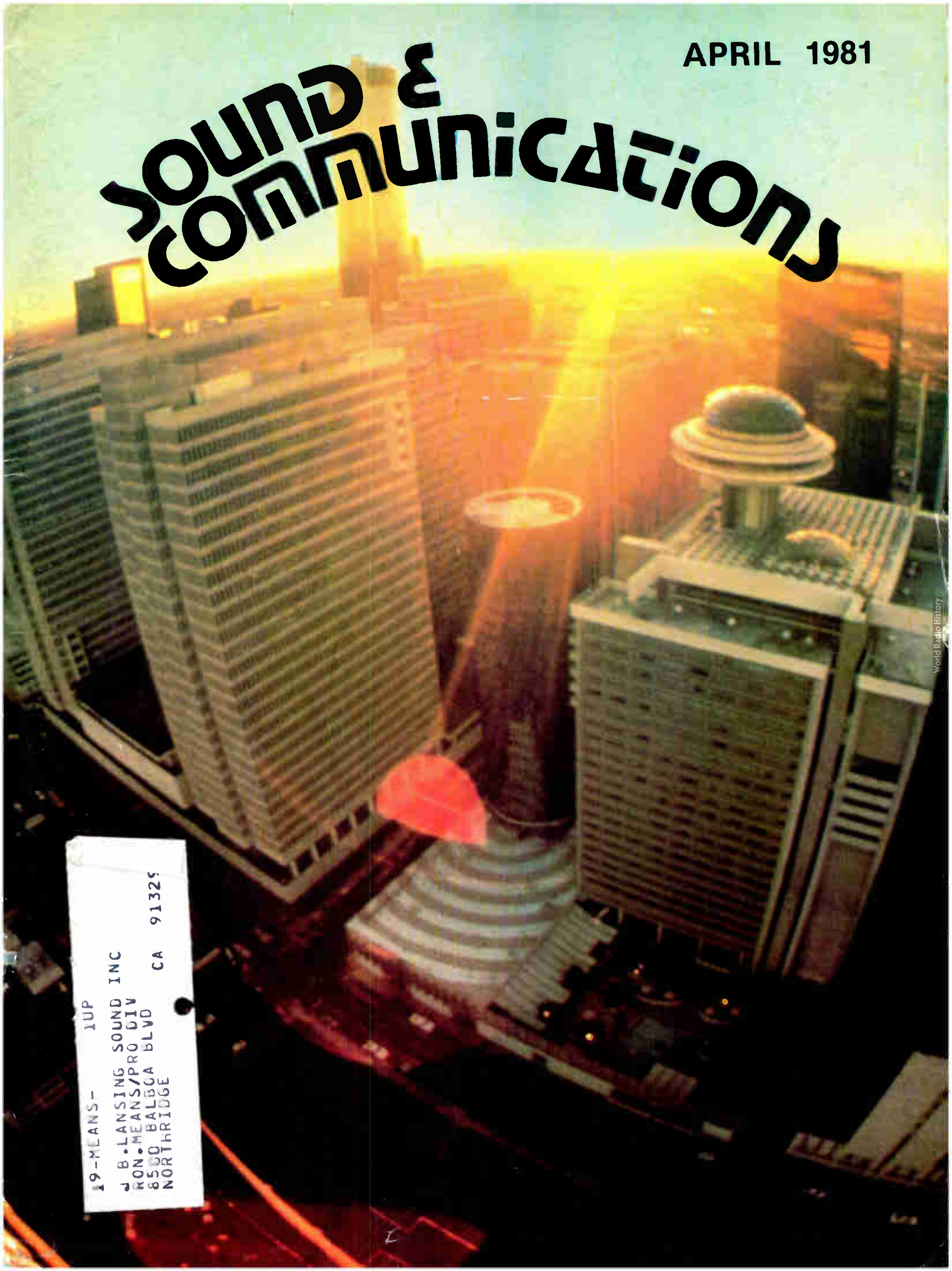
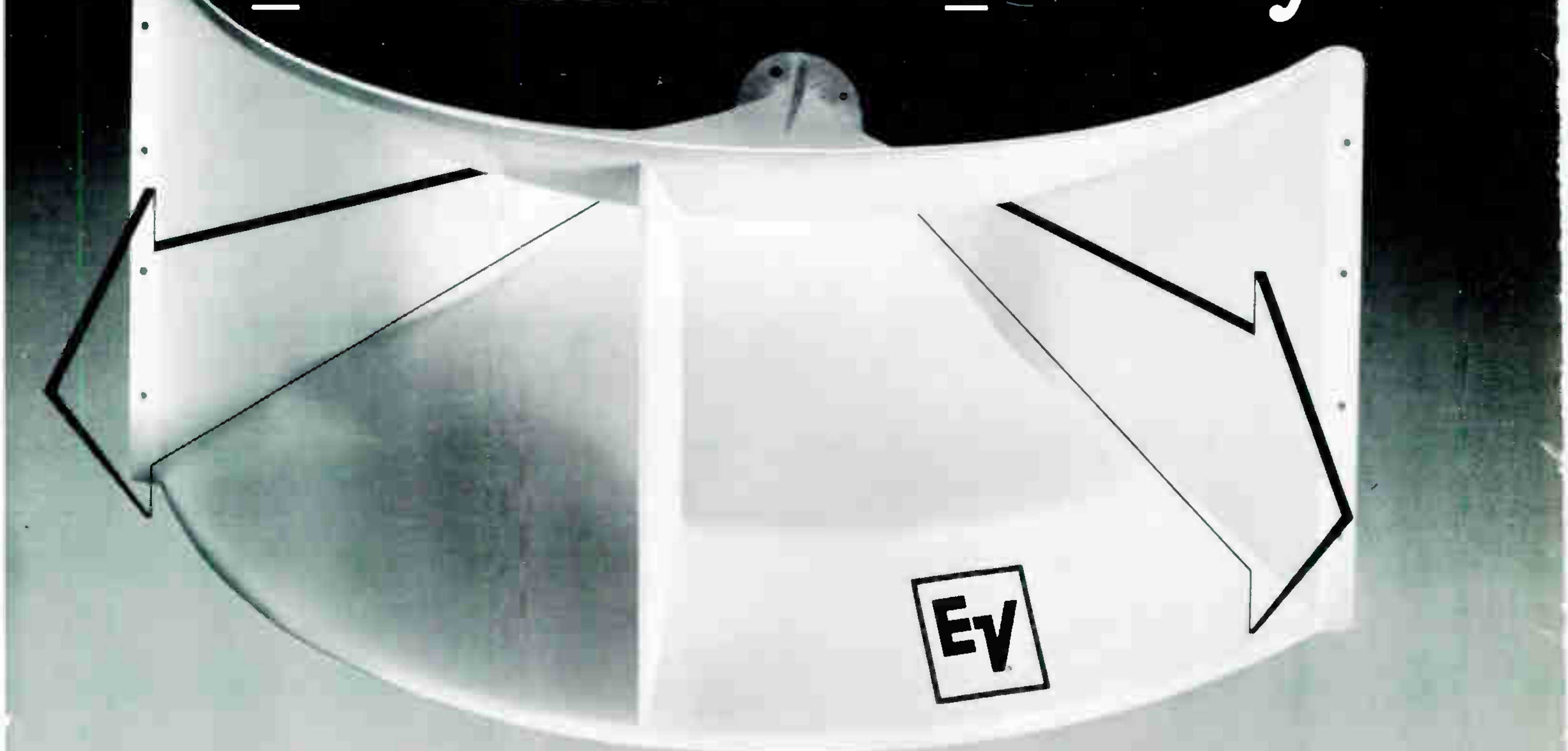
APRIL 1981

Sound & Communications



con'stănt di·rec·tiv'i·ty



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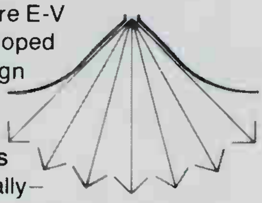

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[1] U.S. Patent Number 4071112

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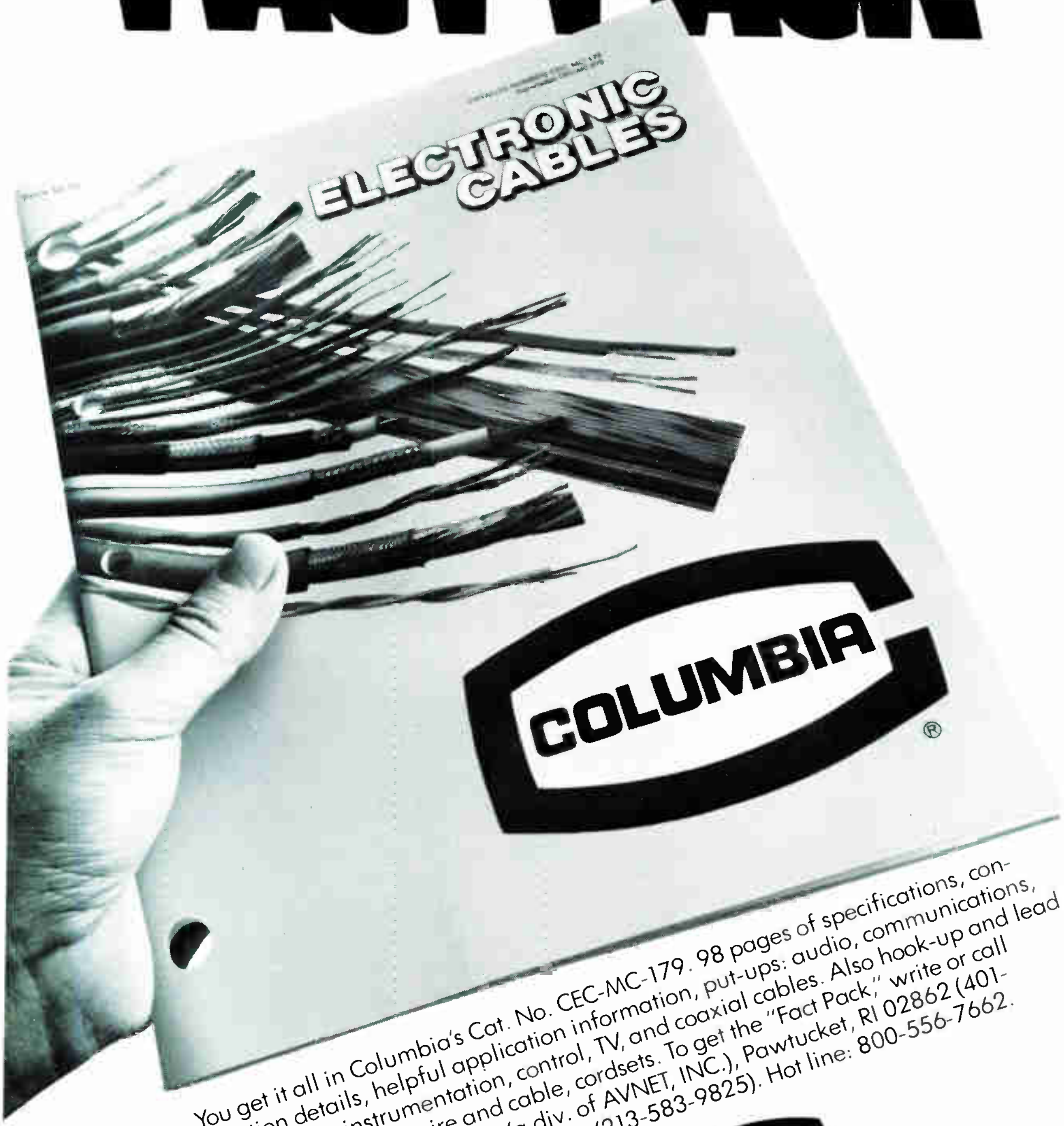

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LATE LINES

Opening Night has come at last to a production that's been in tryouts for six years. Now playing in Federal District Court, Washington, D.C., the show is known as "The Anti-trust Case," starring the Federal Government and AT&T. The sole critic, sitting on the aisle in lonely splendor, is Judge Harold H. Greene.

Here is a rundown on the complex rehearsal and tryout periods this highly anticipated production has gone through.

DECEMBER 11/80—A final round of pretrial briefs in the Government's anti-trust suit against AT&T showed that the Justice Department had narrowed its 6-year old case, but continued to insist that the Bell System's 23 regional operating companies, along with Western Electric, be split off into independent enterprises.

AT&T's brief said, "The Government has dropped 12 of the 67 episodes in which its charges (of classic monopolization) were initially set forth." It added that the company had "moved to dismiss 20 episodes" and would file more such motions. "As matters now stand," AT&T said, "the Government's case centers upon a relatively few actions that occurred" from 1968 to 1978.

AT&T's 272-page brief contended that the Government's case alleging monopolization of the telephone business, in violation of Section 2 of the Sherman Anti-trust Act, was entirely without merit. "The Government cannot establish either the existence of monopoly power or the misuse of such power," the company contended.

The Justice Department countered with an 84-page brief, saying that none of the conduct that would be relied upon by the Government to show illegal monopolization was compelled by regulation, or even approved as being consistent with the public interest. In fact, much of the challenged conduct was specifically disapproved by the FCC or the courts.

"Simply put, the United States alleges a classic case of monopolization with its attendant evils. Rather than competing on the merits, AT&T used its power to thwart the emergence of innovative competitors."

The Government also alleges that the Bell System sought to foreclose competition in various ways, including "early, otherwise unnecessary announcements that Bell Labs would develop a competitive product." Such announcements, it said, "chilled sales" of equipment by companies other than Western Electric.

AT&T scoffs at the charges, answering that after five years of pre-trial proceedings and virtually complete access to the files of the Bell System, all the Government can muster to support its monopolization charge is a few incidents, ranging as far back as 18 years. "And even these few episodes are nothing more than a re-hash of charges, made at various regulatory proceedings, that Bell has not lived up to its regulatory obligations with respect to particular product development or procurement decision."

DECEMBER 24/80—The Justice Department has been freed from a ruling that threatened to hamstring much of its anti-trust case against AT&T. Federal Judge Harold H. Greene, in an order, has allowed the department to get its facts admitted for use in the coming trial, and has authorized it to add new legal arguments to the negotiated record that currently is laying the groundwork for the trial.

A ruling by the special masters who are supervising pretrial negotiations

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Fully electronic exchange with 16-station capacity. Ideal for offices, clinics, small factories, apartment buildings. BGM and remote door control also possible.

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Fully electronic exchange with 32-station capacity. Standard functions include privacy, camp-on-busy, automatic line release, secretary transfer, Mic-off and press-to-talk (selected simplex).

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(EXES-5000 System)
Fully electronic exchange with 64/128 station capacity. Standard functions include user programming with the keys, personal number call, single digit dialing, privacy, group call, Mic-off, secretary transfer and much more.

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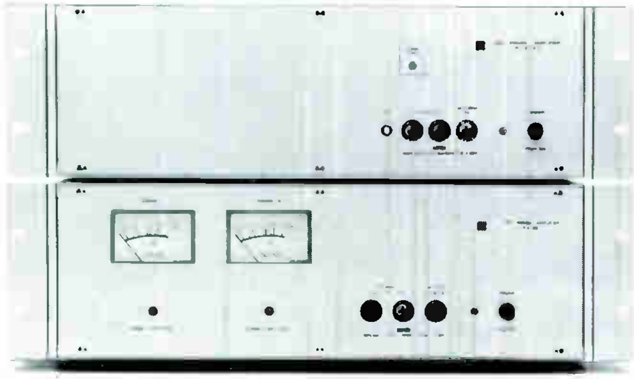
60W Treble/120W Bass Bi-Amplifier with Electronic Frequency Dividing Circuitry

Our professional-use P-2612 uses electronic frequency dividing circuitry to divide input signals into separate bass and treble channels before amplification. To give you more control, we give you a crossover frequency switch (500Hz, 800Hz, 1kHz, 1.5kHz), selectable slope rate (6, 12, 18dB/octave), an input level control for both bass and treble amplifiers and an independent level control for treble (−15dB to +6dB). All this plus bridging for 2 or more additional bi-amps, protection circuitry and a full bank of LED lamps. The main course of Sound Menu Number One—a Bi-Power Amplifier from Toa.

And a wide choice of other Toa Amplifiers.



❶ ❷

❶ **P-2120** Power amplifier with 120W RMS continuous sine wave average power into 8 ohms, 20-20,000Hz, less than 0.25% THD.

❷ **P-2122** Dual power amplifier with 120W RMS continuous sine wave average power into 8 ohms, 20-20,000Hz, less than 0.25% THD.

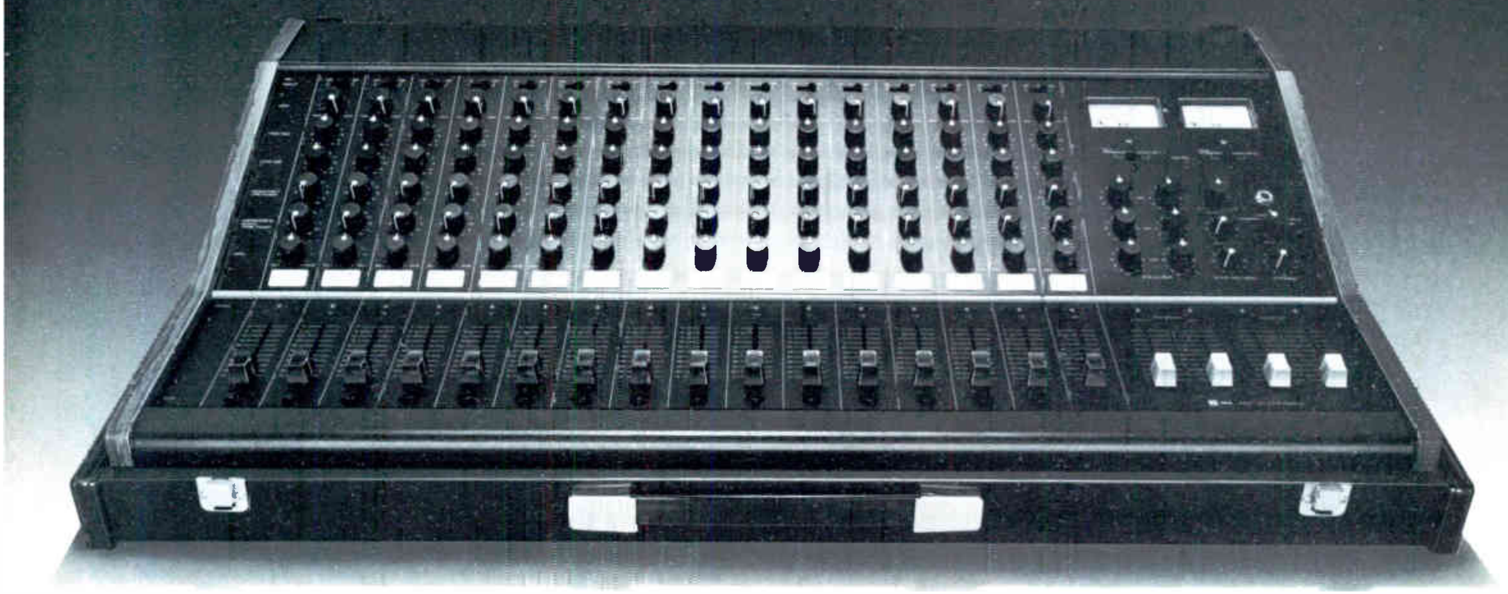
• Note: Toa also offers the P-2240 240W power amplifier and P-2062 60W dual power amplifier and the D-2400 electronic dividing network with switchable 2-channel/2-way or 1-channel/3-way modes.

Quality concert speaker systems to serve up your bi-amplified sound.

HS-15
For the big sound, a hefty 150W power handling capacity. Includes 15" bass driver, sectoral horn and compression driver. Connections for full range or bi-amplification.

HS-12
Just as technically advanced but with less power handling capacity (120W). Components include 12" bass driver, radial horn and compression driver. Full range or bi-amplification connections.

Sound Menu Number Two: Mix it with a Toa Mixer and serve it with Toa Concert Speakers.



RX-5-16

16-Channel Input, 2-Program Output, 2-Monitor Output Mixer

For an endless array of mixing, monitoring and cueing capabilities, you need the Toa RX-5-16 16-channel Mixing Console. With its extremely low noise level (−124dBm equivalent input noise), 70dB total gain and high and low frequency equalizers for each input channel, you're way ahead of the pack. You also get LED peak indicators, optimum gain settings with selectors and gain controls for each input channel, smooth log-linear faders, a cue switch on each input channel for a pre-fader signal audition, and much more. In fact, all of the features and functions for the finest Sound Menu in town.
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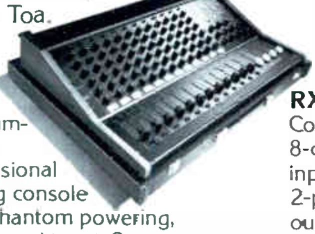

RX-6
Medium-range professional mixing console with phantom powering, 12-channel input, 2-program output and 2-monitor output.

RX-5
Compact 8-channel input, 2-program output and 2-monitor output professional mixing console.

And the same quality concert speakers to take over where the mixer leaves off.

If you thought our big-sound concert speaker systems worked well with the Toa Bi-amplifier, you should hear what they do when they team up with any one of our professional-type mixing consoles. For facts and specs, see preceding pages.

HS-15

HS-12

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A feast for your ears—
Toa Bi-amplification-Ready, 3-Way Concert Loudspeaker System.

150W handling capacity in space-saving bass reflex enclosures

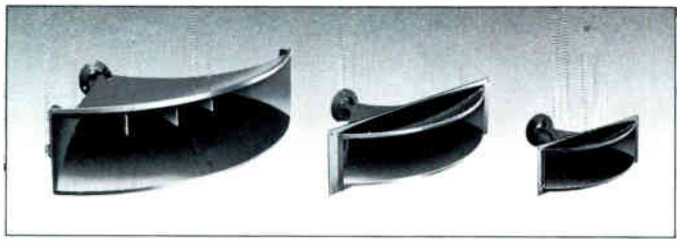
A system that does it all and does it better in churches, small theaters and halls.
Ideally driven by Toa Bi-amp model P-2612 (see next page) with built-in frequency dividing network, these systems include a high-frequency compression driver, heavy-duty sectoral horn and 15" low-frequency loudspeaker.
Frequency response is a wide 40—15,000Hz with pressure sensitivity at 96dB at 4 feet.

120W handling capacity with 45—13,000Hz frequency response

Less power handling capability for less spacious listening areas.
Consists of high-frequency compression driver, radial horn with wide dispersion angle and 12" low-frequency loudspeaker.
Specially designed bass reflex enclosures save space and provide extended low-frequency reproduction.

Quality components—the ingredients behind the feast:

HSH-651
Heavy-duty sectoral horn.



HRH-851/651/311
Radial horns with wide dispersion angle.

HFD-652
60W driver unit.

HFD-352
30W driver unit.

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in the case would have prevented the department from using much of the evidence it has prepared for the trial. It also would have restricted the department's ability to make arguments based on that evidence.

Calling the matter an "inadvertent misunderstanding," Judge Greene said he wasn't "willing to permit the government to be penalized severely" in the technical dispute. As a gesture of fairness to AT&T, he allowed the company to contest some of the additions and submit new arguments of its own where it believes responses are needed.

Gerald Connell, head of the department trial team, said he was "very satisfied" with the ruling.

AT&T spokesman Jay Grossman said that the judge's ruling gave the government attorneys time to recover "from their own errors." He said the company was "pleased" that the ruling would permit some stalled trial preparations to resume.

The dispute arose within the so-called stipulation recess that Judge Greene established to prepare for the trial, scheduled to begin on Jan. 15/81. In the stipulations, AT&T and the department have negotiated for almost two years over what they can agree on before the trial, and what they will dispute. Judge Greene has said the innovative process could slash much of the time and expense of such a huge and complex anti-trust trial.

JANUARY 30/81—The Justice Department and AT&T informed Judge Greene that they were proceeding apace toward a negotiated settlement of the anti-trust case.

But the Justice Department said in a letter that the Reagan administration's new chief of the Anti-trust Division would be charged with evaluating the proposed settlement package. The letter was signed by Charles Renfrew, the Carter administration's deputy attorney general, who continues to function until his successor is confirmed. Attorney general William French Smith has decided not to participate in the case, because he was a board member of Pacific Tel&Tel, an AT&T affiliate.

JANUARY 31/81—Judge Harold Greene, replying to the letters, noted that the parties in the case had pledged they could secure a decision by the Reagan administration on the direction of the case (by Feb. 2/81). "To put it bluntly, the reliability of the parties' current commitments is inevitably impaired by the inconsistency of their present request with representations they made just two weeks ago..... beyond that, the court is not prepared, on any basis, to countenance postponements based on new and ever-changing problems and contingencies." Greene announced his decision two weeks after completion of opening arguments. At the close of the opening arguments, he announced that he would delay the taking of evidence in the case in light of last minute pleas by both the government and AT&T. Greene said in another memo that he would give the two sides until Feb. 2/81 to assert that the settlement of the case could be assured by Mar. 4/81.

