-to-noise, other noise-producing elements in the studio begin to become objectionable.

THE AMBIENT NOISE in a sound recording studio is very often the most significant factor in determining the lower signal limit for recording or reproduction. The internal noises of the equipment—thermal agitation of the atoms in the components, thermal agitation of the electrons in the conductors, transistor or vacuum-tube hiss, etc.—may lie far below the acoustic disturbances originating in the studio. Of these, lamp noise frequently assumes a major portion in the noise of the system. It is the purpose of the following to describe the noise produced by various sources of illumination, and to offer ways and means for reducing this unwanted sound.

FLUORESCENT LIGHTS

Fluorescent lighting of offices, studios, classrooms, etc., is becoming ever more prevalent. The reasons are: greater illumination efficiency, providing from three to four times as much light per watt as heated-filament lamps; cooler operating temperature, which together with the lower power consumption makes for less heat in the room; from three to four times longer life than incandescent lamps; and a more desirable distribution of light in the form of an elongated source—line of light—which tends to avoid shadows.

As with so many other technical advances, however, there are also some disadvantages connected with fluorescent lights, the chief of which is the noise radiated by the luminaire (representing lamp) housing, reflector, and ballast. Fluorescent light is produced by electric discharge lamps, in which electricity is periodically passed through a gas or metallic vapor. So-called ballasts—inductances or coils with iron cores—are placed in series with the lamps to stabilize them. These units, together with the lamp vibrations, make for an extended and conglomerate source of noise of many frequencies. Some of the components are harmonics of the alternating-current frequency and are produced by the non-sinusoidal flux in the ballasts, while others are resonant frequencies of the sheet-metal reflectors and the lamps themselves.

Most attempts to quiet the ballasts by electrical and magnetic means tend to be makeshifts, temporary and unreliable expedients. The best means for reducing fluorescent lighting noise consists in locating the ballasts outside the room in which fluorescent lighting is employed, in such places as adjoining hallways, closets, attics, etc. It is not an inexpensive means, since it involves separate conduits with a four-wire cable between the luminaires and the ballast housings, but it is highly reliable and certain to produce the desired results of quietude. In my experience many fluorescent-light noise-control devices, such as non-metallic fillers in the air gaps of the ballast cores, rubber or Neoprene shock isolators in the ballast depositories of the fluorescent lighting reflectors, air gaps in the ballast cores which are centrally located to avoid stray flux, etc., have not at all proven equivalent in noise control to remotely located ballasts.

Michael Rettinger is a consultant on acoustics. He has written many articles and books on the subject.

INCANDESCENT LIGHTS

For television and motion-picture film work, incandescent lights are generally preferred over both fluorescent and carbon-arc lighting. The reason is that now, with tungsten-halogen (formerly called quartz-iodine)lamps generally available, long-life filament sources of light can be had with high light output of desirable color temperature and relatively small weight. Also, they may be operated satisfactorily with alternating current, unlike carbon-arcs, which generally require direct-current power. However, when lighting load in a studio reaches, say, 20,000 watts of alternating current power, both the magnetic flux about the lights and the large air-conditioning system required to remove the heat from the room may present sources of noise for sound pick-up. One protection against hum generation in the microphone consists in covering the transducer with a perforated iron screen, to act as a magnetic shunt for the flux, so that it may not penetrate the air-gap of the moving element. Another means consists in the use of a dip filter in the electronic circuit.

This article is not well suited to describe in detail the many ways and means available to provide a quiet air-conditioning system, or even how to describe the performance specifications of a quiet system, for the required pages would be far too many. For an extensive analysis of the system, the reader is referred to one of my books[1]. It will be noted here only that, by far, the best means consists in employing a system with low jet velocities (no more than 500 ft./min.). This means, of course, large ducts and large or many outlets in the studio. An alternative consists in turning the system off during a recording.

CARBON ARCS

This type of lighting is used in motion-picture studios. Even there, it is increasingly being supplanted by lighter tungsten-halogen lamps. Carbon arcs often generate a high-frequency hiss or buzz, and amelioration generally consists in keeping the microphones as far away as possible from these lights, employing a frequency selection filter, or a combination of the two expedients.

[1]M. Rettinger, *Acoustics—Room Design and Noise Control,* Chemical Publishing Co., 200 Park Ave. South, New York, N. Y. 10003.

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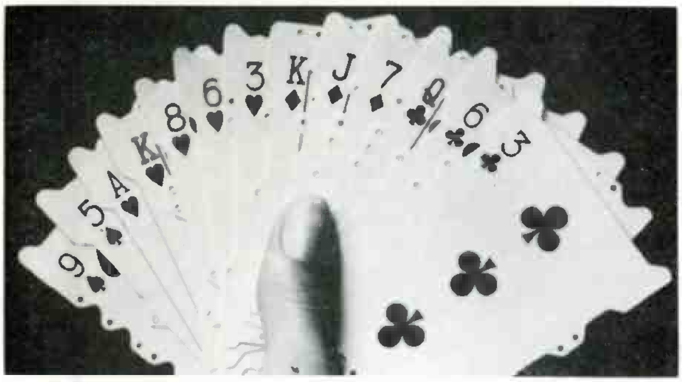
Lesson Number 11



Would you pass?

Today's lesson is on responding to opening bids of one-of-a-suit.

Cover the box below with a sheet of paper so you won't see the answers to the questions until you've come up with your own answers.

You hold the hand in the photograph.

Your partner has opened the bidding with (1♠).

What do you bid?

Pass — READ A
1 NT (*Pass*) — READ B
2♥ (*3♥*)
2 NT (*3 NT*)

What do you re-bid? (after 2♥)

Pass — READ C
3 NT (*Pass*) — READ D
4♥ (*Pass*) — READ E

What do you re-bid? (after 2 NT)

Pass — READ F
4♥ (*Pass*) — READ G

A) You can't pass with a hand that strong.
B) Your response shows 6-9 high-card points and is not forcing.
C) You have enough for game; don't stop now.
D) This is game, but the wrong one. You found a heart fit—that's your spot.
E) Correct bidding. Congratulations.
F) Wrong game. Your 2 NT response is to blame. You can get to no-trump later if that's right, but first you should show your good heart suit.
G) You should have bid 2♥ in the first place, because now you really took a stab in the dark by bidding 4♥. This time you were lucky — 4♥ is the right contract. But what if partner had no heart support for you?

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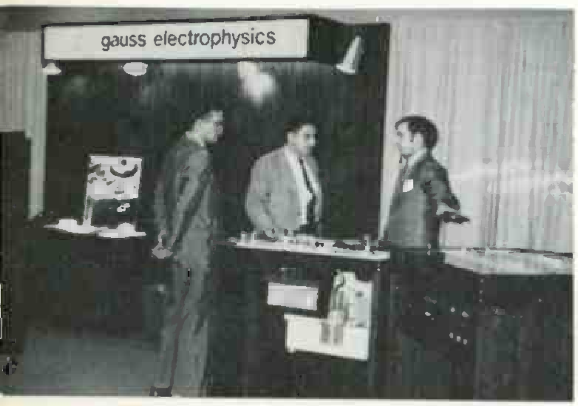
VIEWS OF BOOTHS



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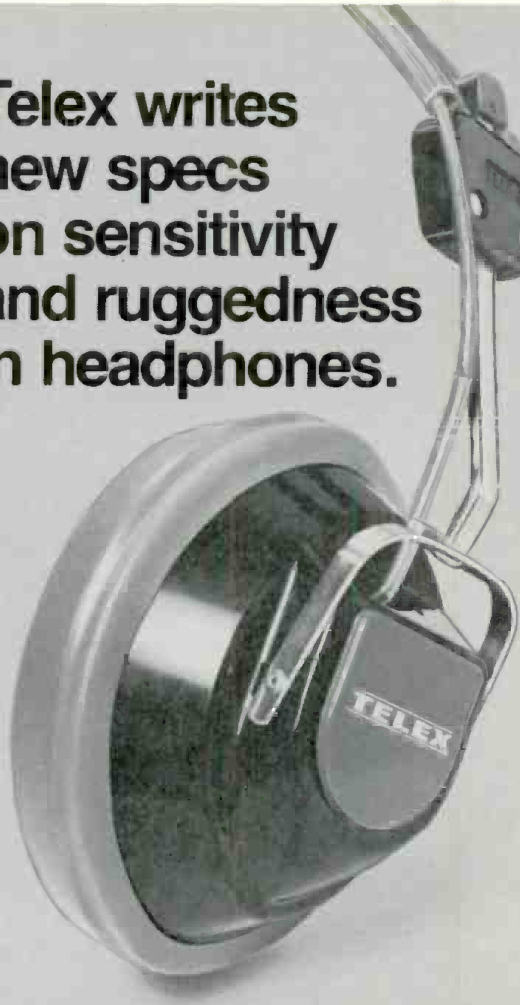