FEBRUARY 23/81—The negotiated settlement that was being worked out by the Justice Department and AT&T would not meet the March 2/81 deadline set by Federal Judge Greene—the announcement came in a letter from Sanford M. Litvack, the assistant attorney general, head of the Anti-trust Div., who would leave office on March 1/81. Litvack noted that Pres. Reagan named Stanford University (Cal.) law professor William F. Baxter to take over as assistant attorney general in charge of anti-trust.

Litvack reminded Judge Greene that because attorney general William French Smith and deputy attorney general Edward Schmultz had removed themselves from the AT&T case (because of possible conflict of interests), it would be up to Baxter to approve any settlement on behalf of the Reagan Administration.

"I am advised that while Prof. Baxter will consider the AT&T case a priority matter, he has not reviewed and will not be in a position to review the terms of any proposed agreement, or to reach any view one way or the other concerning the appropriateness of any suggested decree until some time after March 2/81," wrote Litvack.

AT&T's statement on the turn of events, said (in part) "We have been pursuing the prospect of a Consent Decree in good faith and believed that a final settlement was so reachable that it could have been concluded in a few days.

"As we have said all along, we were prepared to negotiate or litigate. We feel obligated to make it plain that the beginning of the trial will present us with an altogether new set of circumstances and therefore a changed basis for appraising what might constitute a reasonable disposition of our contentions with the Justice Department."

Even before Litvack's letter was made public, some attorneys familiar with the case said that they doubted the settlement could be completed before the deadline. Based on a briefing from the two sides, Judge Greene called the settlement "essentially complete" on Jan. 16/81, and both sides reported substantial progress toward a resolution. But insiders said that important details remained to be settled in the drafting of a Consent Decree, and that negotiations were painstakingly slow.

Neither side disclosed the details of the settlement framework. But it was believed to include divestiture by AT&T of part of its Western Electric Co. equipment subsidiary and at least one local telco, and creation of separate subsidiaries for its Long Lines division and a new unit to enter data processing and other unregulated fields. In return, the Justice Department was believed ready to lift a restriction from the 1956 Consent Decree against AT&T involvement in unregulated fields.

FEBRUARY 25/81—Resumption of the anti-trust trial brought by the Justice Department against AT&T won't prevent a later settlement of the case, anti-trust attorneys say. They argued that the legal problems caused by settling during the trial were minimal, and that these wouldn't block the path of a settlement if AT&T and the Justice Department were close to agreement.

AT&T lawyers have complained that resuming the trial would weaken its legal position regarding other anti-trust suits. Parts of the Clayton Act provide that any settlement reached after testimony begins could be used as evidence against the company in similar private cases. But some attorneys believe that to be a ploy to improve AT&T's negotiating position.

AT&T broke off the talks after the Government made clear that the Reagan administration would not be prepared to approve any settlement in time to prevent resumption of the trial on March 4/81. Government attorneys say they were surprised by that action.

According to one interpretation, AT&T decided that ending the talks would improve its negotiating position regarding the incoming Anti-trust Division chief, William Baxter. If AT&T could not settle the case before March 4/81, this scenario goes, AT&T faced the prospect of continuing talks during the trial, with Baxter attempting to gain additional concessions. After breaking off, AT&T could say it was willing to make fewer concessions in new talks, because of its weakened legal position in other suits. And it could blame the Reagan administration's delay in naming Baxter to head up the Anti-trust Division.

One incentive for AT&T to settle the case is concern that government might win the remedy it seeks in the trial.

Another incentive is AT&T's hope that a settlement would allow it to enter data processing and other unregulated businesses, apparently contrary to the 1956 Consent Decree it had signed with the Justice Department.

MARCH 5/81—AT&T has returned to the New Jersey Federal District Court, seeking a court interpretation of the 1956 Consent Decree, in the light of seemingly contradictory recent decisions in the Federal Communications Commission's Computer II inquiry.

Last December, the FCC ruled that AT&T must establish by March 1/82 one or more separate subsidiaries to provide certain terminal equipment, such as telephones and switchboards and "enhanced" services—services in which some aspects of the original information is changed or by which customers can retrieve stored information.

The FCC said that all equipment offered through the separate subsidiary after March 1/82 would be "detariffed," and Bell would not have to secure regulatory approval of the prices charged for such equipment.

AT&T's view was that the FCC ruling did not conflict with the 1956 Consent Decree, for that decree states that, with relatively minor exceptions, the Bell companies can provide only regulated services.

AT&T maintained in its filings that it is now and would continue to be "subject to" FCC regulation whether or not the new subsidiary's prices are approved regularly by the FCC. It also argued that the modified systems of

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LM Ericsson Telecommunications, Inc. 100 Crossways Park West, Woodbury, New York 11797 regulation envisioned by the FCC for the new subsidiary is sufficiently stringent to ensure that AT&T doesn't use its regulated business to subsidize unregulated businesses, such as data processing communications services.

An AT&T spokesman confirmed that the filing in the New Jersey federal district court was connected directly with the re-opening of the Justice Department's anti-trust suit in Washington, D.C.

In Washington, some viewed AT&T's New Jersey filing as an effort to put extra pressure on the Justice Department to settle its pending suit against AT&T, because a favorable ruling could remove one incentive for AT&T to settle.

In the court filings, AT&T maintains that uncertainty about the proper interpretation of the 1956 Consent Decree is seriously inhibiting its efforts to form a fully separated subsidiary by March 1982.

. . .

Meanwhile, the anti-trust trial, which began in January and was recessed after two days of testimony, started up on March 5th with the first in an expected parade of witnesses for the Justice Department.

Robert L. Feiner, president of Phonetel Inc., Van Nuys, Cal., testified that Bell had restricted his marketing of his "Phonemaster" from 1971 to 1974. Phonemaster is a toll and message restriction system which controls by prefix and/or area code, and can control specified prefixes in specified area codes.)

Feiner testified that Bell had hampered his sales everywhere but in California, first by delaying for months the installation of his equipment on customers' premises and then by charging them fees even larger than the cost of the equipment.

California's state regulatory body, he testified, kept Bell from fixing high charges for making connections installing "protective" circuits that were later found to be unnecessary.

Outside California, only the New York Times signed on, in 1973, as a major customer for the Phonemaster, Feiner said. The device cost the Times $40,000, and the New York Telephone Company then charged the newspaper $4500 to install the equipment, and also made monthly charges for the lease of certain devices to connect the equipment to the phone lines that came to an additional $11,250 a year.

"Because of these kinds of extra charges that Bell was charging, I soon had to abandon the marketing of my equipment outside California," Feiner testified.

The Justice Department said it would try to show that this was only one of many instances where Bell allegedly worked to stifle competition in furnishing telephone-related equipment in an effort to preserve its domination of the business.

. . .

THE SHOW IS ON THE ROAD.

Robert Feiner's testimony signals the start of a parade of witnesses.

Judge Greene says he hopes to complete the trial within a year. But lawyers for both sides predict a much longer session.

S&C's Washington correspondent reports that speculation among the cognoscenti is that a settlement will be reached before the year is out.

Although AT&T has pledged to fight all the Justice Department moves to dismember its "family" of operating local phone companies, Bell Labs and Western Electric's supplying arm, there is much room between the contending factions for a settlement.

Earlier negotiations had the Bell System divesting Pacific T&T, Cincinnati Bell Inc. and Southern New England Telephone Co. Now the expectation is that Pacific T&T will be cast off.

As part of the settlement, the Justice Department was believed to be ready to approve a lifting of the ban against AT&T involvement in data processing contained in the 1956 Consent Decree. The FCC has consented to such a move by AT&T through a separate subsidiary. But court approval is required and the Justice Department is expected to oppose that move.

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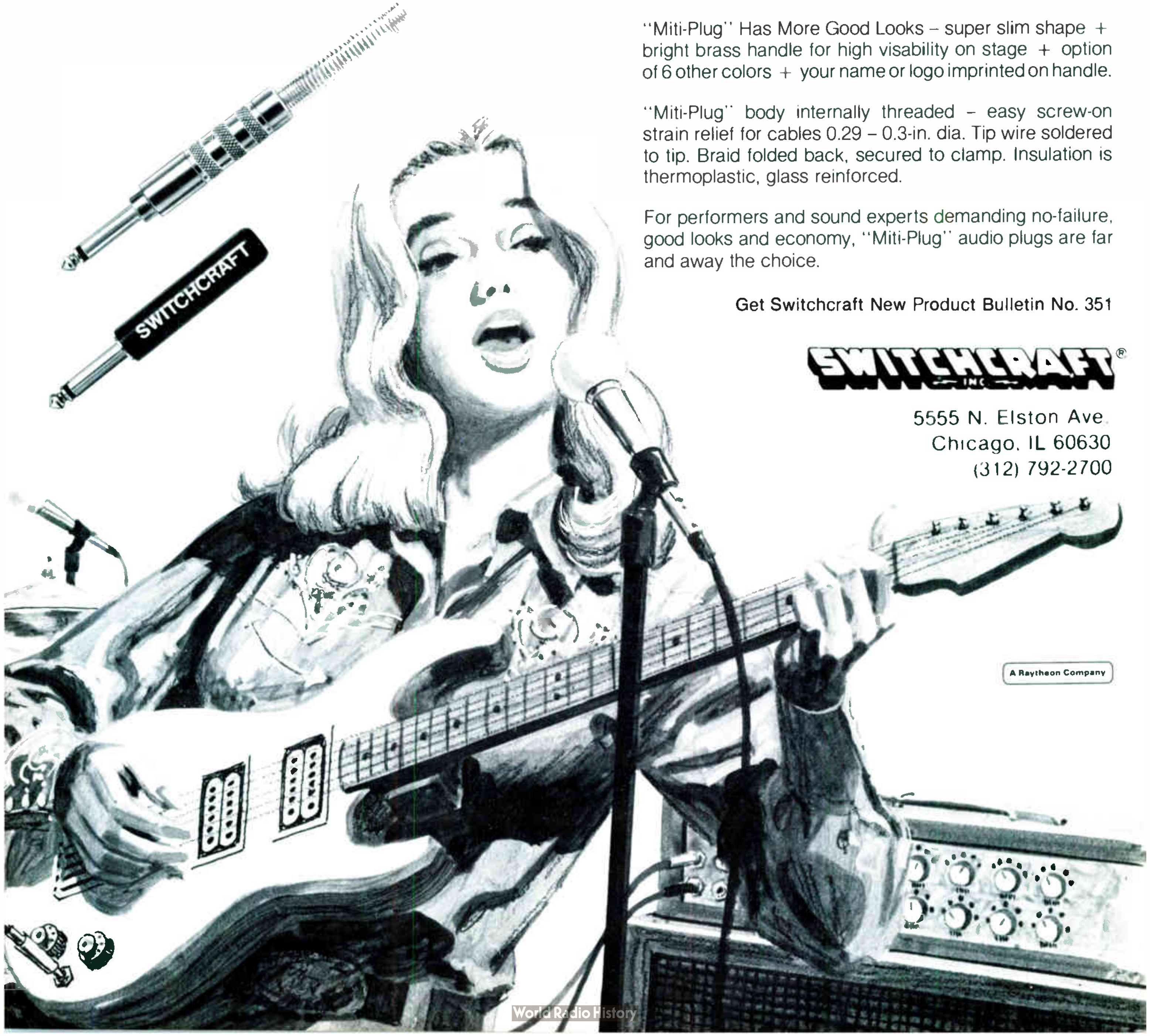

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NATIONAL SOUND & COMMUNICATIONS CONFERENCE UPDATE

This year's National Sound & Communications Conference promises to be uniquely valuable. Here is a rundown of its major events:

TUESDAY, MAY 5

THE MARKETING OF SOUND

10:00 A.M.
WELCOMING REMARKS
Bob Ancha, President
National Sound & Communications Association

KEYNOTE
Jack Berman, Chairman of the Board
Jack Berman Company, Los Angeles
"The Sound Industry Today"
An overview of the sound industry from a marketing standpoint. Where the industry is headed. Proven concepts and ideas on how to market sound products better. Berman, a nationally acclaimed lecturer, author, columnist, and sales trainer, is the exponent of Agreeable Selling, a theory he developed in practice as former Sales Vice President of Shure Brothers Inc. and as a leading electronic sales rep.

10:45 A.M.
PANEL PRESENTATION AND DISCUSSION
Jack Berman, Moderator

"Market Positioning"
Joe Palmieri, Bogen

"Marketing Your Service Department for Profit"
Mike Cady, Electronic Unlimited, Inc.
Houston, Texas

"Customer Recycling"
Jerry Percell, Comcast,
Bala Cynwyd, Pennsylvania

Questions from the audience will follow panel presentations.

12:15 P.M.
LUNCHEON AND SPEAKER
(Grand Ballroom, Atlanta Hilton Hotel)
THE MAGIC OF SOUND
"Innovative and Creative Solutions to Sound Systems Problems."
Peter Tappen, Vice President
R. Lawrence Kirkegaard and Associates, Inc.
Lombard, Illinois
This well-known acoustical consultant and professional magician will combine his skills and present an unconventional talk on unconventional concepts, for solving "tricky" sound problems—illustrated by his magic. The bottom line will be the ideal interaction between the acoustical consultant and the sound contractor.


Tappan


Palmieri

2:00 P.M. TO 5:30 P.M.
Attend EDS '81 Exhibits and Conferences

WEDNESDAY, MAY 6

CONCURRENT MANAGEMENT AND TECHNICAL PROGRAMS

MANAGEMENT SESSION—
HOW TO OPERATE A PROFITABLE SOUND CONTRACTING BUSINESS

8:00 A.M.
FINANCIAL MANAGEMENT
Luke Harris
Dukane Corporation
Technically competent contractors are not necessarily good financial business managers. What are the financial ingredients necessary to profitably operate a sound contracting business? Common pitfalls which plague sound contractors! Financing your business for growth!


Harris

9:00 A.M.
BUSINESS SYSTEMS
Harold B. Lander
Signal Communications, Inc.,
Seattle, Washington
Computer software and hardware systems suitable for use by sound contractors. How sound contractors can use standard software programs

to improve their financial management.

10:00 A.M.
LABOR UNIONS IN THE SOUND INDUSTRY
Kenneth C. Prince, Attorney, Chicago, IL.
Prince, Schoenberg, Fisher & Newman, Ltd.
How to live with your unions. How to live without a union. How to handle union organizing efforts. How labor problems will affect sound contractors.

11:00 A.M.
LABOR ESTIMATING
Rod Uffner
Industrial Communications Company, Oak Park, Michigan
How to estimate the labor and related costs of installing sound systems. Factors which are used. Variables which must be considered.

Uffner

8:00 A.M.-12:00 NOON
TECHNICAL SESSION—
EVERYTHING YOU NEED TO KNOW ABOUT SOUND REINFORCEMENT
Dave Klepper and Larry King
KMK Associates, New York, NY
Basic design, specifications, adjustment, equalization. The importance of selling service. OSHA problems and how to handle them. New products and how to use them in sound installations.

THURSDAY, MAY 7

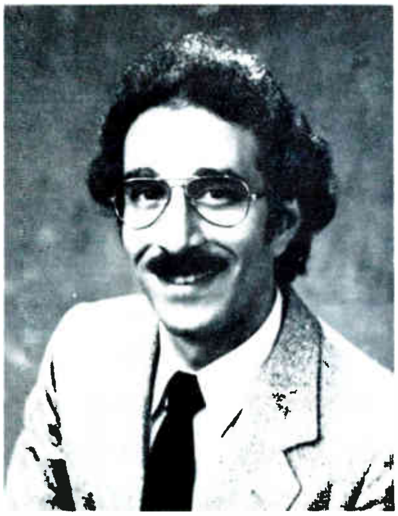
PROVEN OPPORTUNITIES FOR SOUND CONTRACTORS

8:15 A.M. (Two concurrent sessions)
"PROVIDING PERFORMING SOUND"
Jay Bridgewater, Bridgewater Custom Sound
Jeff Pallin, Base Corporation
Methods of pricing, bidding, estimating, servicing. The profitability of providing systems for performing sound.

"COMPUTER CABLING"
Art Smith
Sound & Intercom Systems, Phoenix, Arizona
Lou Valente
West Penn Wire Company
The value-added aspect of the installation of computer wiring systems.

Valente

9:40 A.M. (Two concurrent sessions)
LEASING, RENTING AND SELLING OF TELECOMMUNICATION SYSTEMS
Jerome Brookman, Publisher
Sound & Communications
Ronney Harlow, President
Private Telecommunications, Inc., Chicago, IL
William Bauer, President
National Telecom, Inc., Mequon, WI
Financial considerations, service needs, and facilities requirements for sound contractors to enter this lucrative field.



Pallin

Brookman

Harlow

LIFE SAFETY AND SECURITY SYSTEMS
Bill Ross, V.P. Marketing
Notifier Company
Joe Durham
General Sound Company, Dallas, Texas
New opportunities in the installation of life safety and security systems.

Ross

Durham

Crossover Filters

The use of filter circuits in loudspeakers dates back to the early days of the motion picture industry, when horn-loaded systems were developed to produce the high level of acoustic power necessary in cinemas. As each horn loudspeaker had a working range of only a few octaves, two or three of them were needed to cover the audio spectrum, and electrical networks—later known as crossover filters—had to be provided to distribute the signal components into the appropriate frequency bands.

For domestic high-quality systems however, designers persisted for many years in attempts to produce a single drive unit capable of covering the entire frequency range. No completely satisfactory solution was ever found—in the few cases in which a smooth and extended frequency response was achieved, this performance was confined to a narrow angle about the axis—and in the fifties, with the rise in general standards of quality associated with long-play disc recording and VHF broadcasting, two- or even three-way systems came to be accepted as the future pattern for high-fidelity reproduction.

In the early days of domestic multi-way loudspeakers, however, scant attention was paid to the filters that divided the audio signal between the individual drive units. As a result, the advantage of increased frequency range obtained by the use of additional units was offset in some cases by gross irregularities, such as peaks or troughs, in the response around the crossover point—which is usually located in a part of the spectrum where the ear is very sensitive to any discontinuity. Some of the early crossover circuits were limited by considerations of cost to a few components and could hardly be described as filters at all. Other designs prescribed in the technical literature of the period were based on classical filter theory in a way that would have been valid only if each drive unit had a flat frequency response and a constant, resistive, input impedance—not only throughout the working band, but well into the cut-off region. In practice, this is far from being the case, and as a result the overall performance obtained with these "standard" crossover circuits was often disappointing, an acceptable frequency characteristic being achieved only by modifying the filter component values in a laborious process of trial and error.

Moreover, it sometimes happened that with the arrangement thus arrived at, the input impedance of the filter/drive unit combination in the crossover region was well below the nominal value for the loudspeaker; if the associated amplifier had a very low output impedance, the performance at low signal levels was unaffected, but at higher levels, distortion occurred through premature overloading of the output stage.

Nowadays, amplifier overloading resulting from a badly-designed filter system may be aggravated by the operation of current-limiting devices provided to protect transistors against damage.

By the Sixties it was beginning to be accepted in principle that crossover networks ought to be tailored to suit the individual drive units in the system. But this was easier said than done. The response of the available types of unit was subject to wide variations between one production specimen and another, so that consistently successful overall performance could be attained only by the use of elaborate networks incorporating "adjust-on-test" elements which had to be set individually on the basis of acoustic measurements. The design still involved some measure of trial and error, the results of which were often anomalous in that the best looking measured performance did not correspond to the best subjective effect.

This state of affairs was highly unsatisfactory, not only for professional designers of complete loudspeaker systems, but even more for home constructors attempting to assemble their own equipment from a collection of commercial drive units—possibly from different manufacturers—fed through crossover networks built from "standard" designs or bought ready made.

In recent years however the situation has been completely changed by improvements in manufacturing methods, leading to more consistent performance of commercial units, by the introduction of digital techniques in acoustic measurement and network synthesis, and by a belated recognition of the effect of crossover networks on the directional characteristics of a loudspeaker. These developments have made possible a new and more methodical approach to the design of crossover filters as an integral part of the system.

Essential Filter Requirements

The basic requirements for a high quality loudspeaker include, on the one hand, a smooth and uncolored response maintained over an angle of radiation wide enough to cover the listening area, and on the other, freedom from audible non-linear dis-

This article was created by KEF Electronics Ltd., of Tovil Maidstone, England.

tortion, together with a combination of efficiency and power handling capacity adequate for the conditions of use. For each drive unit in a multi-way system, there is only one frequency band over which all these requirements are simultaneously satisfied; outside this band there will be regions in which some of them cannot be met. A low-frequency drive unit, for example, if allowed to operate in the high-frequency range, would introduce coloration through diaphragm resonance. Again, a high-frequency unit, if allowed to operate at low frequencies at which the necessary diaphragm excursion exceeds the linear limit, would introduce distortion products. To avoid degradation of the overall sound quality by such unwanted contributions, it is therefore essential that the output from each drive unit outside its working frequency range should be reduced to a sufficiently low level by adequate attenuation in the crossover filter.

Filters, in practice, cannot have an infinitely sharp cut-off, so that there is an overlap region around the nominal crossover frequency in which the total sound output is made up of contributions from two different drive units. Ideally, the combined characteristic of each unit working in conjunction with its associated filter network should be such that the sum of the two contributions gives a flat response over the entire transition region; in addition,if the frequency characteristic of a unit within its working band is not quite flat, the network should be designed to rectify this. Each filter has therefore to be tailored to suit the response of its associated drive unit both in the working band and in the nominal cut-off region; moreover, it must be designed to operate into the input impedance of the unit, which will in general be complex and will contain additional components associated with the fundamental resonance of the diaphragm. Finally, the impedance presented by the filters to the power amplifier must be kept within prescribed limits which apply not only to the magnitude or modulus, but also to the relationship between the resistive and reactive components

Measurement of Drive Unit Characteristics

The first step towards a filter specification depends on a detailed measurement of the electro-acoustic characteristic of each drive unit under working conditions. The acoustic response of a drive unit depends in practice on the form of the enclosure in which it is mounted, and at the higher frequencies, on diffraction effects which vary with the position of the unit on the front panel. The characteristics must therefore be measured with all units mounted in the enclosure designed for them.

Since a drive unit cannot cover all frequencies from zero to infinity, it must be regarded as a kind of bandpass filter; as such, it must introduce a certain amount of phase shift which, together with the phase shift in the associated network, will affect the way in which the contributions from different units add up in the crossover region. In measuring the characteristics of each unit, therefore, we have to begin by considering both the amplitude and the phase response.

To measure the phase shift in a loudspeaker has been until recent times a very difficult operation, largely because of the additional—and much greater—phase shift associated with the time taken for the sound to reach the measuring microphone; this phase shift depends on the distance of the microphone from the acoustic center of the drive unit, i.e. that point within the unit at which the sound appears to originate. The exact location of the acoustic center is initially unknown but can be readily determined by the pulse test method developed by KEF; a very short electrical impulse is applied to the unit, and the complete frequency response, in both amplitude and phase, is derived by computer analysis of the resulting transient sound output. This technique allows the phase shift introduced by the drive unit to be separated from the multiple phase rotations associated with the distance of the microphone from the acoustic center, so that the position of the latter can be accurately calculated.

A great number of measurements made in this way have shown that the drive units designed by KEF can be regarded as "minimum-phase-shift" devices. This means that the phase shift—and the associated time delay—that they introduce is just equal to, but no more than, that irreducible minimum amount which by the law of nature is inherent in the shape of their amplitude/frequency response curves. It also means that their transient behavior depends only on their frequency response. Filter networks of the type used in loudspeakers are also of the minimum-phase-shift type, so that the overall phase shift, time delay and transient behavior of the filter/unit combination are completely determined by the overall frequency characteristic.

Target Function Approach

In designing crossover filters to suit individual drive units, the method adopted by KEF is to consider the overall electro-acoustic response of the network and unit together, and to make this conform as closely as possible to some known filter function that gives adequate attenuation in the cut-off region together with a smooth transition at crossover; the response/frequency relation to be aimed at is referred to as the Target Function and is represented by the symbol $T(f)$. The response/frequency function of the drive unit alone, already measured under working conditions, is represented by $S(f)$. The next step in design is to compute the frequency characteristic $H(f)$ of a filter that will convert the existing response $S(f)$ into the wanted response $T(f)$; the functions $T(f)$, $S(f)$ and $H(f)$ are in linear units, not dB, so that the conversion is a multiplication process, i.e.,

$$T(f) = H(f).S(f) \text{ and } H(f) = \frac{T(f)}{S(f)}.$$

The resultant response $T(f)$ may be thought of as the characteristic of the filter that would have been chosen if the drive unit had been an ideal one with a flat frequency response and zero phase shift, i.e., with $S(f)=1$.