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CONSOLES

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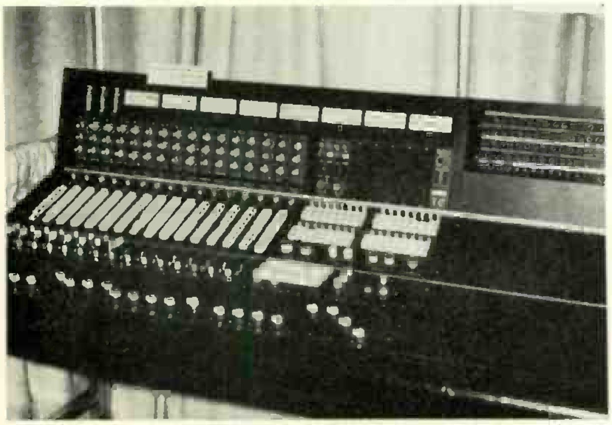
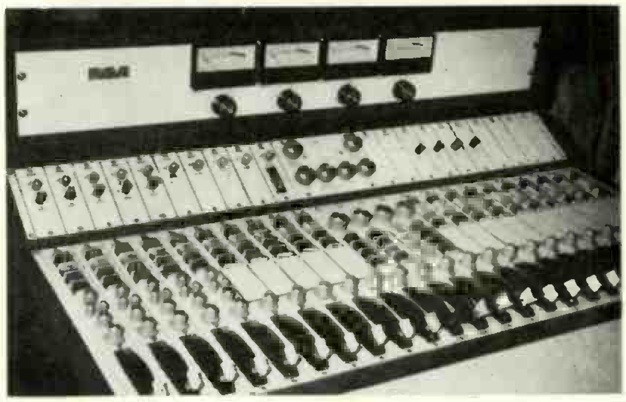
Gotham Audio showed a group of compact Swiss-made Studer mixing desks. Peak level meters are used. Circle 96 on Reader Service Card.

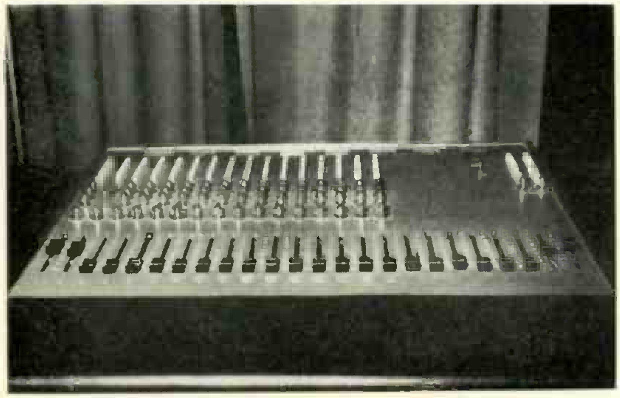


Automated Processes eight-track recording/mixing desk. Circle 99 on Reader Service Card.



RCA has Pointon faders on their consoles, along with a highly layout. Circle 94 on Reader Service Card.

Suburban Sound's eight-track console assembly. Circle 98 on Reader Service Card.



Fairchild has a new portable mixing desk that offers 16 channels you can take with you. Circle 95 on Reader Service Card.