The same principle applies equally whether the filter feeds the associated drive unit directly (passive filter) or via a separate amplifier (active filter), but the design of the network is quite different in the two cases. A passive filter is designed to be fed from the very low output impedance of a loudspeaker amplifier and to operate into the complex input impedance of a particular drive unit; such a filter cannot be expected to function correctly when

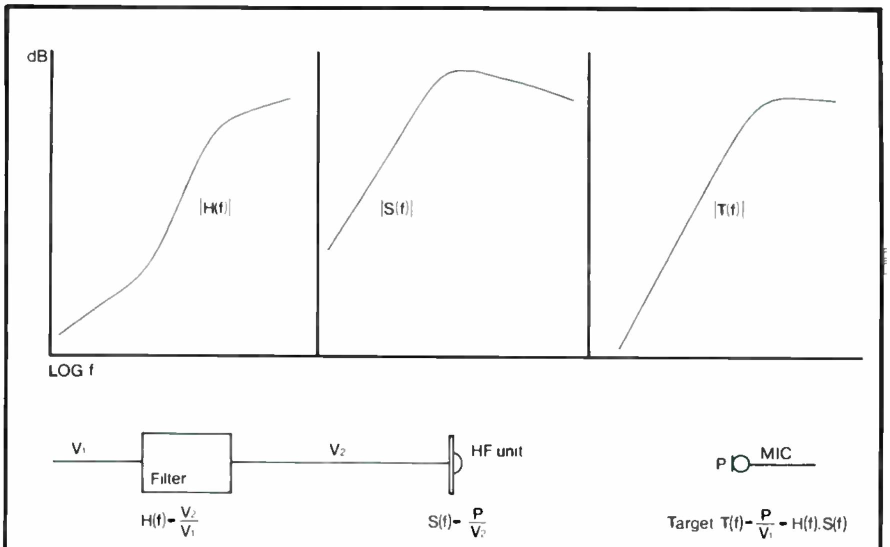


Fig. 1 *Practical realization of Target Function for high-frequency unit.*

connected ahead of the loudspeaker amplifier and thus presented with a completely different combination of source and load.

On the other hand, a filter intended for use ahead of an amplifier is usually of a standard type, the design of which takes no account of the response characteristics of the particular unit, and therefore requires a supplementary equalizing network, covering both pass and stop bands, to introduce the necessary correcting function $H(f)$.

The process of realizing the target function is illustrated in Figure 1 for the case of a high-frequency drive unit. V_1 and V_2 are the input and output voltages of the filter, while P is the sound pressure registered by the measuring microphone. $|H(f)|$, $|S(f)|$ and $|T(f)|$ represent in each case the modulus of the quantity concerned, i.e., the amplitude alone, without regard to phase; the response curves show the corresponding dB values. Figure 2 illustrates the application of the same principle to a three-way loudspeaker system; for clarity the three target function curves are displaced vertically. The subscripts L, M, and H refer to the low, middle and high-frequency bands respectively, while $T_s(f)$ denotes the target function for the whole system. The network feeding the mid-range unit cannot in general be considered as a pair of independent high- and low-pass filters, since the separation between the two crossover frequencies f_1 and f_2 may not be great enough to prevent interaction between the two. $H_M(f)$ must therefore represent a

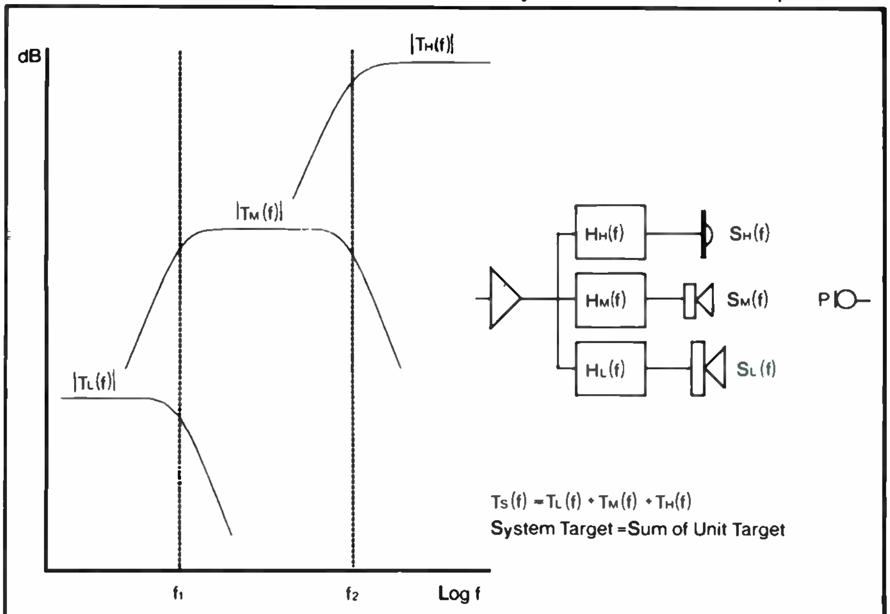


Fig. 2 *Practical realization of Target Function for 3-way system.*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band-pass filter; this function and the functions $S_M(f)$ and $T_M(f)_2$ relate to the frequency band $(f)_1$ to $(f)_2$ plus the cut-off regions above and below it.

Choice of Target Function

In specifying the function $T(f)$ we can use any of the known forms of filter response, ignoring however the circuit configurations conventionally associated with these. The form commonly adopted is that of the classical Butterworth filter. Figure 3 shows three high-pass filters of this type; the corresponding low-pass characteristics are the same but reversed left to right. All these curves are of the type described in filter theory as "maximally flat"; this means that the attenuation within the pass bank is kept as small as possible down to the nominal cut-off frequency f_3—at which the loss is 3 dB—without introducing peaks or ripples in the characteristic. The curves in Figure 3 represent Butterworth characteristics of the first, second and third order; the higher the order, the greater the cut-off slope—which in the three cases illustrated rises to a maximum of 6 dB, 12 dB and 18 dB per octave respectively—but also the greater the number of circuit components required.

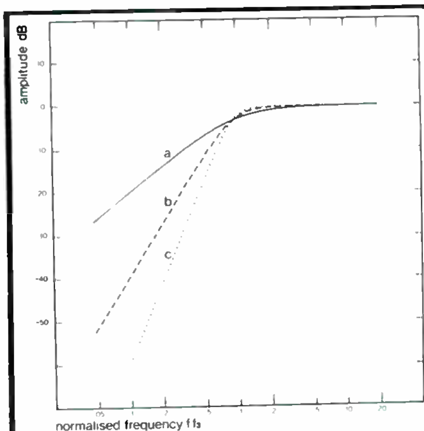


Fig. 3 *Butterworth high-pass filter characteristics*
(a) 1st order: maximum cut-off slope 6 dB/octave
(b) 2nd order: maximum cut-off slope 12 dB/octave
(c) 3rd order: maximum cut-off slope 18 dB/octave

To illustrate the use of these filter characteristics as target functions, Figure 4 shows the overall response obtained in the crossover region of a two-way loudspeaker system when the outputs from the high-and low-frequency filter/unit combinations, represented by $T_H(f)$ and $T_L(f)$respectively, are added together. Following present-day practice, the inputs of the two filters are connected in parallel, so that the same signal voltage is applied to both. The dashed curves show the amplitudes $|T_H(f)|, |T_L(f)|$ and phases $\emptyset_H(f), \emptyset_L(f)$ of the contributions from the two units, while the full-line curves give the corresponding

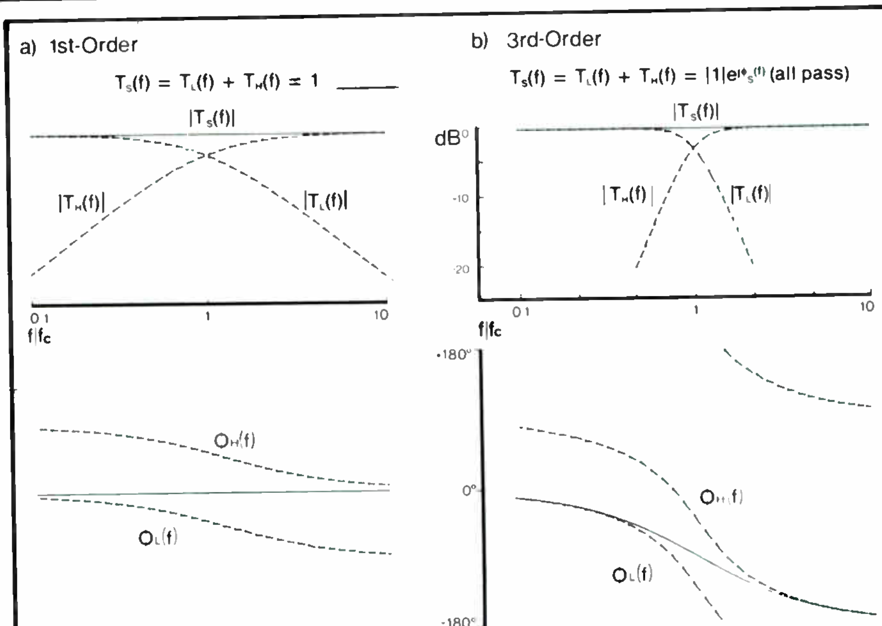
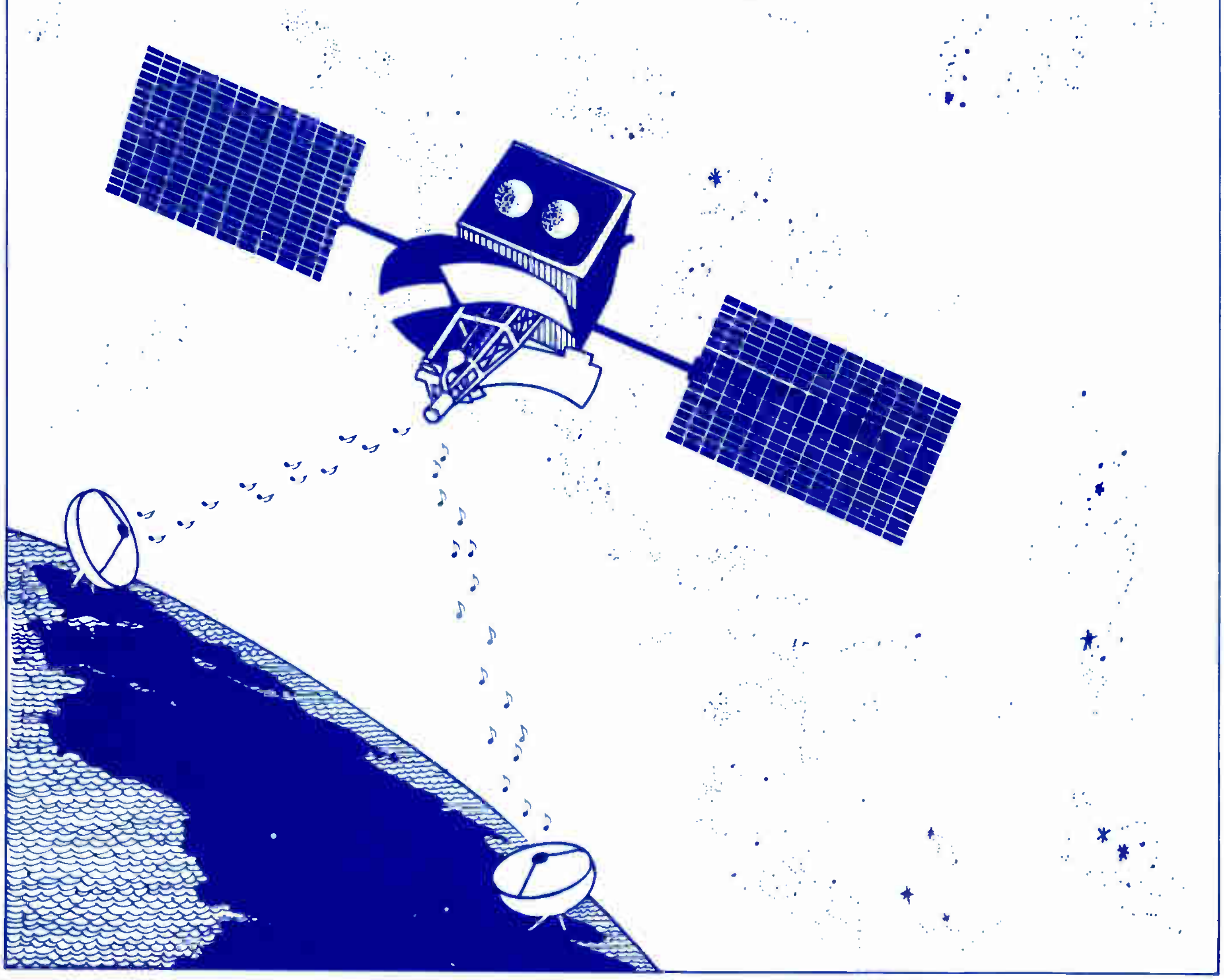


Fig. 4 *Crossover characteristics with Butterworth filters as Target Functions T(f)*
(a) 1st order
(b) 3rd order



amplitude $|T_s(f)|$ and phase $Ø_s(f)$ of the total system output.

First-Order Crossover

In Figure 4 (a) both filter characteristics are of the first order, and high- and low-frequency units are connected in the same polarity, i.e., so that the application of d.c. to the common input without the filters would cause both diaphragms to move in the same direction. At the crossover frequency $(f)_c$, the outputs from the two drive units are both attenuated by 3 dB and differ in phase by 90°; their sum is 3 dB greater than either alone, bringing the overall output up to the zero line. What is more, the amplitudes and phases of the two contributions are such that their combined output has unity amplitude (zero dB) and zero phase shift at all frequencies, i.e., $T_S(f) = T_H(f) + T_L(f) = 1$. But in spite of this desirable feature, which is found only in the first-order filter system, the relatively slow cut-off rate of 6dB/octave gives rise to a number of practical difficulties.

Consider, as a typical example, the design of a high-pass filter network for a 3 kHz crossover, using a high-frequency drive unit having its fundamental resonance at 1 kHz.

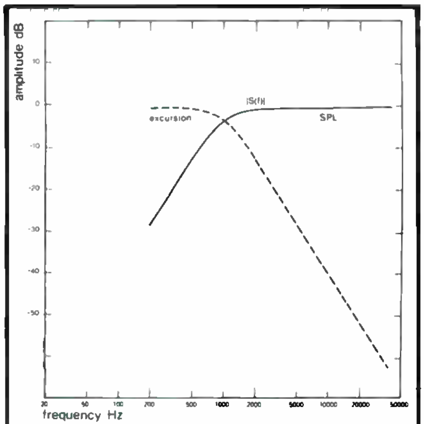


Fig. 5 *Acoustic responses $S_H(f)$ and diaphragm excursion of high-frequency drive unit with constant input voltage. Fundamental resonance frequency: 1 kHz.*

Figure 5. shows the amplitude response $|S_H(f)|$ and diaphragm excursion of such a unit for constant input voltage; it will be seen that even without any filter, the response below resonance is already falling off at 12 dB/octave. It is tempting to assume that any increase in cut-off slope contributed by the unit outside the immediate crossover region must be all to the good.

If however the slope of the combined filter/unit characteristic is increased, the contribution of the unit to the overall system response is altered, not only in amplitude but also in phase; this phase change extends over a wide frequency range and can thus affect the summation of the outputs from the two units in the crossover region, with the result illustrated in Figure 6. Here, a low-frequency drive unit is fed through a correctly designed network, giving a resultant output function $T_L(f)$ in the form of a first-order Butterworth low-pass filter with a 3 kHz cut-off.

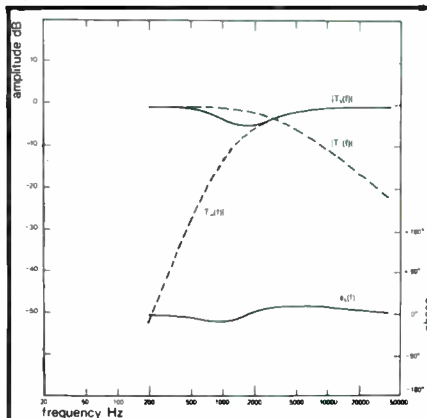


Fig. 6 *Two-way loudspeaker system with 3 kHz crossover. Low-frequency drive unit fed via correctly designed network, giving response $T_L(f)$. High-frequency unit, as Figure 5, fed via conventional network, giving response $T_H(f)$.Overall system response $T_S(f)$ varies with frequency.*

On the other hand, the associated high-frequency drive unit, which has the acoustic response shown in Figure 5, is fed through a conventional 3 kHz high-pass network giving a simple first-order Butterworth filter characteristic with no allowance made for the natural roll-off introduced by the unit. Figure 6 shows the resultant filter/unit response $T_H(f)$ (not strictly a target function in this case, since one would not aim at such a result); this is of a hybrid form which, when added to $T_L(f)$, gives an overall system response $T_S(f)$ that is not flat, but exhibits a dip at crossover.

To achieve a flat overall frequency characteristic in the above example it would be necessary to redesign the network feeding the high-frequency drive unit to give the amplitude response $|H_H(f)|$ shown in Figure 7; it will be seen that at frequencies below 300 Hz the output from the network must exceed the input, a condition that precludes the use of a passive filter since it calls for addi-

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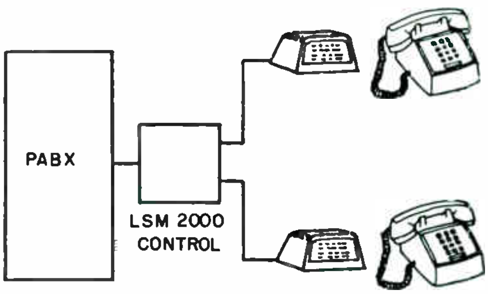

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tional amplification. But even if this amplification were provided, the increasing input to the unit below 300 Hz would lead to excessive diaphragm excursion at low frequencies; the effect is illustrated by Figure 8, which shows the acoustic response and diaphragm excursion of the high-frequency unit fed through the active network of Figure 7. For comparison, the corresponding response and excursion are reproduced from Figure 5.

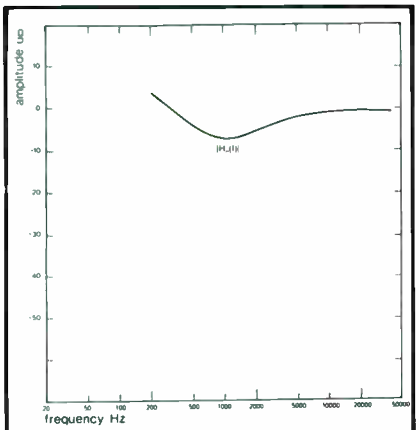


Fig. 7 *Characteristic $H_H(f)$ of active network required to convert response $S_H(f)$ of high-frequency drive unit of Figure 5 to give 1st order 3 kHz high-pass filter.*

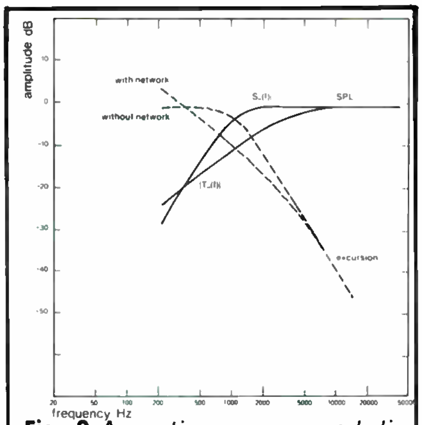


Fig. 8 *Acoustic response and diaphragm excursion of high-frequency drive unit of Figure 5: effect of network giving 1st order 3 kHz high-pass characteristic, $T_H(f)$.*

In general, the response of each filter/unit combination should follow the target function for the first 20 dB of attenuation in the stop band, and the characteristics of the unit have therefore to be controlled over whatever frequency range is necessary to achieve that end. As a final illustration of the disadvantages of first-order filtering, we can apply this requirement to the case of a mid-range drive unit designed for crossover frequencies of 300 Hz and 3 kHz. With a first-order band-pass filter, attenuating at only 6dB/octave, the response of such a unit would have to be controlled in manufacture over a band including at least three octaves in each cut-off region, i.e., from 38 Hz to 24 kHz—the full audio-frequency range.

Higher-Order Crossovers

Crossover networks of the second order were at one time favored but now have little application in high quality systems. The overall frequency response obtained is not flat in the crossover region, but exhibits either a crevasse or a hump, depending on whether the drive units are connected in the same or opposite polarity; moreover, the cut-off slope of 12 dB/octave is still insufficient for many purposes.

Third-order crossovers, on the other hand, satisfy many of the requirements and are widely used. The advantage of having an 18 dB/octave slope is illustrated by Figure 9, which shows the frequency response and diaphragm excursion for the high-frequency drive unit of Figure 5 with and without a 3 kHz crossover network designed to a third-order Butterworth target function; with the network, the diaphragm excursion, instead of rising at low frequencies, as in the first-order system of Figure 8, falls off steadily below the cut-off frequency, thus avoiding non-linear distortion in the stop band.

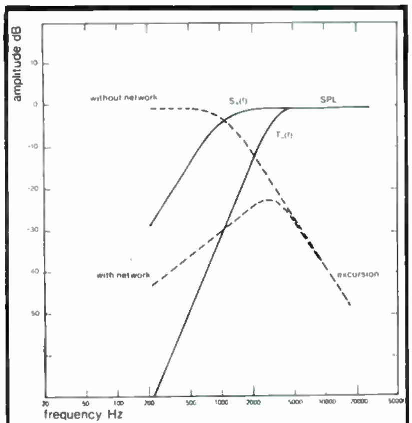
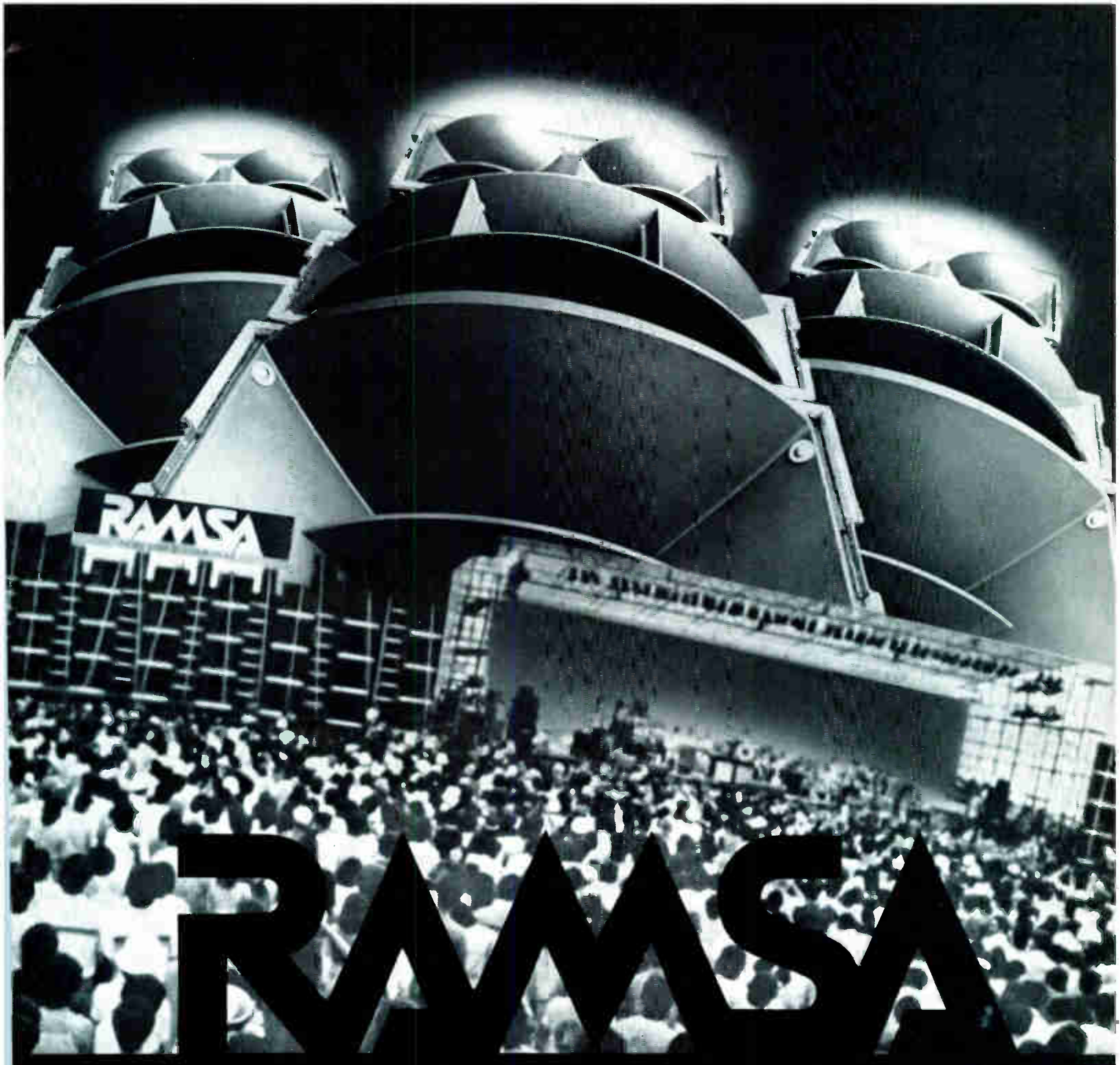


Fig. 9 *Acoustic response and diaphragm excursion of high-frequency drive unit of Figure 5: effect of network giving 3rd order 3 kHz high-pass characteristic, $T_H(f)$.*

To examine the overall amplitude and phase characteristics of a third-order crossover system, we return to Figure 4(b). As in the first-order arrangement of Figure 4(a), the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contributions from the high-and low-frequency units, $T_H(f)$ and $T_L(f)$, are each attenuated by 3 dB at crossover and at this point are 90° out of phase, giving a combined output of unity (zero dB). But whereas the overall response of the first-order system has unity amplitude and zero phase at all frequencies, that of the third-order system has unity amplitude |1| plus a phase shift $Ø_S$ which varies with frequency, i.e., $T_S(f) = T_H(f) + T_L(f) = |1| e^{jØ_S(f)}$, giving the effect of an all-pass filter. The constant amplitude response is independent of the polarity of the drive units, but in practice these are unusually connected in reverse as indicated in Figure 4(b) because this arrangement gives a smoother phase/frequency characteristic; the 180° phase shift resulting from the reversal is then spread over a wide frequency range and in these circumstances its effect is inaudible under practical conditions.