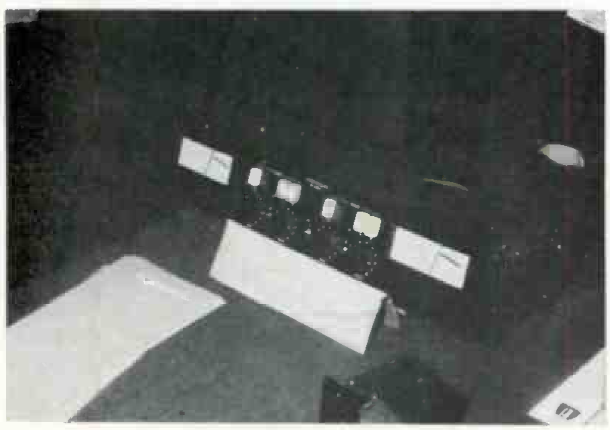
TAPE RECORDERS

Ampex showed a high-speed master duplicator that uses an endless loop of tape for production. Circle 90 on Reader Service Card.

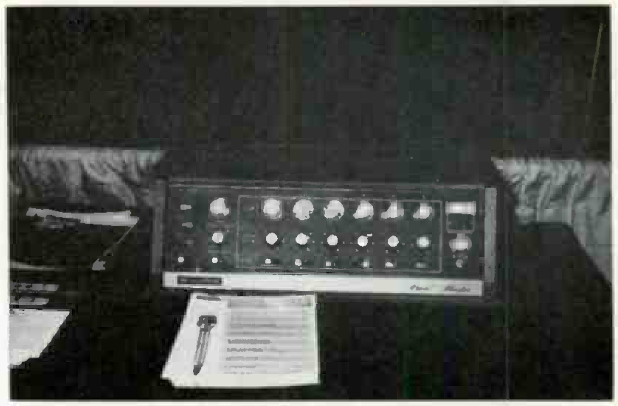
Vega Electronics is offering a four-track half-inch machine. Circle 93 on Reader Service Card.

Gauss sixteen-track, two-inch machines with focused-gap heads. Delivery will be in early 1970. Circle 91 on Reader Service Card.

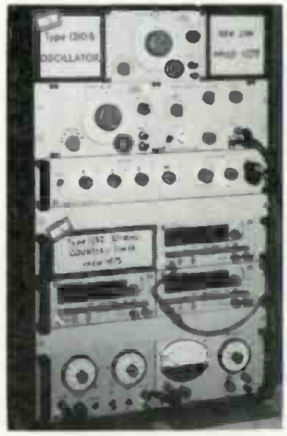
EQUIPMENT



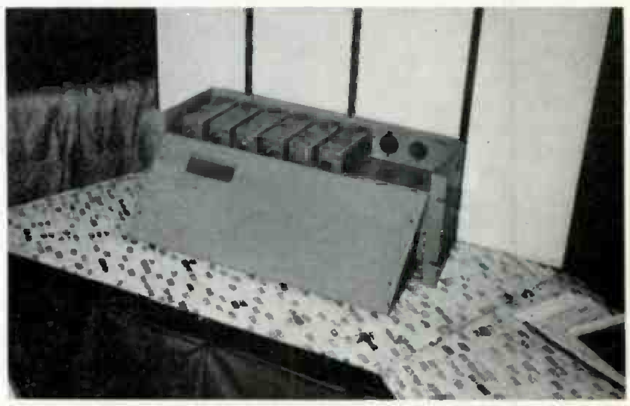
Creatronics has a two-chanel limiter with selectable release time from 0.05 to 0.8. Circle 88 on Reader Service Card.



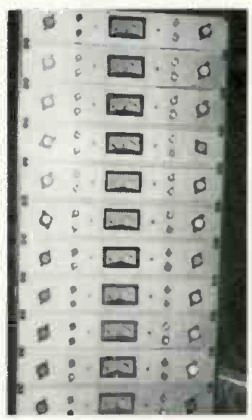
Shure offers its Vocal Master series of amplifier/mixers for the portable and music fields. Circle 85 on Reader Service Card.



General Radio offers complete audio measuring systems for development and maintenance work. Circle 89 on Reader Service Card.



DuKane has its Varacoustics system for the control of acoustics in sound-reinforcement. Circle 86 on Reader Service Card.



The *Spectra Sonics* Complimiter combines compressor and limiter functions with complete control adjustment. Circle 87 on Reader Service Card.

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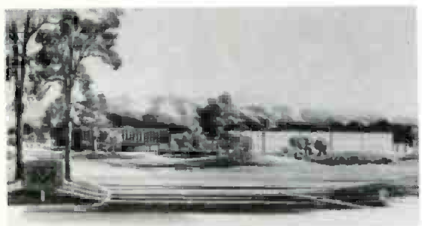
People, Places, Happenings

● **Dan Collins** has been appointed to the newly-created post of director of marketing and corporate development for **Pickering and Company.** According to the announcement by Pickering president **Walter Stanton,** "Collins will be responsible for all domestic corporate sales including Pickering, Stanton and oem in addition to the areas of advertising, promotion, and publicity for the company."

● **Dubbings Electronics** has started a custom service division to provide non-audio industry users with small-run cassette duplication services. In the announcement by **Paul C. Smith,** president of Dubbings, it was noted that this service has been begun in response to the needs of hundreds of firms and institutions that need small-run duplication on short notice and in a short time. Dubbings, a wholly-owned subsidiary of the **North American Philips Corporation** bills itself as the world's largest producer of mass duplicated tapes.

● **Acoustic Research, Inc.** manufacturer of loudspeaker systems and high-fidelity products has announced the establishment of a wholly-owned assembly and distribution center in Amersfoort, Holland. The plant, which is fully operative, will supply AR loudspeaker systems to the European markets. Individual drivers and crossovers will continue to come from the Cambridge, Massachusetts plant to ensure control over quality. An anechoic chamber similar to AR's U. S. one, is in use in Holland so that the cabinet and acoustic packing assemblies conform to their established standard. European readers may write directly to **Acoustic Research International, Radiumweg 7, Amersfoort, Holland** for products, specifications, and dealers.

● **George W. Finhousen** has been appointed assistant to the vice president, **Electro-Voice** professional products, assuming responsibility for product development and management of professional microphone equipment. He works directly with **Louis R. Burroughs** who heads this important E-V division. He has a twenty-year history in the audio field, much of it in sophisticated sound-reinforcement system design.



● A $1.4 million plant complex is going up in Salt Lake City, Utah to house the new home of **Telemation, Inc.** The television equipment manufacturing firm will now have a 60,000 square foot manufacturing block, a two-story 24,000 square foot administration building, and a power plant. The TeleMation facilities will occupy 20 acres of the new 118-acre Technology Park, jointly owned by TeleMation and **KUTV, Inc.,** a Salt Lake City broadcasting corporation. Space has been allocated within the complex for a 3000 square foot t.v. studio, and for classroom space in t.v. production and equipment maintenance. Part of the remaining acreage will be leased or sold to other companies.

● **Richard C. Oldham** has joined the staff of **Ranger Farrell and Associates** as an associate specializing in communications consulting. He will extend the firm's capabilities in aiding architects, educators, government, commerce, and industry in the development of information systems. The company is based in Hastings-On-Hudson, New York and specializes in acoustics, lighting, audio/visual, and theater consulting.

● **CCA Electronics Corp.** has announced the acquisition of the **Rek-O-Kut** division of **Koss Electronics** for an undisclosed amount of cash and 5000 shares of CCA's common stock. The line will now be produced at CCA's west-coast subsidiary, **QRK Electronic Products,** located in Fresno, California. Production is to be started immediately.

● Two division managers of **Ampex Corporation** have been elected vice presidents of the corporation.

● **Ronald A. Polster** becomes vice-president and general manager of the special products division, which engineers and installs complete video and audio systems for use in broadcast, education, government, and industry applications.

● **A. A. Sroka** becomes vice-president, general manager of the professional audio products division, which manufactures professional audio recorders and accessories.

Both divisions are in Redwood City. Both men have been with the company for some years. Polster has held various marketing positions since 1959 and Sroka has held various sales managerial positions in Ampex since 1956.

● **Bob Hope** has accepted the honorary national chairmanship of a special advisory committee for the 1970 observance of broadcasting's 50th anniversary, according to an announcement by the **NAB.** The year-long observance will commemorate broadcasting's half century of service to the American public and focus on how the industry will meet the demands of the future.