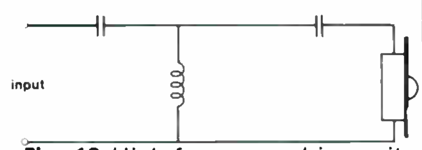

Fig. 10 *High-frequency drive unit with conventional 3rd order Butterworth high-pass filter.*

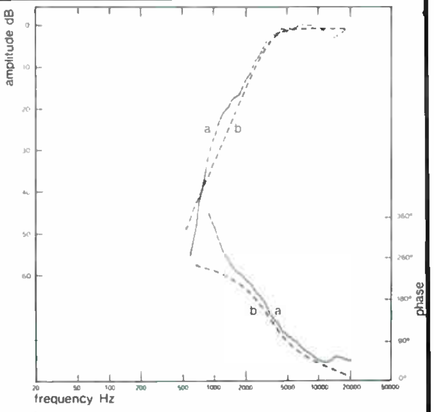

Fig. 11
(a) *Measured amplitude and phase response of high-frequency drive unit with conventional 3rd order Butterworth high-pass filter as in Figure 10.*
(b) *Theoretical amplitude and phase response of filter alone, terminated with correct resistive load.*

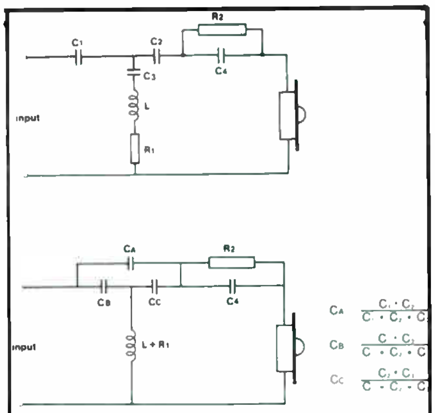

Fig. 12
(a) *Computed Acoustic Butterworth filter designed to compensate for non-flat response and complex input impedance of high-frequency drive unit.*
(b) *Practical realization of Acoustic Butterworth filter.*

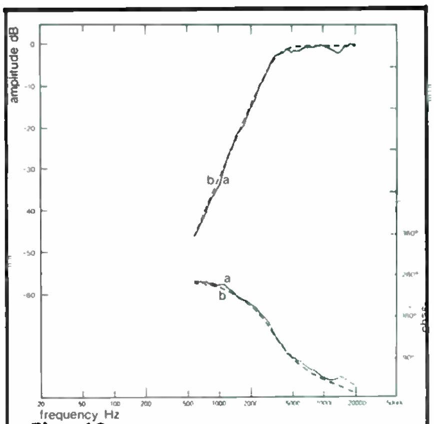

Fig. 13
(a) *Measured amplitude and phase response of high-frequency drive unit with Acoustic Butterworth filter shown in Figure 12.*
(b) *Theoretical 3rd order Butterworth filter characteristic (as in Figure 11b).*

Practical Application of Target Function

The examples given so far have been based on drive unit characteristics of idealized form; Figures 10 to 13, however, illustrate the application of the target function approach to a practical case. Figure 10 shows a commercial high frequency drive unit fed through a conventional third-order Butterworth high-pass filter having a nominal cut-off frequency of 3 kHz, and Figure 11(a) the measured amplitude and phase response of the filter unit together; Figure 11(b) represents the theoretical response of the filter alone when loaded with a resistor numerically equal in value to the nominal impedance of the unit. Comparing curves (a) and (b) it will be seen that the response of the filter/unit combination deviates substantially from that which the filter was intended to produce. At high

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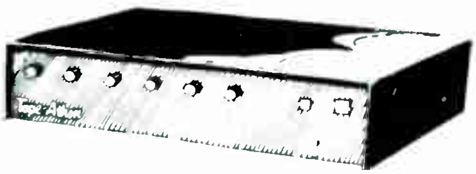

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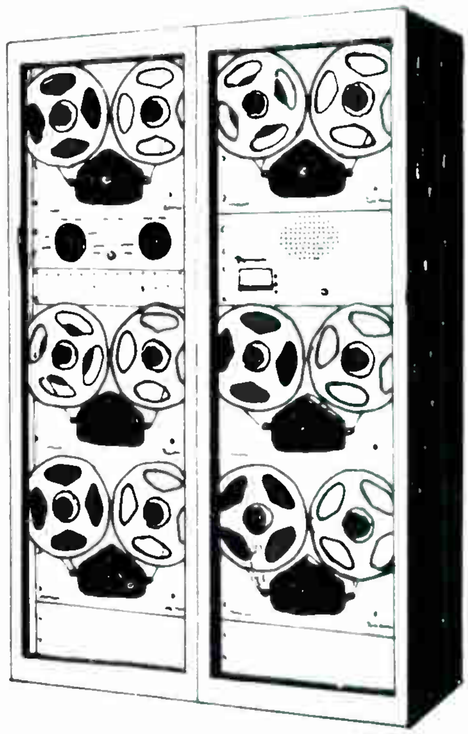

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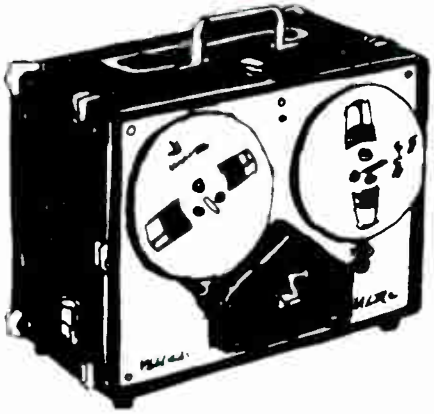

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frequencies the characteristic is modified by the voice coil inductance, which resonates at 5 kHz with the second capacitor of the filter. From 3 kHz downwards, the cut-off slope, which for a third-order filter should be 18 dB/octave, starts off at 12 dB/octave and below 1.2 kHz—the fundamental resonance frequency of the diaphragm—increases suddenly to nearly 30 dB/octave. This large change in slope is reflected in the phase shift in the cut-off region, which far exceeds the proper value; the disparity extends up as far as the crossover frequency and would have a significant effect on the overall loudspeaker response in the transition region.

Figure 12(a) shows the same high-frequency unit with a new network computed by taking the theoretical filter response of Figure 11(b) as the target function; Figure 12(b) illustrates a different but equivalent circuit configuration adopted for greater convenience in manufacture. The new network compensates for the electro-acoustic characteristics of the drive unit, including the effects of the voice coil inductance and the fundamental resonance. The voltage at the terminals of the unit varies with frequency in such a way as to produce the acoustic response shown in Figure 13(a); over most of the range from 500 Hz to 20 kHz this response conforms closely to the theoretical Butterworth characteristics, reproduced in Figure 13(b), the residual deviations being within ±1 dB in amplitude and within a few degrees in phase. The network of Figure 12 combines the functions of a Butterworth filter and an acoustic correction circuit, and may therefore be described as an "Acoustic Butterworth" filter.

Avoiding Interference

A further consideration in the choice of the target function concerns the directional characteristics of the loudspeaker system and their effect on the quality of sound heard under practical conditions.

In a multi-way loudspeaker the acoustic centers of all the drive units should ideally be equidistant from the listener, to avoid interference effects in the crossover regions through unequal time delays. The units should therefore be so positioned that the axis of zero inter-unit time delay passes through some representative point—for example, at the head height of a centrally seated listener—and in determining the response of each unit for design purposes, the measuring microphone should be placed at this point.

For maximum horizontal distribution of sound without interference, the drive units should be mounted one above the other. Because of the unavoidable separation between the units, some interference effects must then occur when the listener is located above or below the design axis and thus no longer equidistant from the different sound sources; the amount of this interference sets a limit to the angle above and below the axis within which the response can be maintained substantially constant.

This situation is further complicated by the phase shift necessarily associated with the high- and low-pass characteristics of the individual filter/unit combinations. The high-frequency drive unit, which at crossover normally has a phase lead over the low-frequency unit, is commonly mounted above the latter; what happens then is illustrated by the polar diagram in Figure 14, which shows how the loudspeaker response at crossover varies with angle in the vertical plane. In this example, the high- and low-pass filter functions are of the third order,

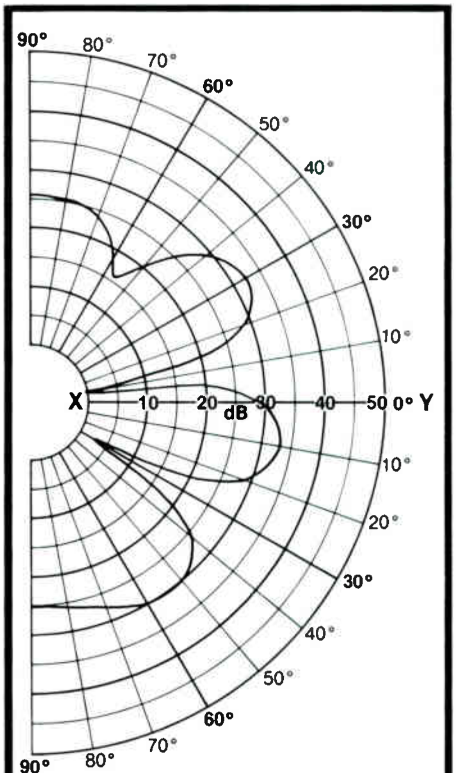
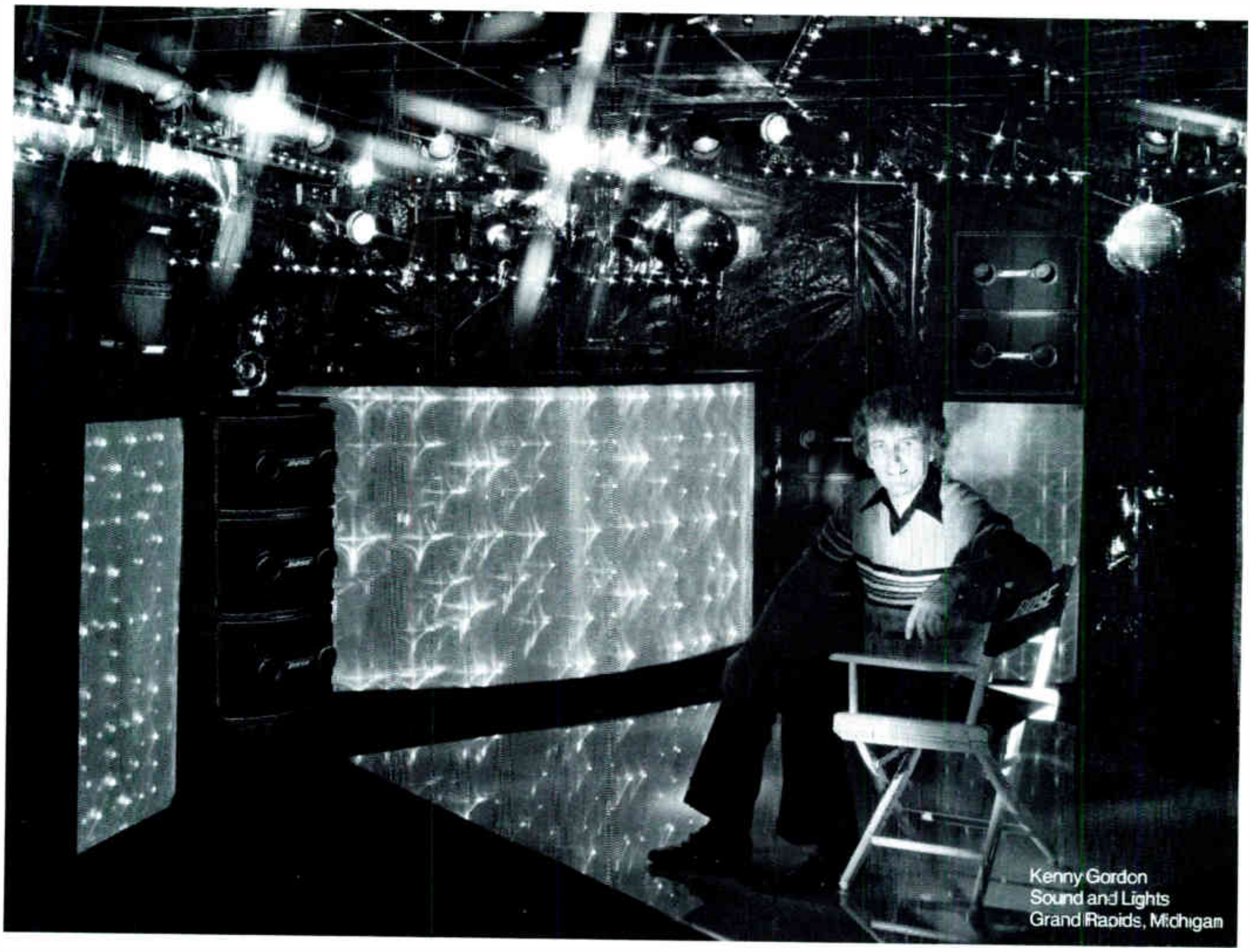


Fig. 14 *Vertical plane polar characteristic of 2-way loudspeaker system at 3 kHz crossover frequency; acoustic center of high-frequency drive unit 170 mm above that of low-frequency unit. X-Y indicates axis of zero inter-unit time delay.*



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for which the inter-unit phase difference is 90°, and the crossover frequency is 3 kHz; the vertical distance between the axes of the units is 170 mm, which at 3 kHz is 1.5 times the wavelength of the sound.

It will be seen that the main lobe of the polar characteristic, instead of coinciding with the axis of zero inter-unit time delay, is tilted downwards and has a maximum amplitude 3 dB above the on-axis response; a great deal of sound energy is thus directed away from the listening area and towards the floor, producing unwanted frequency-dependent reflections which modify the relationship between the direct and reflected sound in the room. Worse still, there is a region, just above the axis, where the outputs from the two units are beginning to get out of phase and at one angle almost cancel each other; as a result, a small vertical displacement produces a large change in the response of the system around crossover, and hence in the spectrum of the reproduced sound. This effect is illustrated in Figure 15, which shows how the frequency characteristic of the loudspeaker referred to in Figure 14 varies with angle above and below the design axis.

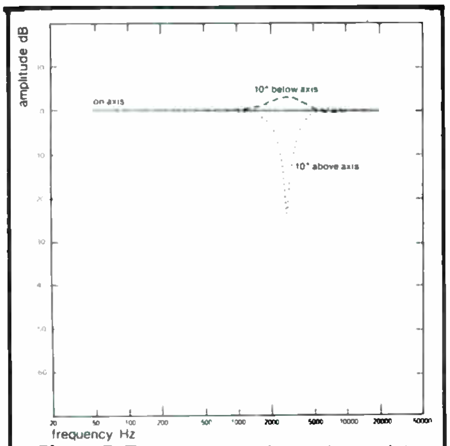

Fig. 15 *Two-way loudspeaker with 3rd order crossover at 3 kHz; variation in frequency response with vertical angle. High-frequency drive unit mounted above low-frequency unit with axes 170 mm apart.*

It may be noted in passing that a similar phenomenon occurs with a first-order crossover; in this case the slower rate of cut-off gives a wider range of overlap between the two sound sources, and the tilt in the polar characteristic extends over at least two octaves.

One way of dealing with this situation is to mount the low-frequency drive unit (or mid-range unit in the case of a three-way system) above the high-frequency unit, thus turning the polar diagram upside down; the main lobe is then directed away from the floor and the cancellation region placed where it can do little harm.

A more radical solution is to choose for the target functions $T_H(f)$ and $T_L(f)$ a form of filter characteristic that keeps the acoustic outputs from the high- and low-frequency drive units in phase over the whole frequency range, so that the main lobe of the polar curve remains symmetrical about the axis of zero inter-unit time delay; the variation in frequency response with vertical angle is then reduced in the above example to the amount shown in Figure 16.

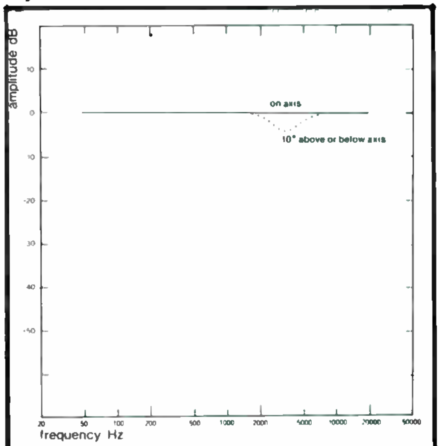

Fig. 16 *Two-way loudspeaker with 4th order crossover at 3 kHz; variation in frequency response with vertical angle. High-frequency drive unit mounted above low frequency unit with axes 170 mm apart.*

The crossover networks used to achieve this end are of a special type of fourth-order filter which is equivalent to two second-order Butterworth filters in cascade and thus gives a cut-off slope of 24 dB/octave. Figure 17 shows the characteristics of high- and low-pass filters of this kind, together with the overall system response. $T_S(f)$ and $T_L(f)$ are phase-shifted in opposite directions by angles $Ø_H(f)$ and $Ø_L(f)$ which, while varying with frequency, have a constant separation of 360°; the angular difference thus amounts to

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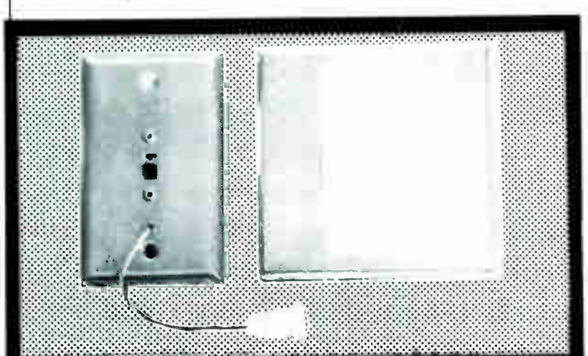

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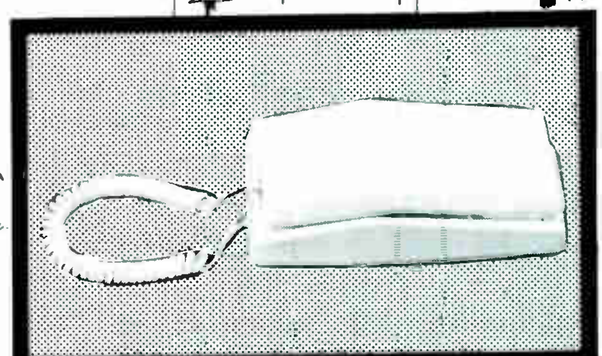

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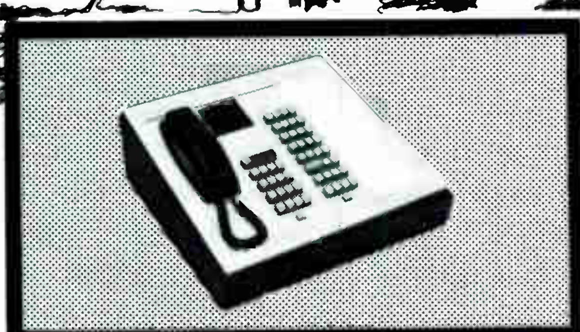

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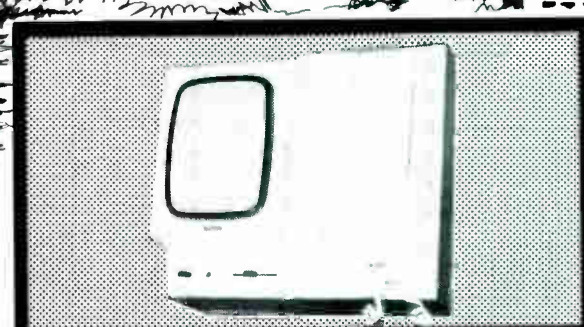

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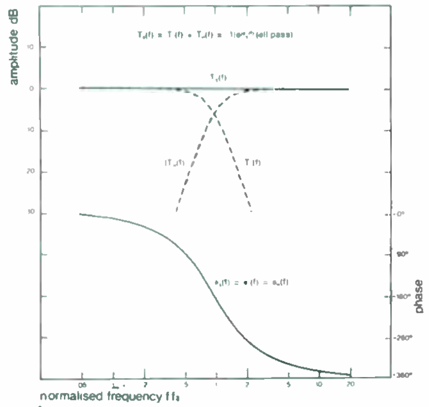

Fig. 17 *Crossover characteristics with 4th order filters, equivalent to two 2nd order Butterworth filters in cascade, as Target Functions T(f).*

Before leaving the subject of interference, it may be noted that the acoustic center of a high-frequency drive unit usually lies approximately in the plane of the panel on which the unit is mounted, while that of a low-frequency or mid-range unit is located further back, a short distance in front of the voice coil. The resulting difference in time delay can be allowed for, as indicated earlier, in the physical positioning of the units in the loudspeaker assembly. It is, however, possible in some cases to achieve the equivalent result electrically by modifying the amplitude response, and hence the phase shift, in the crossover filters in such a way as to introduce a compensating time delay, while still satisfying the basic requirements of flat overall response and adequate cut-off slope. The target functions adopted then, differ from the classical forms illustrated above—for example, the high- and low-pass characteristics at crossover may not be of the same order; given the necessary computational facilities, a number of useful variants of this kind can be evolved to meet particular design requirements.

Network Synthesis

So far we have dealt only with design principles. Implementation of these principles in the form of hardware is a matter of engineering economics; inductors and capacitors are expensive items and it is quite common for crossover filters to cost as much as the associated drive units. The design of networks for manufacture on a commercial scale therefore calls for a systematic approach aimed at minimizing the cost of the components needed to achieve the prescribed performance.

The design of the KEF Model 105.2 loudspeaker provides a good example of modern methods of network synthesis. By way of illustration, we will consider the successive steps in the process of arriving at the optimum specification for the mid-range filter; a similar procedure is adopted for the high- and low-frequency networks.

The first step is to examine the frequency response curves of a large number of mid-range drive units, measured under standard production test conditions, and to select one specimen, the characteristic of which coincides with the mean of the production spread. This unit is then mounted in the enclosure designed for the complete loudspeaker system, and its response under these conditions measured without a filter, i.e., with constant voltage

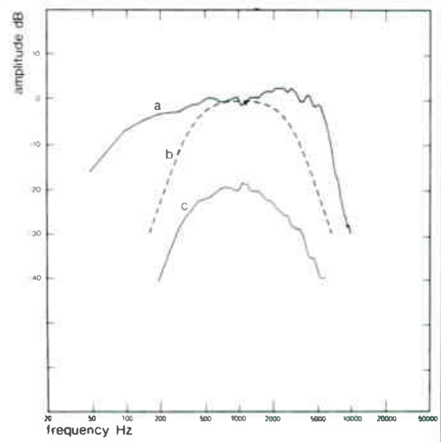

Fig. 18
(a) *Measured frequency response $|S_M(f)|$ of mid-range drive unit for Model 105.2 loudspeaker. No filter.*
(b) *Target function $|T_M(f)|$ representing desired response of filter and unit together.*
(c) *Response $|H_M(f)|$ of filter required to achieve target. (Curve displaced.)*

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applied to the input terminals. In Figure 18, curve (a) shows the amplitude/frequency response $|S_M(f)|$ of the drive unit alone and curve (b) the desired target response $|T_M(f)|$ to be achieved by the unit and filter together. Curve (c), which is obtained by subtracting (b) from (a) (subtraction being appropriate in this case since the quantities concerned are expressed in dB), is displaced vertically for the sake of clarity; it represents the frequency response $|H_M(f)|$ of the filter required to produce the desired overall performance.

Since the filter has to be designed to operate into the complex impedance presented by the input of the drive unit, this impedance must now be measured. For the purpose of network synthesis, however, it is convenient to represent the result by an equivalent electrical circuit with specified component values rather than by a series of resistance and reactance figures at a number of frequencies; this approach makes it easier to calculate the effect of certain parameters of the unit.

The next step is to decide what circuit configuration will produce the best fit to the desired network response curve while using the minimum number of components—taking into account the complex load imposed by the drive unit and the need to present an acceptable impedance to the power amplifier. The order of network required can usually be deduced by comparing the slope of the frequency characteristic for the drive unit alone with that of the target function representing the desired overall response curve. Thus, in Figure 18 the unit response (a) falls off at the low-frequency end with a slope approximating to that of a first-order high-pass filter (6 dB/octave), while the target function (b) in the same frequency range has the slope of a fourth-order filter characteristic (24 dB/octave); the high-pass network required to make up the difference must therefore be of at least the third order (18 dB/octave). In principle, a number of alternative circuit configurations could be considered at this stage, but in the light of the designer's experience the choice will usually be narrowed down to one or two.