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DMC's Model 6100 Test Set is a complete instrument for magnetic tape recorder system alignment and testing. It combines a wide band—10Hz to 10mHz—oscillator, a multi-range AC voltmeter, and a self-tracking harmonic analyzer—all in one neat little package. It conveniently measures any system or network gain and signal-to-noise ratio. It reads second and third harmonic distortion—directly in percent, because of internal leveling and normalizing circuitry.

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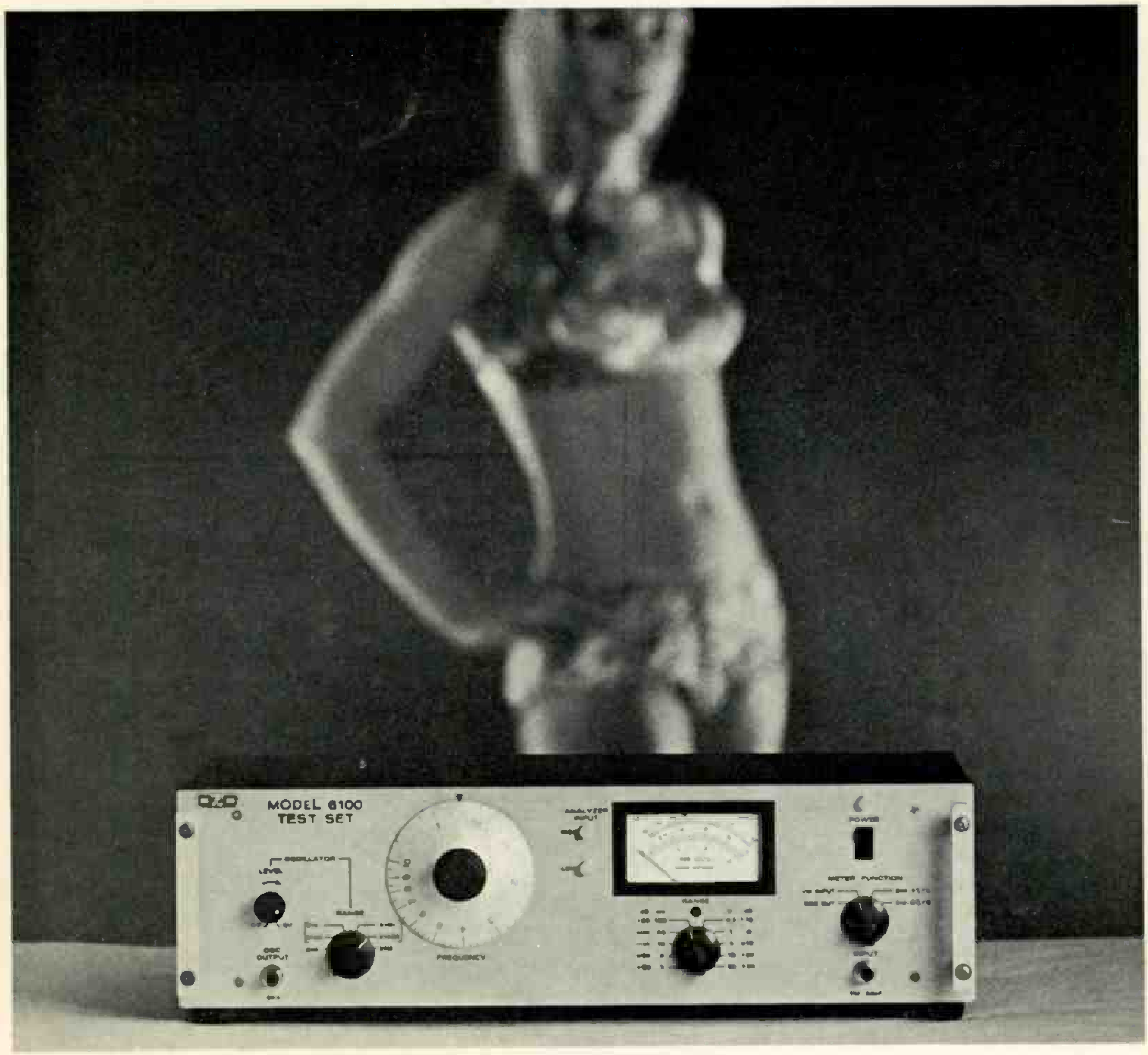

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