Details of each network to be investigated, the response characteristic required and the equivalent circuit for the drive unit input impedance are now fed into a computer; this is programmed to carry out an optimization routine, which determines the network component values giving the best fit to the desired response curve and also the degree of accuracy achieved. The optimization process is initiated by assigning approximate values to the various circuit elements; the computer then calculates the effect of making small changes in each element, and retains any of the new values that bring the response nearer to the ideal. This operation is repeated—possibly a thousand or more times—until the residual error in the curve fitting cannot be reduced any further. With the component values thus arrived at, the input impedance of the network is then checked to ensure that it remains within acceptable limits throughout the working frequency range.

The above procedure is repeated, if necessary, for alternative types of network so that a final choice of the optimum circuit configuration can be made.

Component Tolerances

At this stage the designer has to consider ways of utilizing readily available circuit components, avoiding the need for non-standard values and close tolerance limits, both of which add considerably to the cost. The computer program is accord-

The Dependables.

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Exclusive BGW features include:

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BGW Systems, Inc., 13130 S. Yukon Ave., Hawthorne, CA 90250 (213) 973-8090 In Canada: Omnimedia Corp., 9653 Cote de Liesse, Dorval, Quebec H9P 1A3 ingly re-run, with the calculated values of capacitors and resistors replaced by the nearest preferred values. Provided that a sufficiently accurate fit to the target response was achieved in the original calculation, the effect of these changes can be offset without appreciable detriment to the performance of the filter by altering the inductance values in the circuit—a simple matter, since the coils are in any case wound to suit the individual design.

The process is now extended to allow for the production spread in component values. By arranging that the deviations of different circuit elements from their nominal values have opposing effects on the overall performance of the filter, it is possible to utilize stock components, having normal commercial tolerances, with very little waste. The known manufacturing variation in component values, expressed in statistical form, is fed into the computer, which calculates the maximum percentage of stock items that can be utilized in this way while keeping the filter characteristics within tolerance. Finally, permissible combinations of component values are worked out and incorporated in the instructions for assembling the networks on the production line. Thus, the process of network synthesis is not, as might be expected, confined to the initial design work, but plays an essential part in achieving the desired result at minimum production cost.

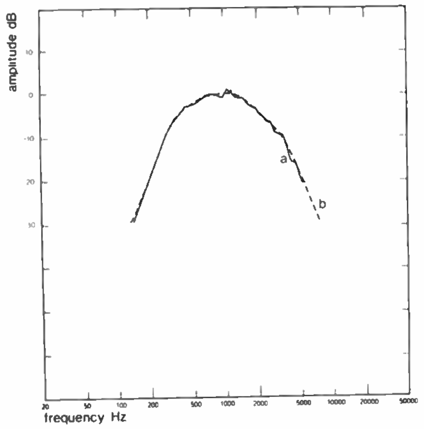

Fig. 19
(a) Desired response $|H_M(f)|$ of mid-range filter for Model 105.2 loudspeaker.
(b) Measured filter response at input of mid-range drive unit.

Performance of End Product

We return now to our practical example. Figures 19 to 21 illustrate the result of applying the target function concept and the network synthesis technique described above to the filters for the Model 105.2 loudspeaker. In Figure 19, curve (a) shows the desired response $|H_M(f)|$ of the mid-range filter reproduced from Figure 18, and curve (b) the response of an actual filter, measured at the input terminals of the associated drive unit. In Figure 20, curve (a), reproduced from Figure 18, shows the desired acoustic response $|T_M(f)|$ for the filter and unit together, while the corresponding measured response is plotted in curve (b). It will be seen that the two curves of Figure 20 fit within 1 dB

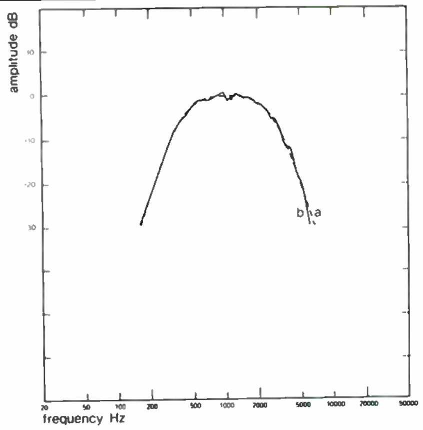

Fig. 20
(a) Desired frequency response $|T_M(f)|$ of mid-range drive unit for Model 105.2 loudspeaker, fed through its filter.
(b) Measured response of filter/unit combination.

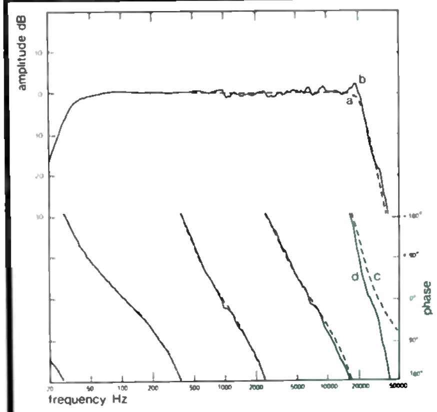

Fig. 21
(a) Amplitude/frequency response $|T_S(f)|$ calculated for Model 105.2 loudspeaker system.
(b) Measured amplitude/frequency response of Model 105.2 loudspeaker system.
(c) Phase/frequency response $_S(f)$ calculated for Model 105.2 loudspeaker system.
(d) Measured phase/frequency response of Model 105.2 loudspeaker system.
Please note that the phase curves cover four complete rotations.

Oaktron Architectural– Industrial Sound System

Speakers and Accessories

- Warning and Alarm speakers
- Public Address and paging speakers
- Architectural speakers and controls
- Baffles and grills
- Aircraft specification speakers
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Architectural/Commercial Sound Speakers

OA54U

OA48U

OA55U

OA12U

Oaktron Architectural Sound Speakers are designed specifically for commercial sound applications. Specially treated, weather-proof cones provide the most pleasing acoustical characteristics for paging, and maintain minimum distortion and maximum efficiency for high response music programming. These speakers, with heat-resistant and moisture-proof voice coils, have proven durability where other speakers may fail. All speakers have transformer mounting facilities except OA12U, as noted.

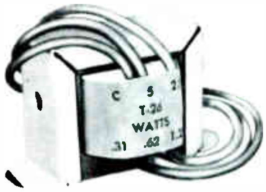
Model Number	Nominal Size and Shape	VOICE COIL Nom. Imped. (Ohms)	VOICE COIL Dia. Ins.	MAGNET Wgt. in Ozs.	MAGNET Mat.	RMS Power in Watts	fs: Nom. Free Air Res. (Hz)	Frequency Response (Hz)	Max. Depth in Inches
OA12U	4 1/2" P.C.	8	1	10.0	F	18	75	45-15,000	2 1/4
Free Edge Cone—No Transformer Bracket									
OA12UTR	4 1/2" P.C.	8	1	10.0	F	18	75	45-15,000	2 1/4
Free Edge Cone									
OA43	8" P.C.	8	3/4	3.16	A	10	85	40-14,000	3 9/16
OA46U	8" P.C.	8	1	6.0	F	12	80	40-12,000	2 7/8
OA48U	8" P.C.	8	1	10.0	F	18	100	90-8,500	3
Red Acrylic Cone and Dust Cap. Waterproof.									
OA49U	8" P.C.	8	1	10.0	F	18	75	40-12,000	3
OA50U	8" P.C.	8	1	10.0	F	18	70	40-14,000	3
Extended range version of OA49U									
OA54U	8" P.C.	8	1	10.0	F	18	80	40-16,000	3
Twin Cone									
OA55U	8" Rd.	8	6	10.0	F	18	50	35-16,000	3
Free Edge, Twin Cone									
OA56U	8" P.C.	Dual 8	1	6.0	F	10	80	40-9,000	2 7/8
OA57U	8" P.C.	Dual 8	1	10.0	F	18	80	40-9,000	3
OA95U	8" Rd.	8	1	10.0	F	20	45	35-16,000	3 1/2
Co-axial									
OA125	12" Rd.	8	1 1/2	20.0	F	30	30	40-16,000	5 1/4
Co-axial—Free Edge, Air Suspension, Woofer Cone									

Constant Voltage Line Transformers

Impedance matching to 70.7 and 25 volt lines. Transformers can be mounted to selected speakers at the factory. Supplied with 6" pigtail leads.

Model Number	Voltage	Primary Impedance/ Power	Secondary Impedance	Nominal Watts	Core Size	DIMENSIONS Height	DIMENSIONS Width	DIMENSIONS Depth	Mtg. Centers
Supplied with 6" pigtail leads									
T-71	70.7V	2/1/.5	8 ohm	2	3/8 × 3/8	1 1/4"	1 1/2"	1 1/4"	1 3/4"
T-72	70.7V	5/2.5/1.25 .62/.31	8 ohm	5	1/2 × 5/8	1 3/8"	1 3/4"	1 1/2"	2"
T-74	70.7V	10/7.5/2.5	8 ohm	10	5/8 × 5/8	1 5/8"	2"	1 5/8"	3 3/8"
T-25	25V	2/1/.5	8 ohm	2	3/8 × 3/8	1 1/4"	1 1/2"	1 1/4"	1 3/4"
T-26	25V	5/2.5/1.25 .62/.31	8 ohm	5	1/2 × 5/8	1 3/8"	1 3/4"	1 1/2"	2"
T-29	25V	10/7.5/5/2.5	8 ohm	10	5/8 × 5/8	1 5/8"	2"	1 5/8"	2 3/8"

25 Volt Constant Voltage Line

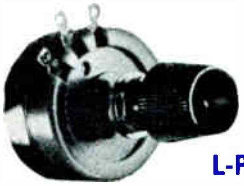


PIGTAIL TRANSFORMER

Primary Center Tapped Transformer
For use with privacy function switch. 25 volt constant voltage line, 6" pigtail leads.

Model Number	Power Taps	Speaker Impedance	Core Size	DIMENSIONS Height	DIMENSIONS Width	DIMENSIONS Depth	Mtg. Centers
T-28	2/1/.5	8 ohm	5/8 × 5/8	1 5/8"	2 13/16"	2 13/16"	2 3/8"

L-Pad



L-PAD

Use Oaktron's L-Pads to adjust individual speaker volume without affecting others. Supplied with hardware, control knob and dust-proof housing. Mounts through ½" material.

Model Number	Speaker Impedance	Power Rating	Dimensions
LP-8	8 ohm	10 Watts Audio	Dia. of Control: 1 5/8" Length of Bushing: 11/16" Length of Shaft: 3/8"

L-Pads can be premounted to wall baffle or ceiling grilles at factory.

Wall Mount Baffles

All wall baffles feature tough, durable vinyl coverings in handsome woodgrain finishes over rugged ½" warp-resistant hardboard construction. All baffles completely assembled, speaker mounting hardware included. Selected speakers can be premounted at factory on order.

Speaker Size	Model Number	Finish	Maximum Dimensions Height	Width	Depth

Standard "Picture Frame" Baffles

Speaker Size	Model Number	Finish	Height	Width	Depth
8"	B8VB B8VW	Blonde Walnut	10¹/₈"	10¹/₄"	6"
12"	B12VB B12VW	Blonde Walnut	14¹/₂"	14¹/₂"	7¹/₂"

Slimline "Picture Frame" Baffle

Speaker Size	Model Number	Finish	Height	Width	Depth
8"	SB8VB SB8VW	Blonde Walnut	10¹/₄"	11⁷/₈"	4⁷/₈"

Corner "Picture Frame" Baffles

Speaker Size	Model Number	Finish	Height	Width	Depth
8"	K8VB K8VW	Blonde Walnut	10¹/₄"	10¹/₄"	7³/₄"
12"	KB12B KB12W	Blonde Walnut	15¹/₈"	13⁵/₈"	7³/₈"

Positive Mount "Notched" Baffles

"Picture Frame" Slimline and Standard 8" baffles can be ordered "NOTCHED" for secure, but removable, attachment to wall or ceiling with the B-8 mounting bracket. Inhibits tampering. Order brackets separately, below.

Speaker Size	Model Number	Finish	Height	Width	Depth
8"	B8VB-N B8VW-N	Blonde Walnut	10¹/₄"	10¹/₄"	6"
	SB8VB-N SB8VW-N	Blonde Walnut	10¹/₄"	11⁷/₈"	4⁷/₈"

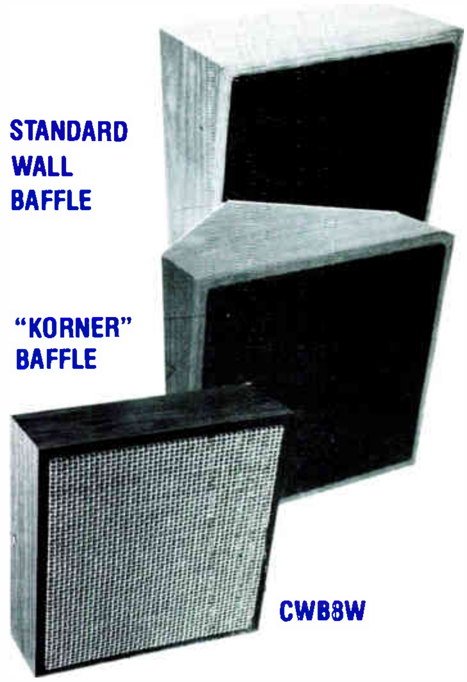
Positive-hold steel mounting bracket for installing "NOTCHED" baffles. Fabricated to fit standard electrical utility boxes.

Speaker Size	Model Number	Finish	Height	Width	Depth
	B-8	Gray	9³/₄"	1"	¹/₁₆"

Ceiling Baffle

Square, non-sloping enclosure, in vinyl woodgrain finish, gives a "Hi-Fi" look to ceiling or wall mount baffle. Mounting brackets included.

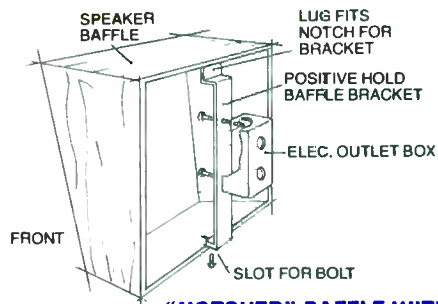
Speaker Size	Model Number	Finish	Height	Width	Depth
8"	CWB8W	Walnut	10³/₈"	10³/₈"	3³/₈"



STANDARD WALL BAFFLE

"KORNER" BAFFLE

CWB8W



"NOTCHED" BAFFLE WITH TAMPER-PROOF BRACKET

8" Ceiling Grilles

High efficiency ceiling grilles provide wide dispersion and superior sound reproduction. Of one piece construction to eliminate vibration, these grilles mount directly to ceiling or plaster ring. Speaker mounting hardware included. Speakers can be premounted at the factory (add $.90 to unit cost). Accepts all 8" round and pincushion speakers.

Perforated Circle Pattern Grille

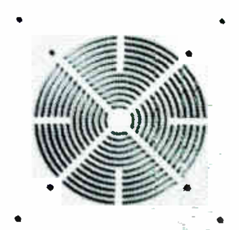
Model No.	Material	Shape	Diameter
SL8S	Brushed Satin Aluminum	Round	13"
SL8W	White Painted Steel	Round	13"

Louvered Circle Pattern Grille

Model No.	Material	Shape	Diameter
CR8S	Brushed Satin Aluminum	Round	12³/₄"
CR8W	White Enamel Steel	Round	12³/₄"
CS8S	Brushed Satin Aluminum	Square	12¹/₈"
CS8W	White Enamel Steel	Square	12¹/₈"

SL8S

CR8S SATIN ALUMINUM



CS8W WHITE PAINTED STEEL

Outdoor/Patio Speakers

PVS800C

Full range, high-fidelity in a completely waterproof, heat resistant enclosure. Hang it on your patio and leave it–or take it on the road– It's a speaker made for the outdoors. Specially designed speaker opening delivers full-fidelity sound through an exceptionally wide dispersion angle.

Model Number	Finish
PVS800W	Off-White
PVS800C	Charcoal

- 8″ full range speaker in 12⅛″ diameter hemispheric enclosure with detachable mounting bracket; 3½ lbs. total weight.
- 15 Watts RMS, 30 Watts peak.
- 45 to 15,000 H_z response. 8 ohm
- Available in charcoal and off-white with leather-like finish.

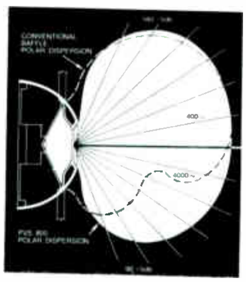
AI-10 Environmental Sound Control Speaker

High-efficiency noise-masking speaker, with pressure-velocity "lens" opening, can achieve acoustical privacy in the open-office area with fewer units than the average system. Better frequency range coupling is achieved with the installed 12 watt air-suspension speaker. (can be ordered with dual voice coils)

- Textured-resilient-charcoal ABS housing. 1.6 Kilo (3.5 lbs.)
- 2-ft.—16AWG stranded twin lead input cable.
- Can be ordered with knob-controlled switch (for easy level adjustment or deactivation), and/or desired line transformers.

Model Number	Switch	Trans.
AI 10	no	no
AI 10-26	no	25V
AI 10-26SW	yes	25V
AI 10-72	no	70.7V
AI 10-72SW	yes	70.7V

AI-10



Aircraft Voice Communications Speakers

Built as original equipment to meet or exceed the exacting specifications of the aircraft manufacturer or airline, these speakers emphasize the critical voice frequencies, and reduce the harmonic effects of interference and spurious signals. With flame retardant cones, as required, and with heat-resistant and moisture-proof voice coils, these speakers can operate continuously at full rated power.

Oaktron Model No.	Aircraft/ Airline Model No.	Aircraft/ Airline Spec. No.	Aircraft/ Airline Company	Nominal Size & Shape
3C8CSFR	3C8CSFR		Piper	3″ SQ
3C2773	487-467		Piper	3″ SQ
3EU8TFR	3EU8TFR		Piper	3″ SQ
4C8CFR	4C8CFR		Douglas	4″ SQ
4C2752	LS-15366-2		Lockheed	4″ SQ
4EAMFR	4EAMFR		Douglas/Piper	4″ SQ
4EU2742	487-192		Piper	4″ SQ
4EU3075	T4873		Douglas	4″ SQ
5D1943	T1545		Bellanca	5″ P.C.
5D3240	P5VA-C8880	60B40132	Boeing/Weber	5″ P.C.
⌀ T5401	⌀ P5VA-C8962	60B40130	Boeing/Weber	5″ P.C.
5DU3039	T4053		Dehavilland	5″ P.C.
5FU3201	587-122		Piper	5″ P.C.
5FU3210	5FUAS		Piper	5″ P.C.
53FU1914	T791		Cessna	5 1/4″ P.C.
6E2304	487-195		Piper	6″ P.C.
6EU1937	487-242		Piper	6″ P.C.
6FU3211	585-015		Piper	6″ P.C.
‡ 8EU2986	‡T5950		Boeing	8″ P.C.
8EU3070	T6116		Delta	8″ P.C.
8HU2951	LS-15366-1		Lockheed	8″ P.C.
‡ 8HU3107	‡C8R-C8783	60B40129	Boeing	8″ P.C.
‡ 12HU3106	‡C12RS-C8782	60B40128	Boeing	12″ Rd.
28A3219	585-044		Piper	2 3/4″ Rd.
35D3246	35D8MS		Delta	3 1/2″ SQ
36D2122	487-253		Piper	3 x 5 oval
46C3FR	46C3FR		Piper	4 x 6 rec.
46C2175	487-193		Piper	4 x 6 rec.
48FU2103	48FU2103		Cessna	4 x 8 oval
57E2174	487-194		Piper	5 x 7 oval
57E2337	7000014		Bellanca	5 x 7 oval
57E3128	587-497		Piper	5 x 7 oval
57GU2590	70000137		Bellanca	5 x 7 oval
57GWFR	57GWFR		Bellanca	5 x 7 oval
280140-1	Z3691-1		Boeing/Weber	Transformer

‡ Transformer Premounted to Speaker.

⌀ Generally used in conjunction with 280140-1 (Z3691-1) line transformer. Order transformer separately. Transformer is not premounted.

Theater and Music Speakers

Exceptionally strong, high-performance speakers with excellent power capacity, especially designed for bands, electronic organs, and musical instruments requiring the extreme ranges of amplification. Heavy-duty magnets and matched voice coils on heat-resistant aluminum forms keep putting out the power where other speakers may fail. All models have Barium Ferrite (ceramic) magnets and 8 ohm voice coils.

Extended Range—Organ and Stage Projector

Foam-edge, air-suspension speakers with high-frequency enhancers, to deliver clear tonal response across a full instrumental range.

Model Number	Nominal Size and Shape	V.C. Dia. Ins.	MAGNET Wgt. in Ozs.	MAGNET Mat.	RMS Power in Watts	fs: Nom. Free Air Res. (Hz)	Frequency Response (Hz)	Max. Depth in Inches
* BF10YW	10″ Rd.	2	54.0	F	100	30	25-9,500	4 7/16
* BF12YW	12″ Rd.	2 1/2	54.0	F	100	30	25-8,000	5 5/16
* BF15YW	15″ Rd.	2 1/2	54.0	F	100	25	20-8,000	6 1/2
* BF15Y2W	15″ Rd.	2 1/2	108.0	F	150	25	20-8,000	7
▶ * FE18YW	18″ Rd.	2 1/2	54.0	F	125	30	18-8,000	7 3/4
▶ * FE18Y2W	18″ Rd.	2 1/2	108.0	F	175	30	18-8,000	8 1/2

Lead and Rhythm Guitar

Speakers designed to meet the challenge for clear resolution of the complex figures demanded by today's artists–these speakers are powerful enough to lead the way.

Model Number	Nominal Size and Shape	V.C. Dia. Ins.	MAGNET Wgt. in Ozs.	MAGNET Mat.	RMS Power in Watts	fs: Nom. Free Air Res. (Hz)	Frequency Response (Hz)	Max. Depth in Inches
* M10Y	10″ Rd.	2	54.0	F	100	75	70-5,000	4 7/16
* M12TU	12″ Rd.	1 1/2	30.0	F	75	70	65-5,500	4 15/16
* M12Y	12″ Rd.	2 1/2	54.0	F	100	60	55-6,000	5 3/16
* M12Y2	12″ Rd.	2 1/2	108.0	F	150	56	55-6,000	5 3/4
* M15Y	15″ Rd.	2 1/2	54.0	F	100	60	50-6,000	6 1/2
* M15Y2	15″ Rd.	2 1/2	108.0	F	150	60	50-6,000	7 1/16
▶ * M18Y	18″ Rd.	2 1/2	54.0	F	125	60	50-5,500	7 3/4
▶ * M18Y2	18″ Rd.	2 1/2	108.0	F	175	60	50-5,500	8 1/2

Horn Radiators

Exponential horns reinforce the critical frequencies, help sound "stay together" through wide dispersion angles and high sound pressure levels. All horns feature ten ounce Ferrite magnets with matched voice coils and phenolic dome diaphragms. 8 ohm impedance.

Model Number	Application	Nominal Size	Actual Size	⌀ Avg. Sound Pressure Level	Peak Power Watts	Frequency Response	Max. Depth In Inches
H35	Tweeter	3 1/2″ Sq.	3 7/16″ Sq.	106 dB	70	1,500-20,000	1 3/8
H373	Tweeter	3″ x 7″	3″ x 7 1/4″	113 dB	60	2,000-20,000	4 5/8
H4105	Mid-Range	4″ x 10″	4″ x 10 5/8″	116 dB	60	800-16,000	7 3/8

Disco and Bass Guitar

Controlled power to set the beat, with positive bass action–these speakers deliver a low range you feel in your toes.

Model Number	Nominal Size and Shape	V.C. Dia. Ins.	MAGNET Wgt. in Ozs.	MAGNET Mat.	RMS Power in Watts	fs: Nom. Free Air Res. (Hz)	VAS (Cu. In.)	CMS (Cm/Dyne)	M (Gms)	Q	Frequency Response (Hz)	Max. Depth in Inches
BFW10Y	10″ Rd.	2	54.0	F	100	25	3,640	$.474 \times 10^{-6}$	36.9	.250	20-3,500	4 7/16
BFW12Y	12″ Rd.	2 1/2	54.0	F	100	23	29,253	1.33×10^{-6}	38.3	.360	18-3,000	5 1/2
BFW15Y	15″ Rd.	2 1/2	54.0	F	100	24	32,900	$.810 \times 10^{-6}$	65.5	.303	20-3,200	6 1/2
BFW15Y2	15″ Rd.	2 1/2	108.0	F	150	20	21,800	$.448 \times 10^{-6}$	112.0	.240	18-2,500	7 3/16
▶ FEW18Y	18″ Rd.	2 1/2	54.0	F	125	30	42,500	$.310 \times 10^{-6}$	93.0	.595	18-2,200	7 3/4
▶ FEW18Y2	18″ Rd.	2 1/2	108.0	F	175	30	49,800	$.364 \times 10^{-6}$	89.0	.532	18-2,200	8 1/2

⌀ Measured at 18″ with 4V RMS input. * Bright aluminum dust cap. ▶ Indicates new entry.

General and Industrial Replacement Speakers

Precision-crafted to meet or exceed original manufacturers' specifications, the replacement speakers on these pages will meet most general and industrial needs—from data alarm devices to full-fidelity music reproduction systems. For special auto and tractor applications, see Oaktron's "Auto Sound" Catalog. Speakers for advanced, multi-component applications can be found in Oaktron's "Home Systems" Catalog.

Round **Square** **Pin Cushion**

Model Number	Remarks	Nominal Size and Shape	VOICE COIL Nom. Imped. (Ohms)	VOICE COIL Dia. Ins.	MAGNET Wgt. in Ozs.	MAGNET Mat.	RMS Power in Watts (1000 Hz)	fs: Nom. Free Air Res. (Hz)	Frequency Response (Hz)	Max. Depth in Inches
R23A8①		2 1/4″ Rd.	8	9/16	.53	AC	2	530	350-6,500	1
25A8		2 1/2″ Sq.	8	9/16	.53	AC	1	350	250-5,000	1 3/16
Has same mounting centers as 2 1/4″ Sq. speaker										
R28A8①		2 3/4″ Rd.	8	9/16	.53	AC	1	300	250-5,000	1 3/16
R3A8①		3″ Rd.	8	9/16	.53	AC	2	300	250-6,000	1 1/16
3A3C		3″ Sq.	3.2	9/16	.53	AC	2	240	150-6,000	1 5/16
3C3C		3″ Sq.	3.2	3/4	1.1	AC	5	240	150-6,000	1 3/8
3C8C		3″ Sq.	8	3/4	1.1	AC	5	330	250-7,000	1 3/8
R35A8①		3 1/2″ Rd.	8	9/16	.53	AC	2	200	150-6,000	1 3/8
35C3		3 1/2″ Sq.	3.2	3/4	1.1	AC	5	200	160-5,000	1 9/16
35C8		3 1/2″ Sq.	8	3/4	1.1	AC	5	200	160-5,000	1 9/16
4A3C		4″ Sq.	3.2	9/16	.53	AC	2	175	140-7,500	1 9/16
4C3C		4″ Sq.	3.2	3/4	1.1	AC	5	170	140-7,500	1 11/16
4C8C		4″ Sq.	8	3/4	1.1	AC	5	170	140-7,500	1 11/16
4D3		4″ Sq.	3.2	9/16	1.47	A	6	175	160-7,000	1 3/16
4EAM	M-P	4″ Sq.	4-8	3/4	3.0	F	9	300	170-6,000	1 11/16
5A3C		5″ P.C.	3.2	9/16	.53	AC	4	175	140-7,500	1 11/16
5D3		5″ P.C.	3.2	9/16	1.47	A	6	180	160-7,000	2 5/16
5DAS		5″ P.C.	4-8	9/16	1.47	A	6	150	130-8,000	2 5/16
R5EA		5″ Rd.	4-8	3/4	3.0	F	9	115	95-9,000	1 3/4
5FUA		5″ P.C.	4-8	3/4	5.5	F	9	160	120-11,000	1 7/8
* FE5HA	Hi-Fi	4 1/2″/5″ P.C.	4-8	1	10.0	F	18	80	60-13,000	2 1/4
53EA		5 1/4″ P.C.	4-8	3/4	3.0	F	9	140	130-6,500	1 13/16
53GA		5 1/4″ P.C.	4-8	1	6.0	F	12	110	90-7,000	2 1/8
* BF53H	Hi-Fi	5 1/4″ P.C.	4-8	1	10.0	F	18	90	50%9,000	2 1/4
CABF53H	Coax	5 1/4″ P.C.	4-8	1	10.0	F	18	90	80-15,000	2 7/16
* BF53KW	Hi-Fi	5 1/4″ P.C.	4-8	1 1/4	16.0	F	25	90	90-15,000	2 7/16
CABF53K	Coax	5 1/4″ P.C.	4-8	1 1/4	16.0	F	25	75	60-16,500	2 11/16
6C3C		6″ P.C.	3.2	3/4	1.1	AC	6	100	80-8,000	2 3/16
6E8C		6″ P.C.	8	1	2.18	AC	8	100	90-8,500	2 3/8
6G8M	M-P	6″ P.C.	8	1	6.0	F	12	120	100-6,500	2 3/8
FE6GW	Hi-Fi	6″ Rd.	8	1	6.0	F	15	60	90-14,000	2 7/16
BF6H2W	Hi-Fi	6″ Rd.	8	1	20.0	F	30	55	80-15,000	3 1/16
8E8C		8″ P.C.	8	1	2.18	AC	9	95	80-8,500	2 13/16
8EUA		8″ P.C.	4-8	3/4	3.0	F	9	90	70-11,000	2 5/8
8F8		8″ P.C.	8	3/4	3.16	A	10	90	70-9,500	3 9/16
8GU8		8″ P.C.	8	1	6.0	F	12	90	70-10,000	2 7/8
8HU8		8″ P.C.	8	1	10.0	F	14	90	70-10,000	3
8H8W	EX-R	8″ P.C.	8	1	10.0	F	14	80	80-15,000	3
BF8HW	Hi-Fi	8″ Rd.	8	1	10.0	F	18	50	40-16,500	3
CAFE8H	Coax	8″ Rd.	8	1	10.0	F	18	80	50-14,000	3 1/2
FE8KW	Hi-Fi	8″ Rd.	8	1 1/2	10.4	A	25	55	50-13,500	4 9/16
* BF8KUW	Hi-Fi	8″ Rd.	8	1 1/4	16.0	F	25	50	60-12,000	3 1/2
CAFE8H2	Coax	8″ Rd.	8	1	20.0	F	30	80	50-14,000	3 5/8
* BF8TW	Hi-Fi	8″ Rd.	8	1 1/2	30.0	F	40	45	40-12,000	3 3/4
10HU8		10″ Rd.	8	1	10.0	F	15	75	65-8,500	3 3/4
* BF10KUW	Hi-Fi	10″ Rd.	8	1 1/4	16.0	F	25	40	35-16,000	4 3/4
* BF10TW	Hi-Fi	10″ Rd.	8	1 1/2	30.0	F	45	35	30-12,000	4 3/16
BF10YW	Hi-Fi	10″ Rd.	8	2	54.0	F	100	30	25-9,500	4 7/16
12HU8		12″ Rd.	8	1	10.0	F	18	60	40-7,500	4 1/2
12H8W	EX-R	12″ Rd.	8	1	10.0	F	18	60	60-13,000	4 1/2
BF12HW	Hi-Fi	12″ Rd.	8	1	10.0	F	18	40	35-10,000	4 1/2
* FE12KW	Hi-Fi	12″ Rd.	8	1 1/2	10.4	A	45	35	30-10,000	5 7/16
CAFE12H2	Coax	12″ Rd.	8	1	20.0	F	30	30	50-16,000	5 1/4
* BF12TW	Hi-Fi	12″ Rd.	8	1 1/2	30.0	F	50	30	25-10,000	5 1/8
* BF12YW	Hi-Fi	12″ Rd.	8	2 1/2	54.0	F	100	30	25-8,000	5 5/16
* BF15YW	Hi-Fi	15″ Rd.	8	2 1/2	54.0	F	100	25	20-8,000	6 1/2
* BF15Y2W	Hi-Fi	15″ Rd.	8	2 1/2	108.0	F	150	25	20-8,000	7 3/16

* Bright aluminum dust cap.

① No mounting holes on frame. Speaker must be secured by pressure, clamps or cement.

General and Industrial Replacement Speakers (Cont'd)

Oval **Rectangular** **Football**

Model Number	Remarks	Nominal Size and Shape	VOICE COIL Nom. Imped. (Ohms)	VOICE COIL Dia. Ins.	MAGNET Wgt. in Ozs.	MAGNET Mat.	RMS Power in Watts (1000 Hz)	fs: Nom. Free Air Res.(Hz)	Frequency Response (Hz)	Max. Depth in Inches
18X3A8		1 3/4" × 3"	8	9/16	.53	AC	2	380	300-3,000	1
2X3A8		2" × 3"	8	9/16	.53	AC	2	330	300-4,000	1 1/8
2X38A8		2" × 3 3/4"	8	9/16	.53	AC	2	330	300-4,500	1 3/16
26A8		2" × 6"	8	9/16	.53	AC	3	260	170-5,500	1 11/16
3X5A3		3" × 5"	3.2	9/16	.53	AC	3	175	160-8,500	1 5/8
3X5C3		3" × 5"	3.2	3/4	1.1	AC	5	175	160-8,500	1 11/16
3X5C8		3" × 5"	8	3/4	1.1	AC	5	175	160-8,500	1 11/16
3X5EA		3" × 5"	4-8	3/4	3.0	F	9	200	160-8,500	1 11/16
3X5FA		3" × 5"	4-8	3/4	5.5	F	12	175	160-8,500	1 13/16
46C3		4" × 6"	3.2	3/4	1.1	AC	6	150	140-7,000	1 9/16
46C8		4" × 6"	8	3/4	1.1	AC	6	150	140-7,000	1 9/16
46DA		4" × 6"	4-8	9/16	2.35	F	7	135	130-7,000	1 11/16
46FW	EX-R	4" × 6"	4-8	3/4	5.5	F	9	180	150-8,500	1 3/4
48E8		4" × 8"	8	1	2.18	AC	7	150	110-7,500	2 1/8
48GAM	M-P	4" × 8"	4-8	1	6.0	F	12	140	100-6,000	2 1/16
CAFE48H	Coax	4" × 8"	4-8	1	10.0	F	18	90	80-15,000	2 1/2
57CA		5" × 7"	4-8	3/4	1.1	AC	6	110	80-9,500	2 3/16
57EA		5" × 7"	4-8	1	2.18	AC	9	115	100-8,500	2 3/8
57EW	EX-R	5" × 7"	4-8	3/4	3.0	F	8	110	90-10,500	2 3/16
57GW	EX-R	5" × 7"	4-8	1	6.0	F	12	110	90-10,500	2 3/8
57GAM	M-P	5" × 7"	4-8	1	6.0	F	12	110	110-7,000	2 3/8
57HAM	M-P	5" × 7"	4-8	1	10.0	F	15	110	100-7,000	2 9/16
FE57HW	Hi-Fi	5" × 7"	4-8	1	10.0	F	18	80	80-9,000	2 9/16

REMARKS:
"EX-R" —"Extended Range" speakers have matched twin-cone high frequency enhancer.
"Hi-Fi" —"Hi-Fi" speakers have free-edge, air-suspension cones.
"Coax" —"COAXIAL" speakers have free-edge, air-suspension cones with high frequency Tweeter coaxially mounted on same frame.
"M-P" —"Moistureproof.
"FE" —prefix denotes cloth-surround air-suspension cone.
"BF" —prefix denotes foam-surround air-suspension cone.

3X5A3

48GAM

CAFE48H

Intercom Speakers

Especially designed to function as both loudspeakers and microphones, these speakers are the most popular sizes for intercom systems. However, any speaker within Oaktron's design inventory can be supplied with "Intercom impedance" when requested.

Model Number	Remarks	Nominal Size and Shape	VOICE COIL Nom. Imped. (Ohms)	VOICE COIL Dia. Ins.	MAGNET Wgt. in Ozs.	MAGNET Mat.	RMS Power in Watts (1000 Hz)	fs: Nom. Free Air Res.(Hz)	Frequency Response (Hz)	Max. Depth in Inches
25A45		2 1/2" Sq.	45	9/16	.53	AC	1	350	250-5,000	1 3/16
3A45		3" Sq.	45	9/16	.53	AC	2	240	150-6,000	1 5/16
4D45		4" Sq.	45	9/16	1.47	A	6	175	160-6,000	2 3/16
8F45		8" P.C.	45	3/4	3.16	A	10	90	75-9,000	3 9/16

8F45

Special Impedance

Any Oaktron speaker model listed in current catalogs can be supplied in special impedance, if desired. For details, contact your Oaktron sales location referring to the Oaktron model number and the special impedance desired.

Pre-Installed Speaker Accessories

Oaktron can preassemble a variety of speaker accessories and components, when ordered. Any Oaktron architectural/commercial sound speaker with a transformer emboss can have a constant voltage line transformer premounted at the factory. Additionally, a variety of selected combinations of wall and ceiling baffles, matching speakers, transformers, and L-pads can be preassembled at the factory. See pages 18 and 19 for selecting combinations. When ordering, connect chosen model numbers with dashes; for example: OA125U — T29 — B12VW — LP8 would be the series to order co-axial 12 inch speakers, with 10 watt, 25 volt transformer, installed in a walnut "picture frame" baffle, with L-pad premounted.

4D45

Oaktron's "All-Weather" Speakers

Oaktron speakers are not only capable of reproducing delicate sound with full-fidelity and quick response—they're tough enough to do it under conditions that could destroy the average speaker.

Oaktron speakers are built to do the job: Solid construction, no bolted parts; electrostatically painted baskets to resist rust; magnet structure and pole-piece fully plated against corrosion; available with weather-proof and fire-resistant cones, or even as completely waterproof speakers that can take a drenching and keep on working. All with Oaktron's high-efficiency, low-mass aluminum voice coil form. Long-lasting, heat-resistant, and moisture-proof, only Oaktron puts the aluminum voice coil form in *all* its speakers, to guarantee you speakers with long life and the ability to take the heat of full-rated power.

Moisture Resistant Speakers

Any catalog speaker can be supplied with a weather resistant treatment applied to the standard speaker. Add $1.00 to the unit cost.

Fire Retardant Speakers

Any catalog speaker can be supplied with a fire retardant treatment applied to the standard speaker. Add $1.50 to the unit cost.

Waterproof Speakers

Oaktron can provide totally immersion-proof speakers, with waterproof voice coil, cone, dust cap, and edge roll treatment. For details, contact your Oaktron sales location with your specs.

You've Heard Oaktron...

Over the past 25 years, you may have heard more Oaktron speakers than any other single brand–without knowing it. Oaktron has designed, built, and delivered speakers for most of the well-known manufacturers of audio products in the United States: Entertainment, architectural, automotive, and communications; you've heard Oaktron speakers in elevators, theaters, cars, and living rooms; from the Trucker's Channel to the Audiophile's cabinet. Oaktron has been there–and you liked what you heard.

Why Oaktron?

A full range of sound reasons:

All speaker-makers know *some* of Oaktron's qualities; but no one else offers *all* the points that Oaktron does.

- All Oaktron speakers have the high-power capacity aluminum voice coil form, the driving heart of the speaker, for greater efficiency and longer life.
- All Oaktron speakers are 100% tested in Quality Control, and then spotchecked again–and again.
- Oaktron carries a stock of over 185 popular models, ready to ship.
- Oaktron will build speakers to your specs, modify existing designs to your needs, and private-label for you–quickly and efficiently.
- Oaktron's main manufacturing plants are in the "Heartland" of mid-America; easy to reach, deal with, ship from, talk to–and understand.

Oaktron's Performance Warranty

All speakers in this catalog are guaranteed to perform within the parameters stated. In addition, we guarantee every speaker to match or surpass the actual performance of any other speaker of equal physical, electrical and acoustical characteristics when evaluated under identical conditions.

OAKTRON INDUSTRIES, INC.
700 30th Street,
Monroe, Wisconsin 53566
608/328-5560

National Sales
1000 30th Street
Monroe, Wisconsin 53566
608/328-5560

OEM Sales
9690 W. Allen St.
Rosemont, Illinois 60018
312/625-2742

Canadian Sales
Omnitronix, Ltd.
2056 S. Service Rd.
Trans Canada Hwy.
Dorval, P.Q. H9P 2N4
514/683-6993

Export Sales
E.D. Magnus & Assoc.
5717 N. Lincoln Avenue
Chicago, IL 60659
312/334-1502

SEE OAKTRON'S COMPLETE SPEAKER LINE IN CATALOG NO. C-81.

ALSO SEE CATALOG FAC-80 AND AEC-81 FOR OAKTRON'S "FINE ARTS COLLECTION" OF SPEAKER ENCLOSURES, EQUIPMENT CABINETS AND TABLES IN FINE FURNITURE STYLING.

over the frequency range 200 Hz to 6 kHz, at which points the response is 24 dB below the mid-band level; since the target function in the present case is of the fourth order (24 dB/octave), this means that the overall response of the filter and unit together has been controlled over a range extending about one octave above and below the nominal cut-off limits.

The same process of network design, applied to the filters for the high- and low-frequency units, likewise produces for each filter/unit combination an acoustic response that closely fits the corresponding target function over a frequency range extending well into the cut-off region. The three target functions, $T_L1(f)$, $T_M(f)$ and $T_H(f)$ have been individually designed so that the amplitude $|T_S(f)|$ of the total system response, shown in Figure 21 curve (a), is constant over the working frequency range; it will be seen that the measured response of the complete loudspeaker, plotted in curve (b), lies within ±2 dB of this target up to the cut-off point.

It has already been pointed out that for crossover systems other than the first order, the combined response of the two drive units concerned has the phase characteristic of an all-pass filter network. In the case of the three-way loudspeaker in the present example, there are two crossover regions, each giving an overall phase characteristic of the kind illustrated in Figure 17; these two characteristics combine to produce the phase/frequency function $Ø_S(f)$ for the complete three-way system. In Figure 21, curve (c) shows the calculated phase response $Ø_s(f)$ and curve (d) the corresponding characteristic measured on a production loudspeaker; it will be seen that the measured phase characteristic, like the measured amplitude characteristic, lies close to the calculated value.

This example of modern loudspeaker technology shows how a comprehensive system engineering approach to filter design leads to an end product the performance of which is predictable and controllable.

Conclusion

The overall performance of a multi-way loudspeaker system is dependent, to a degree not generally realized, on the precise design of its crossover filters; each of these has to be tailored to suit the acoustic and electrical characteristics of the associated drive unit, taking into account the effect of the enclosure and the tolerance of the power amplifier to departures from the nominal load. To avoid audible discontinuities in the response around crossover, the position of the individual units in relation to the listener and the way in which phase differences between their outputs affect the directional properties of the system have also to be considered. Neglect of these factors often leads to anomalous results, particularly in attempts at design by trial and error; for example, while a modification to the filter circuit may remove a discontinuity in the response as measured at some arbitrary point, the offending feature may then appear in the sound output at some other angle, and the subjective effect may be worse.

It will now be clear why the standard of reproduction potentially attainable with a modern high quality system cannot be realized with an assemblage of ready-made networks and drive units selected simply on the basis of their nominal frequency range, impedance and sensitivity ratings. Attempts have been made to ameliorate this situation by publishing descriptions of complete loudspeakers incorporating commercially available drive units, and giving circuit details of the filters to be used.

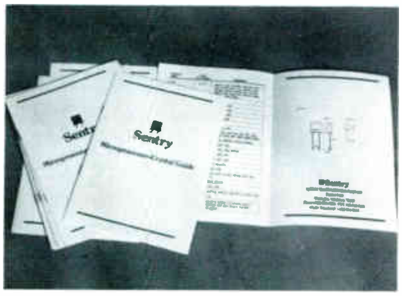
The success of such designs, however, depends on the extent to which the author has taken into account all the factors referred to and has been able to measure the electro-acoustic characteristics of each type of unit specified—allowing for manufacturing tolerances—before attempting to determine the appropriate network parameters.

On the other hand, those manufacturers who have good facilities for acoustic measurement are usually well aware of the various pitfalls in filter design, and by means of computerized data-handling methods are able to produce the components of a multi-way loudspeaker in matched sets. These techniques ensure that the end product—whether in the form of a kit for assembly in an enclosure of prescribed construction, or a complete system—represents the best combination of performance and cost-effectiveness that modern technology can provide.□

NEW LITERATURE

For free copies, write company names on the inquiry card.

MICROPROCESSOR CRYSTALS: A broad line of gold-plated crystals is shown in the Microprocessor Crystal Guide from Sentry Manufacturing Co., Chickasha,



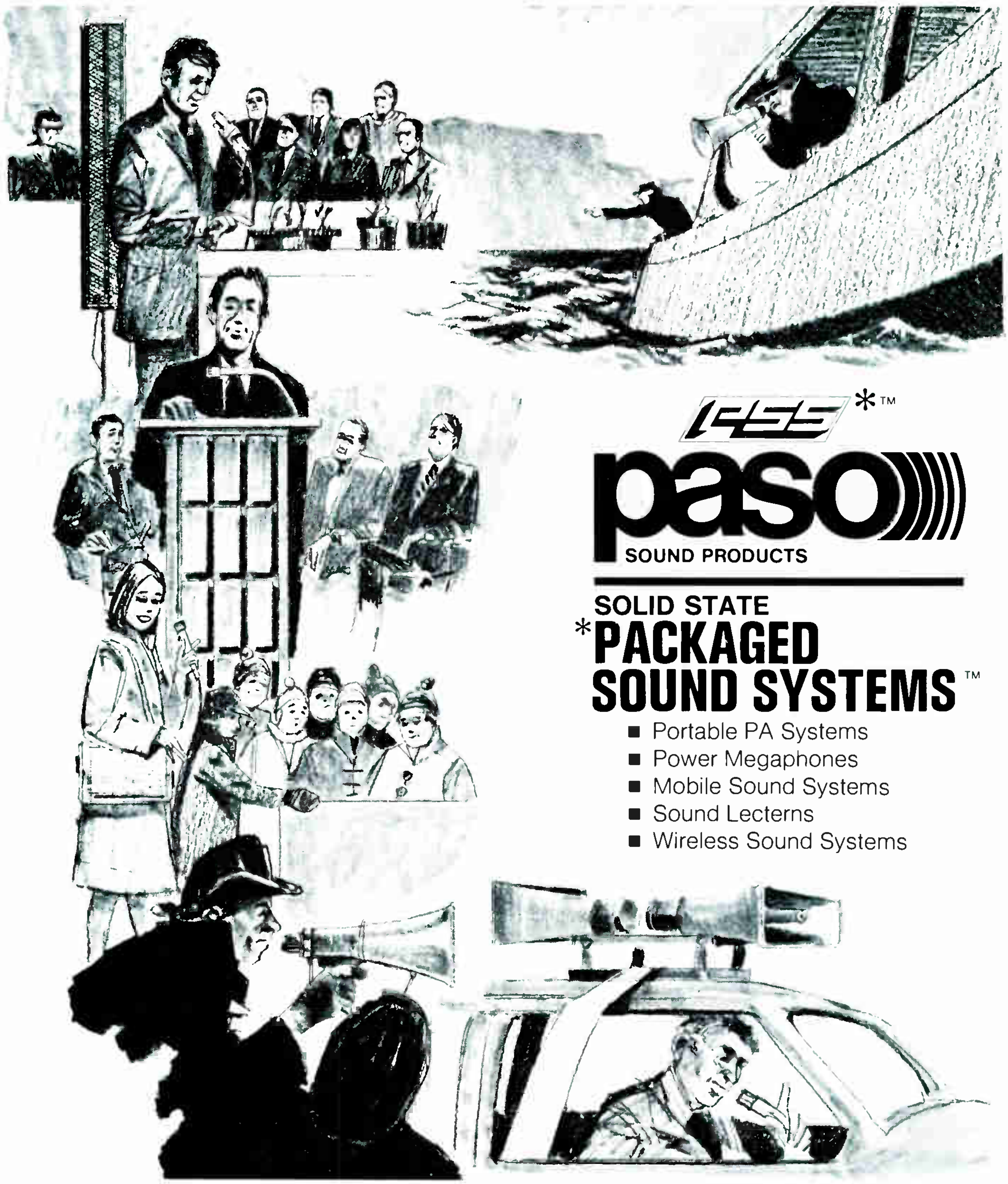
Oklahoma. Information on available frequencies and their applications is included; most special frequency requests can be complied with as well. Calibration tolerance is ±0.005% at 26°C; temperature tolerance is better than ±0.005% from −30 to +60°C. Sentry maintains a semi-finished crystal bank, along with complete correlation data, for emergency needs.

SOUND SYSTEMS: Designed for small or medium-sized applications, five new sound systems are discussed in a brochure from Argos Sound, Genoa, Ill. Each system includes an amplifier, a microphone and sound columns. Every system is defined in terms of audience size, sound projection distance, room configuration and type of sound desired.

PHONE SYSTEMS: Innovator II, which provides small business communications in a compact, modular package, is the subject of a data sheet from Tone Commander Systems, Inc., Redmond, Wash. The system facilitates call processing and inter-office communication; more than 30 standard features are offered. The modular design allows the setup to be adapted to the individual specifications of each installation, from 5 to 65 stations. Attractively packaged, the Innovator II is fitted for rack or wall mounting. The diagnostic circuitry uses light emitting diodes, visible through the translucent front panel, to indicate circuit packs in use. Housings are all pre-wired and 25-pair connectorized to expedite installation.

CONNECTORS: A 36-page booklet from Switchcraft, Inc., Chicago, describes many audio and general purpose connectors and AC receptacles. Full engineering specs, detailed drawings and mating charts showing connecting compatibility with similar products are included. Among the items are Tini "Q-G" miniature connectors and accessories; "Q-G" audio connectors, including a variety of panel and wall plate receptacles, adapters, inserts and accessories; "Slim-Line" audio connectors and accessories; various other microphone connectors, CB connectors and phono plugs and jacks, as well as AC receptacles for electrical/electronic applications.

INTERCONNECT: FCC-registered couplers for interfacing customer-premises equipment with telephone company facilities are explained in the Interconnect Guide by Pulsecom Division, Harvey Hubbell Inc., Falls Church, Va. The 12-page guide discusses several Universal Service Order Codes and all Loop Start/Ground Start combinations; it uses a USOC/Interconnect Arrangements matrix, definitions, diagrams and photographs. Also shown are rack-mounted assemblies and station packages for mounting the interconnect arrangements, as well as power supplies and ring generators that may be accommodated by the mounting arrangements.



NEW PRODUCTS

MOBILE AMPLIFIERS

Two battery-operated mobile amplifiers, the MA-20 and the MA-40, and the MU-1040 for battery or AC operation, offer weather-resistant splash-proof design, wide operating temperature range and rugged construction for public address systems in cars, emergency vehicles, tour buses, boats, sound trucks and amusement rides. Each amplifier provides for the use of two inputs, a low-impedance microphone and a high-impedance auxiliary unit, such as a cassette deck, at the same time.

Individual gain controls permit mixing the inputs as desired. For convenience, the inputs are located on the front panel. The MA-20, with twenty watts, and the MA-40 and MU-1040, with forty watts of output, will operate at full power with less than 5% distortion and a frequency response of 200-12,000 Hz ±2 dB for good intelligibility. These mobile units can be powered from any 12-16 VDC source with negative ground and have a quiescent current drain of a minimal 500 mA. When the MU-1040 is operating from AC, the quiescent drain drops to 300 mA at 120 VAC and 150 mA at 240 VAC, 50/60 Hz. A rear-panel terminal strip offers output impedances of 8 ohms and 16 ohms on the MA-20 and MA-40, as well as 125 ohms (70 volts) on the MU-1040. The 16-ohm output on the MA-40 and MU-1040 also can feed a 25-volt system. Quick, flexible installation in mobile and portable applications are designed into the units. The MA-20 and MA-40 have a U-type adjustable bracket with thumbscrews for easy mounting and removal or repositioning under a dashboard or on any other convenient surface. All three amplifiers also can be used as self-standing units. Protection against output shorting, thermal overload and reversed polarity, and the ability to operate within a −22° to +149°F. temperature range, increase dependability under extreme conditions.

☐ For more information write 911 on the inquiry card. Or write: Bogen, div. of Lear Siegler, Inc., P.O. Box 500, Paramus, N.J. 07652.

WALKIE-TALKIE

Model T-355 is a 6-channel, 5-watt 27-MHz hand-held transceiver for use on any of the 40-channel CB frequencies. It includes a carrying case: an S/RF meter, a battery monitor meter, a switchable 1-watt—5-watt battery saver, a belt clip and a hi-lo mike gain control. It operates on eight alkaline "AA" penlight cells or 10 nickel cadmium batteries.

Model T-352 is a 3-channel, 2-watt unit with all the same features as the more powerful T-355. Both units have accessory 12-VDC cigarette lighter adaptors, with battery charger/AC power supplies available.

☐ For more information write 912 on the inquiry card. Or write: Fanon/Courier Corp., 990 S. Fair Oaks Ave., Pasadena, Cal. 91105.

TESTER

The Tracer, Model 77M, is an I & R tone test set equipped with a modular connector in addition to two test leads. It sends tone, checks continuity, indicates line condition, determines AC/DC voltages, supplies "talk power," verifies lines and approximates resistance. The LED indicates Tip and Ring polarity.

☐ For more information write 913 on the inquiry card. Or write: Progressive Electronics Inc., Mesa, Ariz. 85201.

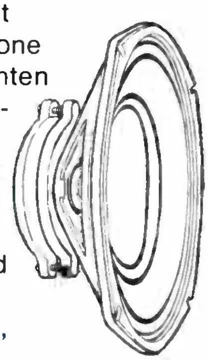
MIC STAND

The UMS 105 floor stand is especially lightweight and folds easily. Its five-point collapsible base does away with the need to carry a heavy, detached base. The bright chrome stem assembly is adjustable from 34 to 62 inches in height. Smooth clutch action permits pressure position with no-slip locking. Compatible booms, microphones and accessories are available.

☐ For more information write 914 on the inquiry card. Or write: University Sound, 10500 West Reno Ave., Oklahoma City, Okl. 93126.

WHAT DO FARMERS AND BURGLARS HAVE IN COMMON?

They both listen to Quam speakers.



Quam makes a speaker to meet any application. From tractor radio replacement speakers for the farmer, to single tone speakers for security alarms to frighten burglars and alert police, and everything in between.

If there's a speaker application, Quam has the unit for it...or can make one. There are 127 different units listed in our catalog; and carried in stock for immediate delivery. These include sound system speakers, high impedance intercom units, outdoor and weatherproofed models, and line matching transformers.

Naturally we don't expect you to be interested in every Quam speaker item...we know that sound contractors don't do many tractor radio installations. But we do think you'll be interested in the exceptional quality... and quality control...that are part of Quam's method of operation. No guess work...no costly testing time or call-back problems. No matter what Quam speaker you choose you'll know its power ratings are established in accordance with the new EIA RS-426 Standard for Loudspeaker Power Ratings. And you'll know there's a Quam representative close by, knowledgeable and helpful. Ask him about our customized engineering service.

Don't let the lack of such services burgle away your profits. Choose from the rich crop of Quam speakers.

Quam:
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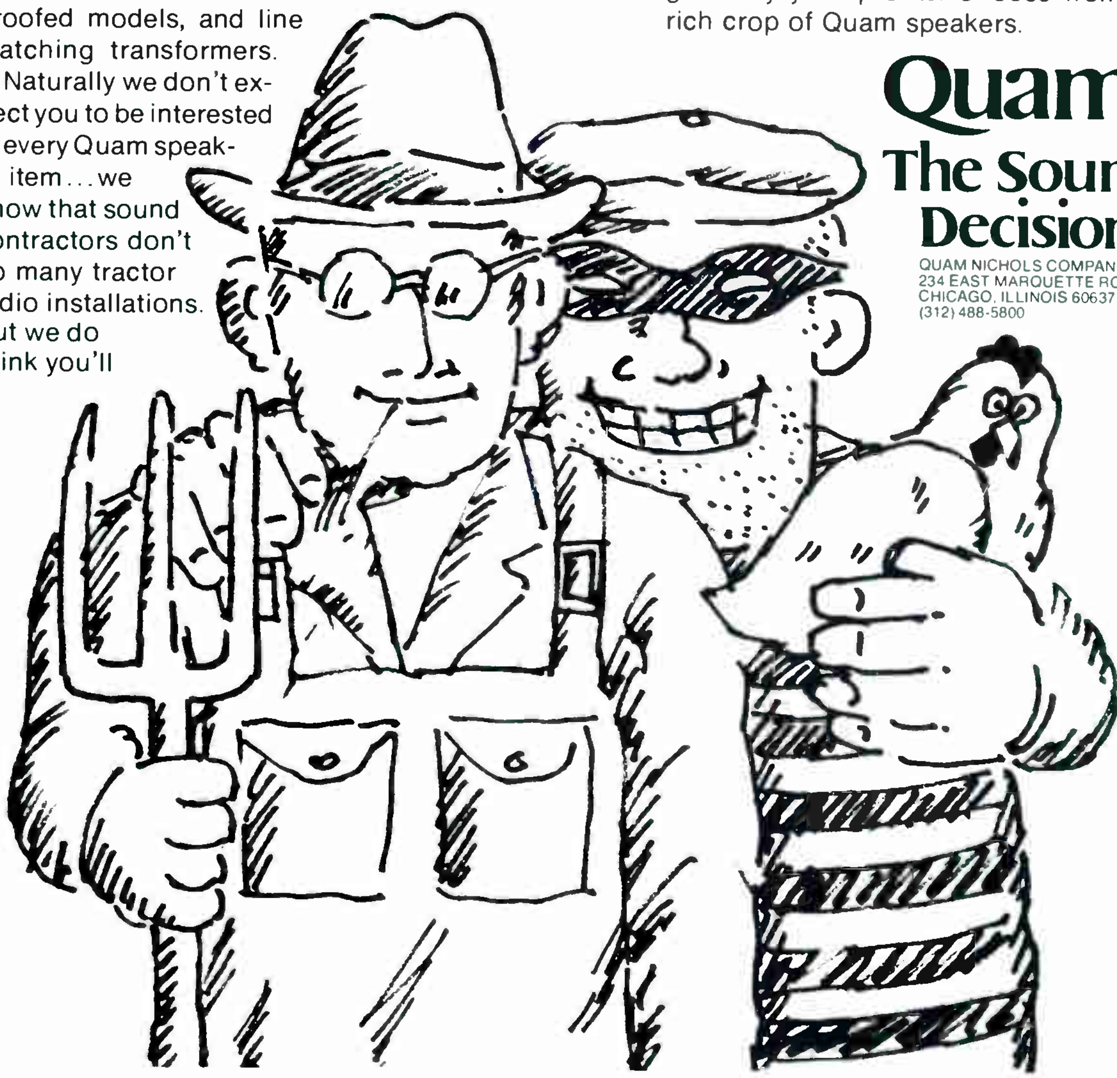


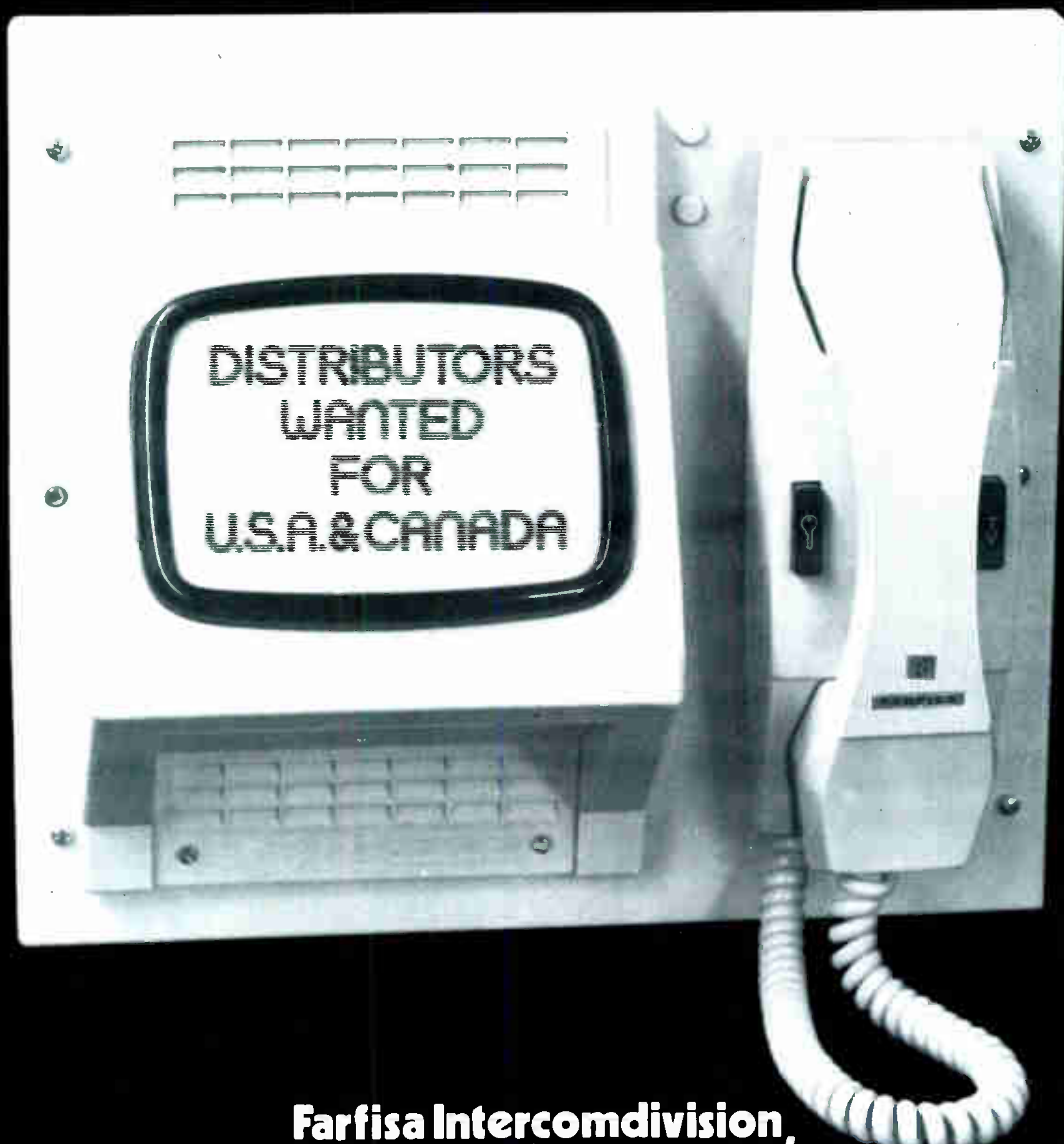
SOUND SYSTEM

Suitable for operation by non-technical personnel, yet able to meet sophisticated reinforcement demands, the Pro Master sound system is an economical, monophonic setup. Incorporating a power console and two speaker systems, it is particularly suited for small clubs, schools and churches. The console has a 200-watt amplifier, a 10-band combining-type graphic equalizer for feedback reduction and sound quality adjustment, a "Feedback Finder" that uses LEDs over the equalizer to indicate frequencies causing feedback, and an innovative "Patch Block" panel that is a block diagram of the internal console circuitry incorporating eight patching jacks located at appropriate points right on the diagram. On the front of the console are eight input channels: six high and/or balanced low-impedance microphone inputs, plus two auxiliary inputs. The balanced low impedance inputs are transformer-coupled, and have a built-in 24-volt simplex power supply for professional condenser microphones. There are outputs for loudspeakers, effects devices, tape monitors and headphones, plus a low-impedance, balanced microphone-level output that allows the console to "feed" a house system to achieve maximum gain without feedback. A separate complete monitor mixer for either stage monitoring or

for a separate "broadcast feed" is also supplied. The console is protected against damage from open or short-circuits on inputs or outputs and against heat damage by a highly efficient cooling fan and automatic thermal shutdown circuit. The console is totally shielded, and each input and output is protected against radio-frequency interference and line noise. The electronics are housed in a rugged but lightweight enclosure. The speaker system consists of a 15-inch woofer in a front-ported bass reflex cabinet and three piezo-electric horns, which disperse sound at an exceptionally wide angle, with clarity and intelligibility.

The 709 is designed to operate with an amplifier capable of delivering 150 watts continuous to an 8-ohm load. The 8-ohm system produces 98 dB SPL (sound pressure level) at 1 meter with one watt of EIA shaped noise input. The plywood cabinet is covered in scuff-resistant black vinyl. The black fabric grille is rugged, cleanable, and replaceable. Corners of the cabinet are covered by steel protectors.

☐ For more information write 915 on the inquiry card. Or write: Shure Brothers Inc., 222 Hartrey Ave., Evanston, Ill. 60204.



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Farfisa, known throughout the world for the quality of its musical instruments, has for several years now been diversifying its production dedicating itself to the field of closed circuit telephone systems. Its profound knowledge in the field of electronic music and high level of personnel specialization have contributed to the rapid affirmation of Farfisa in the fields of intercommunication and electronic door-answering systems.

All items are entirely produced in its own factories, including the receiver and transmitter capsules, renowned as beeing among the best in the market, and the videophones. In this field too, Farfisa production is present in many countries in which it is acknowledged for its very high standards of quality.

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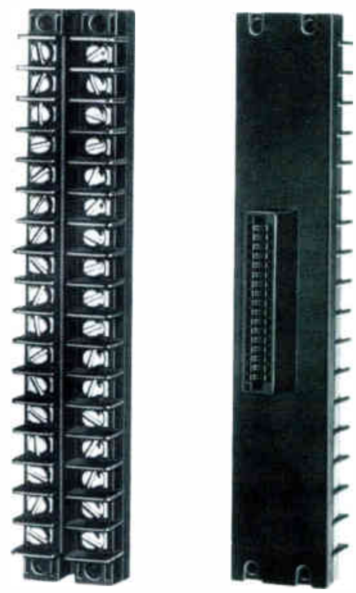
CABLE CORER

A cable coring tool, designed to end splicing problems, has a special blade design which prevents dielectric jam-up. Foam falls free in a neat spiral, so coring can be accomplished in one cut. The blade design also prevents flaring of the conductor; since no stress is placed on the cable when removing it from the tool, premature cable failure is eliminated. The tool is lightweight; the one-piece, fully-insulated handle is cast aluminum. The blade is carbon steel. Overall size is about half that of typical coring tools. T-handle and cylindrical styles are available, each in six, color-coded diameters. The tools may be ordered with a special cutter extension for power use.

☐ For more information write 916 on the inquiry card. Or write: Lemco Tool Corp., RD 2, Box 330A, Cogan Station, PA. 17728.

INTERFACERS

Type 10 and Type 12 Mag-Master interface devices offer economical, efficient interconnect of field wiring with electrical and electro-mechanical circuits, equipment and systems. The devices have two rows of terminal strips on one side and an edge card connector on the other, connected directly through. The Mag-Master features a variety of circuits and quickly plugs into mating edge card terminations. Screw terminations are then made quickly and easily to any field wiring desired.



The Type 10 Mag-Master interface devices offer a choice of 20, 30, 34 and 36 circuits on .100 x .200-in. edge card centers. Screw connections are on .325-in centers. The Type 12 devices have 20, 24, 30 or 36 circuits on .156 x .200-in. edge card centers. Screw connections are on .325-in. centers. Both devices have bright tin-coated terminal screws of 70/30 cartridge brass which accept AWG 14 and smaller wiring, or .250-in. wide wire lugs. Terminal strips are rated 3 A, 150 V and are molded of fire retardant nylon 94V-0.

☐ For more information write 917 on the inquiry card. Or write: Magnum Electric Corp., 6385 Dixie Highway, Erie, MI 48133.

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QSC Audio Products are designed and built to earn a living, day after day, without fail. Each QSC unit is a blend of unique circuitry and solid engineering.

We offer eight stereo power amps from 40 to 325 watts per channel. Add to that our stereo electronic crossover and a 90 watt monaural amplifier and you've got one hard-working line-up.

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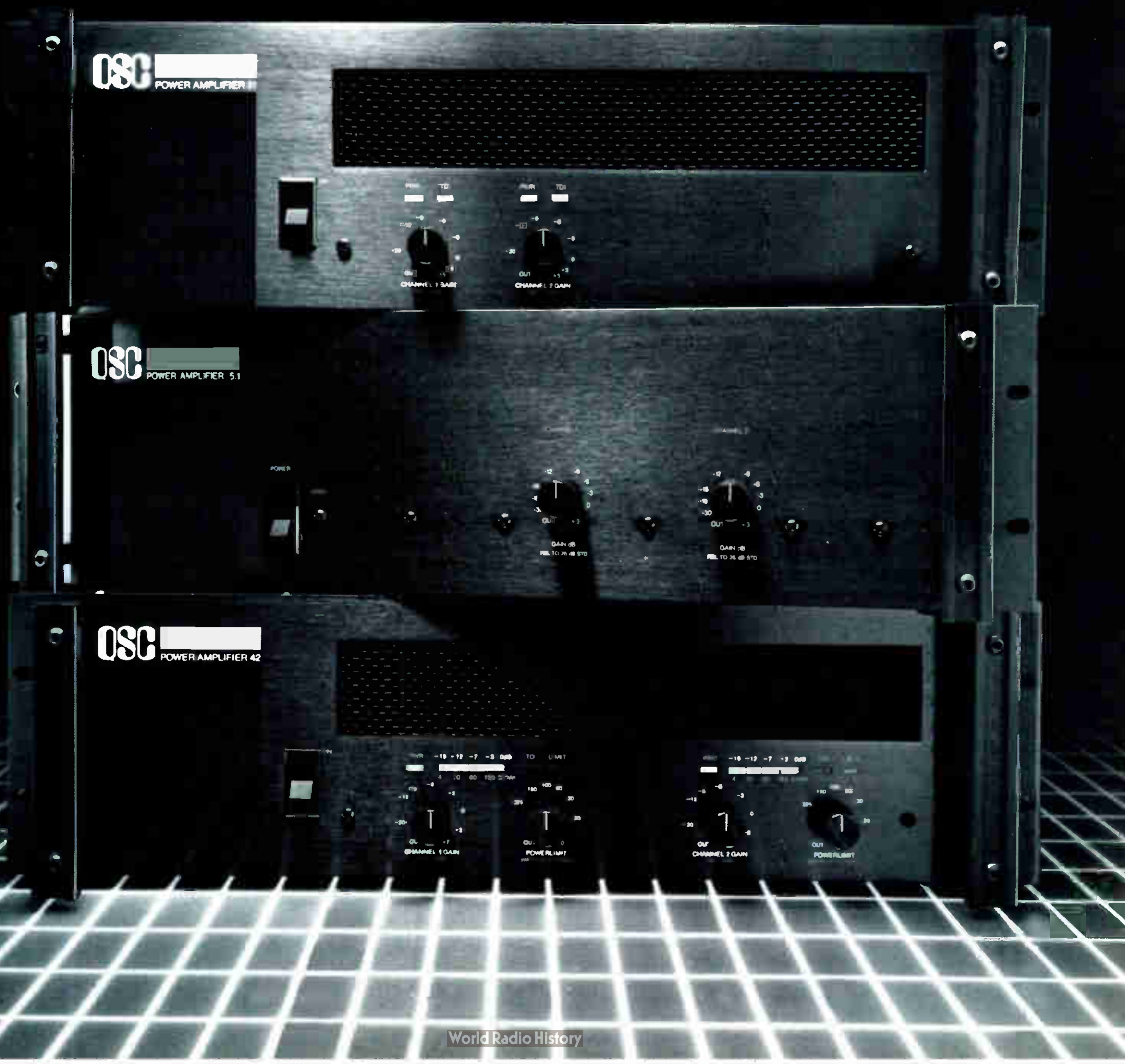
QSC AUDIO PRODUCTS



LEVEL CONTROLLER

An automatic level controller, Model LR-1009, automatically adjusts the level of background music or a page announcement, depending on the changing level of extraneous noise in the area. The rectified and integrated sensing signal provides AGC voltage for the two independent adjustable attack and release functions. A dual-mode function switch provides continuous expansion adjustment during paging or can "freeze" the gain setting during the page announcement. The unit operates on 120 volts 50/60 Hz or 24 volts DC.

☐ For more information write 918 on the inquiry card. Or write: McMartin Industries Inc., 4500 S. 76th St., Omaha, Neb. 68127.

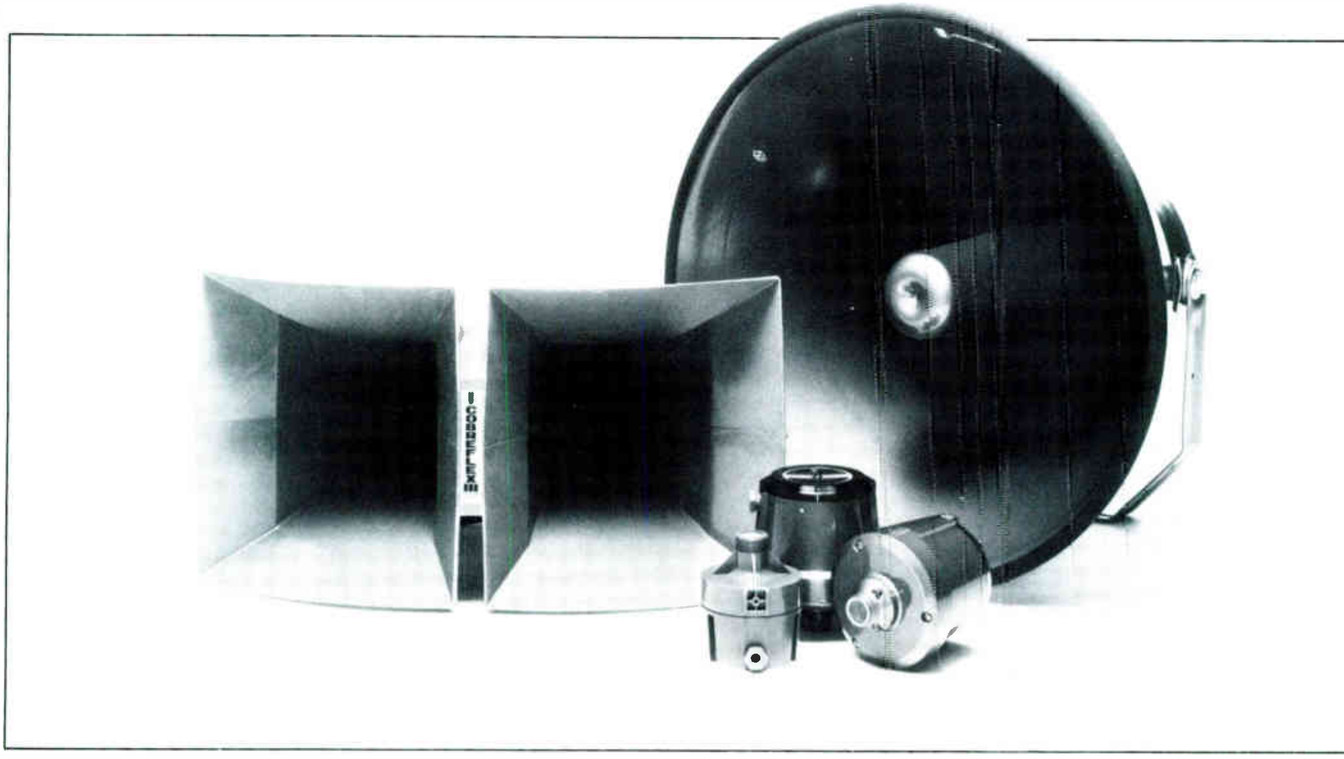
DIGITAL REVERB SYSTEM

Model 8X32 produces a wide range of natural and artificial reverberation effects suitable for studio, broadcast, live performance, and other applications where clean, high-quality sound is important. The microprocessor-based front panel has separate LED read-out and control for each adjustable reverberation parameter. These displays and controls make the 8X32 a "friendly" system to operate, despite its sophistication. It features a bank of 32 non-volatile storage registers (retaining their contents even when the power is turned off) that allow users to store and recall 32 complete reverb setups, and to edit them at will. Four basic programs are available with the 8X32, ranging from a small, fast-diffusing "Plate" to a large, echoing "Space" simulation.

Within each of these programs, 16 decay times can be selected (0.2 seconds—19.9 seconds, depending on program), and the level (8 steps) and delay time (approx. 6—9mS in 16 steps) of both the early reflection pattern and the initial reverberation may be independently controlled. LF and HF decay can also be individually trimmed (4 values each). Two unique controls, "Input Mute" and "Reverb Clear," provide especially useful effects for performing artists. The system has a bandwidth of 8 kHz and a dynamic range of 80 dB. The 8X32 is a compact, rack-mountable unit measuring 3½" high, 19" wide, and 10" deep. Controls and displays are available on the front panel or in a remote unit suitable for use on consoles, or both.

☐ For more information write 919 on the inquiry card. Or write: Ursa Major, Inc., Box 18, Belmont, Mass. 02178.

There is a Difference
Horns and Drivers are not all alike



University Sound proves it with new concepts for today's market

Whether designing a new sound system or updating an old one, our new one-inch throat horns and drivers are your natural choice.

Their larger voice coils and diaphragms work harder and longer. The new ID40C and ID60C one-inch throat drivers (8 ohm and transformer models) have screw-driver selectable taps for both wattage and 25/70 volt selection. They are completely sealed for protection from any environment and have a built-in BX connector. Covered with an acrylic finish which will not crack or chalk, they are easily and quickly field serviced. The new medium powered 30-watt drivers (ID30C8, ID30C16, and ID30CT) feature one-inch throats and are adaptable to all University Sound horns.

Of critical importance in updating an existing system is the compatibility of all one-inch throat units with the older three-quarter-inch models. Matched with all the new one-inch throat LH-1 and COBREFLEX® III horns, you will have increased efficiency and reduced distortion.

This horn and driver combination has a predictable response over a controlled dispersion angle. A first in the Commercial Sound field!

The COBREFLEX III ensures a flat response over 100-degrees horizontal in the speech range with excellent available response both above and below. Where narrow, controlled dispersion is a design factor, the LH-1 is a true 40-degree horn for use in short, medium, and long throw applications. The response is flat throughout the speech range but has usable response from 100 to 20,000 cycles.

Both horns are available with completely documented specifications. What you design is what you get.

For further information see your University Sound representative or write direct to:

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ALTEC CORPORATION

EPABX Spells Versatility

by **Arthur F. Donovan**

The GTE-60 EPABX was created to fill the need for a modern system with a capacity between that of a key telephone system and a PABX. This GTE-60 EPABX provides the relatively small PABX user with a large range of features formerly available only with larger systems, by economically incorporating the advantages of stored program control, electronic switching and LSI technology.

The GTE-60 EPABX is made and marketed by GTE Automatic Electric to the public carriers, from Northlake, Ill.

GTE Business Communications Systems, Clearwater, Fla., is offering the GTE-60 EPABX to the interconnect marketers.

The GTE-60 EPABX is a stored program switching system using a 16-bit microprocessor as the central processor unit. Switching between stations, trunks, DTMF circuits and tone generators is by means of time division multiplexed Pulse Amplitude Modulation (PAM) techniques. Audio signals to be transmitted are sampled at a rate high enough to ensure fidelity. A change corresponding to the instantaneous amplitude of the analog signal is impressed upon the PAM highway in synchronism with the enabling of the receiver circuit of the destination. On the receiving end the charges are stored, thus restoring the analog nature of the original transmission.

A fully equipped system, consisting of 60 stations and 16 trunks, is contained in a wall-mounted cabinet 18″ high by 38″ wide by 12″ deep. A separate, stylish, low profile attendant's console is provided to assist call processing. In addition, a portable System Test Unit (STU) is available as an ancillary device for programming and maintenance.

The attendant's console consists of a cabinet, keyboard assembly and four plug-in PWBs. The console power supply receives unregulated DC voltage via the connecting cable and provides the fixed, regulated voltage required by the console. These voltages are therefore independent of cable length.

A self-scan type keyboard circuit serves all keys, including the keypad. An oscillator activates the scan circuit. Debouncing, and errors due to simultaneous key depressing, are eliminated. The keypad is touch-type but not DTMF (Dual Tone Multifrequency). All the keys necessary for attendant control (camp-on, page queue, night-service, etc.) are arranged for attendant convenience.

The console registers receive information from the Central Processor

Mr. Donovan joined the GTE Automatic Electric Laboratories in 1974, and is currently a senior marketing engineer in the product evaluation group of the supply division of GTE Automatic Electric Inc.

Unit (CPU) to control the displays to be activated.

The display control unit contains the driver circuits to turn on appropriate LEDs and display segments. The console display unit contains the 76 station/trunk busy LEDs, the alphanumeric class display (NO, ANS, LD, RES, etc.), and the seven-segment station number, trunk number and trunk group numbers.

Configuration Control

The GTE-60 EPABX is comprised of three major equipment groupings including:

- the basic stock package
- the System Test Unit (STU), and
- a series of optional cards designed to provide special service features.

The basic stock package is comprised of five groups of hardware: a cabinet assembly including I/O cards, control cards, and a DBU (Data Base Unit); a power supply; three 8-station cards; two 2-trunk cards; and a console unit with handset. The issue number of the basic stock package will always be at least as high as, or higher, than the highest issue number of any of these five hardware groups. That is, should a change in the power supply cause its issue number to be advanced by one number, the issue number of the basic stock package is also advanced by one. Or, if the issue of the console advances from issue three to issue four, the issue number of the basic stock package also advances. The same concept applies to the other two major equipment groupings. However, a change in issue of the basic stock package will not affect the issues of the STU, or the optional cards. Likewise, changes in issue of any of these equipment groupings will not affect the issue number of the basic stock package.

An advancement of the issue number of any hardware group can come about as the result of a change in component, card layout, or circuit design, as well as a change in generic program. An advancement of the basic stock package issue number may reflect more than one simultaneous hardware change, together with a change in the generic program. An advancement of the issue number of the basic stock package can also come about as the result of adding a new feature in the generic program, although no associated hardware changes are involved.

Features of the GTE-60 EPABX.

System related features

AC powered (standard)
DC powered (optional)
CO trunks—loop/ground start
Predetermined night answer
Universal night answer
Combined night answer
Zoned night answer
Day/night class of service
Direct-in trunks
E&M tie lines
Four trunk groups
Immediate/distinctive ring
Ten classes of service
Intercept
Line lockout
Music on hold
Toll call restriction
Power fail transfer
Self diagnostics
First digit timeout option

Station related features

Call forwarding
Dial call pick-up
Dictation access
Direct outward dialing
Executive override
Hotline to attendant
Meet-me conference
Paging access

Station related features (cont'd.)

Speed calling
Speed call toll barrier override
Camp-on to busy station or trunk
Station controlled transfer
Consultation/3-way conference
Hunting groups
DTMF dialing
Trunk call queuing
Data line security

Attendant related features

5-way conference control
Single trunk blocking
Trunk group blocking
Timed recall—hold
Timed recall—no answer/busy
Break-in
Call splitting
Multiple camp-on
Direct trunk access
Extension of incoming calls
Extension of information calls
PNA destination changes
Page queue
Series calling
Paging access
Pushbutton dialing
Trunk number display
Class of call display
Station/trunk busy display

GTE 60 EPABX Software

The software is organized in a structure that yields clear, easily understandable and maintainable program, yet the generic program is as short as possible in order to save memory.

The program is organized around a supervisor routine, which eliminates need for interrupts in most cases. This routine performs the "housekeeping" of the CPU (central processor unit), determining its order of jobs. These jobs are organized in decreasing priority, where priority is determined in terms of processing urgency.

The highest priority job is to perform scanning of stations' and trunks' E wires, which carry all line activity information within the system. The same job interrogates the attendant's keyboard and DTMF (Dual Tone Multifrequency) receivers. The scan is carried out periodically approximately each 12.6 ms, ensuring dense sampling for dial pulses. Information reading is performed on an 8-bit word basis. Thus, for example, 8-stations are interrogated simultaneously. This job resolves on-hook, off-hook, end-of-digit, etc., conditions, and creates proper jobs for further treatment. These jobs are placed in queues A and B according to their priority, in which final call processing occurs. Entering a queue job, the program performs processing of one item in the queue and reverts to the supervisor. No internal priority within these queues is provided, and each queue is treated on a first in, first out basis.

Each routine within the jobs is limited to three milliseconds (ms) of processing time. In case of long routines, these are split into functional subroutines, thus preserving the principle of returning to the supervisor in less than three ms. This method eliminates the use of interrupts, and yields flexible and modular programs.

Since the job with the highest priority appears every 12.6 ms, the time between scans is sufficient for three to five processing routines, the probability of postponing a low priority item is very low, and all delay objectives stated in the guidelines are easily met.

The CPU test circuit which continuously supervises the CPU, is based on the software structure described above. The circuit tests the cycling of the program between the supervisor and jobs, and checks return to supervisor within three ms. In case of malfunction, alarm interrupt occurs, CPU is cleared and program initialization takes place (existing calls are not disturbed.) Periodic appearance of alarm interrupt causes major alarm power fail condition.

Diagnostic Routines

The software controlled diagnostic routine is a 16-segment test procedure performed by the system's generic program. This procedure tests most of the control functions of the EPABX.

The diagnostic routine is the lowest priority job the program will perform. Thus, there is no influence on the capability of the CPU to handle calls.

Each time there is no higher priority to be done, the supervisor of the generic program will instruct the CPU to perform one segment of the diagnostic routine. Once this is done, no more segments will be performed until the next scan job. In other words, only one segment is performed in each scan cycle of 12.6 ms—if the CPU is available to the diagnostics. Each segment, like other jobs, takes no more than three ms.

A complete cycle of all 16 segments is called a diagnostic frame. One frame takes at least 201.6 ms (in moderate traffic conditions). Statistically, the probability that a frame will take longer than 300 ms is very low. The philosophy of resolution, whether a detected fault is a momentary misbehavior, or a permanent fault, is based in most tests on getting two consecutive fault indications. Consecutive tests are separated by one full frame, and that provides time diversity in tests.

Test includes: CPU self diagnostics, system memory tests (all type of memories), I/O test, control memory diagnostics, console test, etc., thus virtually all common control functions of the system are tested. Test results are reported to alarm circuits.

The GTE-60 EPABX, with an expansion of PABX versatility and corresponding memory, can amply serve the requirements of hotel/motel communications services.

HISTORY . . .

WANLASS is a name that has stood for quality, inventiveness and service in the electronics industry for over 20 years. Our past achievements have been in the areas of power conditioning, communications and sound. We have the experience necessary to offer the highest quality product as well as the service you deserve.

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Data Exchange Through Coaxial Cable

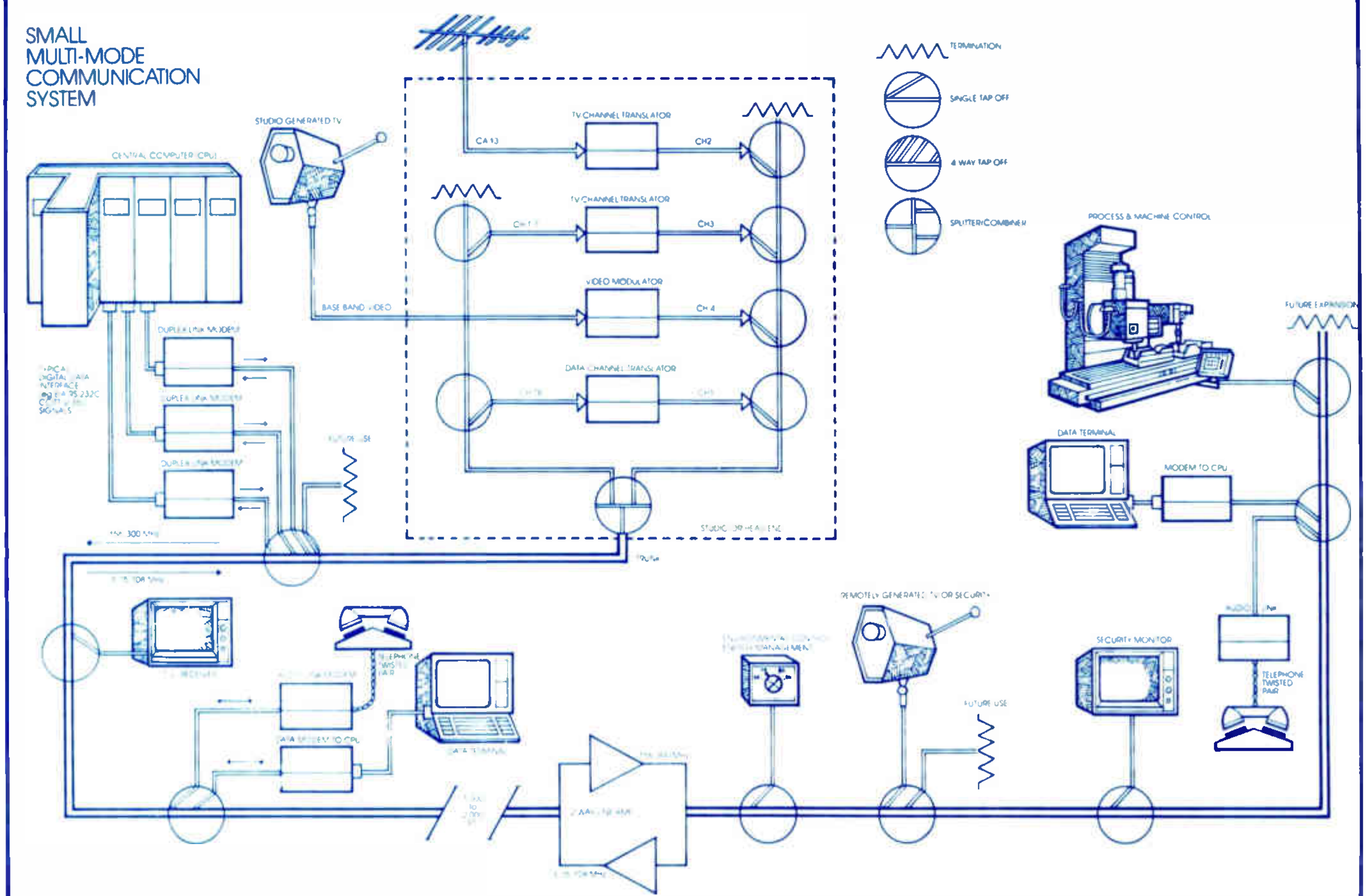
Data. It's collected, evaluated, processed, transmitted. It's something we will hear more and more about in the 80s—a decade that will witness the growth of the electronic office, of distributed data processing, of computerized assembly lines, of video conferences, of communications even more sophisticated than the current state-of-the-art.

The internal communications and informational needs of most companies are already expanding at a rapid pace. So a communications system or network that proves satisfactory today may not be compatible with a company's future needs. It may fast become outmoded or need to be expanded in just six months or a year.

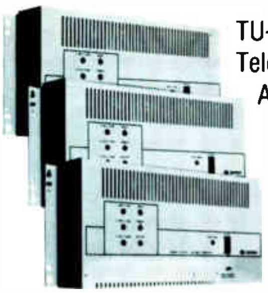
"Snake Farms" of Wires

Until now, the task of meeting these growing needs was becoming increasingly complex. Since data (in the form of digital information) is normally transmitted from remote terminals to a central or host computer over twisted pairs of wires, every time another data point is added, so is another pair of wires. Plants soon become "snake farms" of wires. As a result, not only the installation, but also the maintenance of these thousands of wires becomes a virtual nightmare.

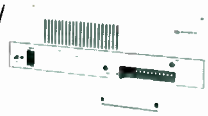
Twisted pairs of telephone wire, moreover, were not originally designed to carry digital data. Rather they were meant to transmit such analog information as the human voice. As a result, the transmission of digital data on these wires can prove troublesome. A user, for example, might encounter problems due



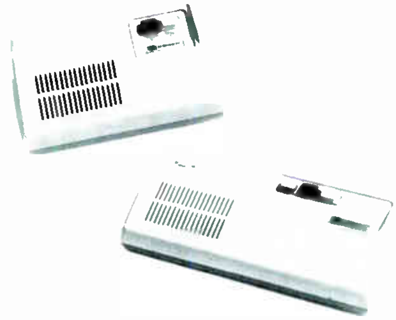
A typical DAX data-exchange network utilizing broadband coaxial cable.



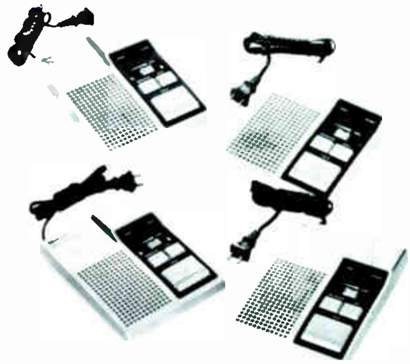
TU-A Series Telephone Paging Amplifiers



TBA-20 Paging/ Talkback Amplifier



IE-2S Two-Station Intercom System



WI-1 and WI-3 One-Channel and Three-Channel Wireless Intercoms

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The sound market doesn't stand still. To help you serve today's customers, Bogen has introduced all these new products, and more, in just the past year.

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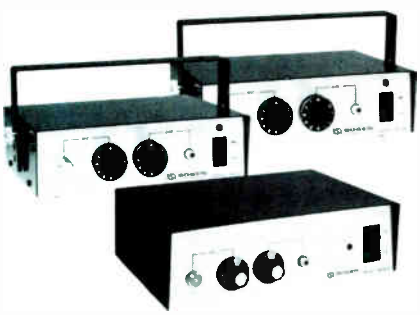
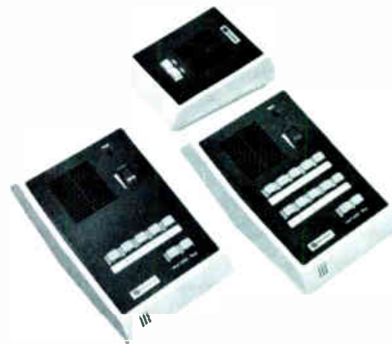
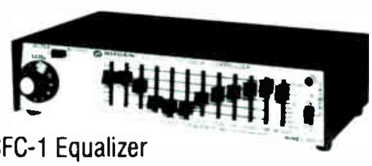


MA-20, MA-40 Mobile Amplifiers and MU-1040 AC/DC Amplifier



IE Series Five-Button and Ten-Button Masters, RE-1 Remote

CDM Six-Channel Mixer-Preamplifier



CFC-1 Equalizer

TG-4A Multiple Tone Generator

VIM Series Five-Button and Ten-Button Masters, VIR-1 and VIR-2 Remotes

PI-10 Power Intercom and PIR-1 Remote

TIS Series Telephone Intercoms

TIM Series Telephone Intercoms

Attending EDS 1981? Come see us in Atlanta Hilton Suite 1208.

to interference from power lines, fluorescent lights or other external noise sources.

Coaxial Cable: The Alternative

Now there is an alternative to traditional wiring or twisted pairs—broadband coaxial cable. This single, two-conductor cable can replace hundreds or even thousands of twisted wire pairs. It can literally carry hundreds of data channels simultaneously. And any number of peripherals can be linked with just a single continuous run of that cable.

Coaxial cable consists of a center copper-clad aluminum conductor surrounded by a polyethylene or phlystyrene dielectric. The dielectric is, in turn, surrounded by a semi-rigid aluminum sheath which serves as an outer conductor and which shields the center conductor from electrical interference. A polyvinyl jacket protects the entire coax cable from the environment.

Originally developed by the cable television industry, coaxial cable offers a multitude of advantages over conventional wiring. First, it requires considerably less space to carry as much (or more) information in the same (or shorter) period of time. And since coax is fully shielded from interference by its solid outer conductor, it has considerably higher immunity to electrical noise than does standard wiring.

Installation and maintenance of coax is easier than wire, too. Wires must be placed inside rigid conduits to support them over long spans, to protect them against the elements and to conform to fire and safety regulations. Repair of damaged wiring is time-consuming, requiring cutting through conduits to reach the damaged wires. But coaxial cable, with its semi-rigid aluminum sheath, can be strung without need for conduits. For this reason, installation costs are much lower with cable. Where standard wiring can cost as much as $7 to $15 per foot to be installed, cable installs for less than $2.) And repairs are simplified.

System Expansion Simplified

Broadband coax takes the headaches out of system expansion. Once the cable is installed, expansion or modification of a company's network configuration is an easy matter. New data sources are added by simply tapping into the cable. These taps, or directional couplers, are installed by cutting the cable and inserting the tap—without cutting through conduits. And they can be placed anywhere along the cable with no effect on the integrity of the system. Since coax eliminates the need to run wires back from the source to the central point of a system, the only new wires required would be a few feet of drop line connecting new equipment to the coax network.

Putting Coax to Work

In light of the advantages just cited, it is clear that coaxial cable is well suited to industrial data-collection/transmission systems. However, in order to get digital or analog data on and off the cable and to and from data sources and central computers, it is necessary to use a cable interface module or modem. A modem (modulator/demodulator) transmits and receives analog or digital data. It superimposes information onto a particular radio frequency (RF) carrier signal which is subsequently transmitted along the cable.

The data-handling capacity of broadband cable can be expanded through two techniques—frequency division multiplexing (FDM) and time division multiplexing (TDM). With FDM, each data source is assigned its own non-interfering RF

Amdax's "Local Network Starter Kit," including the hardware needed to start an in-house coaxial cable network. Shown are a channel translator, two data exchange interface units, two directional couplers and 100 feet of broadband coaxial cable.

signal in which to transmit information. This means that a single broadband coaxial cable can handle simultaneously more than 500 individual sources of data, (data channels) or 50 TV channels. Additionally, TDM allocates a portion of time on each of the above frequencies to a particular data source. This makes it possible to extend a cable's capabilities to thousands of data sources. Data rates to several megabaud, in fact, are possible.

RF Married to Digital Technology

Coincident with the realization of broadband coaxial cable's potential for data transmission was the discovery by researchers at Amdax Corporation (Bohemia, N.Y.) of a way to interface and "marry" RF with digital technology. Until now, this area has been neglected, mainly because today's electronics engineers are weaned on, and therefore focus their expertise on, digital and analog aspects of electronics. Their background in RF is limited. In fact, researchers and engineers with extensive experience in RF signal processing tend to be a rare commodity.

Amdax is now also producing the hardware that is required to tap the benefits of broadband coaxial cable signal transmission—devices such as channelizers, and a variety of data-exchange interface modems (DAXs) that allow a wide array of data sources to plug into a user's coax network.

The system resulting from the joining of Amdax units and coaxial cable is not constrained by existing network protocols, being transparent to a vast variety of network channels. Because of this, it can handle hundreds of data channels simultaneously, as well as transmit data at extremely high speeds. In fact, a single broadband coaxial cable can support data rates ranging from 150 to 19,200 baud with the same DAX. Currently, the highest speed DAX provides rates of 50,000 to 56,000 baud.

With electronic data communications expanding and growing at the rapid pace it is, data exchange through coaxial cable stands to become an integral element in business offices and industrial plants—the wave of the future, in fact. □

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THE SOCIETIES PAGE

Electronic Industry Show Corporation reports that nearly 250 manufacturers will participate in this year's Electronic Distribution Show, to take place in Atlanta on May 5, 6 and 7.

The Show will be preceded by an all-day "Outlook on Distribution" presented on Monday, May 4, by the National Electronic Distributors Association, with the cooperation of Electronic Business Magazine. NEDA will also sponsor distributor management and marketing seminars on each Show day, from 8:00 to 9:30 AM. A special session on the future of semiconductor distribution has been announced for Wednesday afternoon.

The Young Tigers Growl, the traditional Show opener, will be held on May 4th, at the Hyatt Regency, and will feature a southern style buffet. The Electronic-VIP Club will host a party in the park on May 5th, at Georgia Park Plaza.

The Show Corporation has announced that two newcomers have

Carroll

been nominated to fill upcoming vacancies on its Board of Directors. They are Paul Carroll, president of Semiconductor Specialists, Inc., Chicago, and William Harding, of the rep firm Electronic Sales, Inc., Dayton, Ohio. Carroll will fill the seat being vacated by Lewis Shuler, Dixie Electronics, Columbia, S.C., current president of the Show board. Harding will take over for Jess Spoonts, J.Y. Schoonmaker

Harding

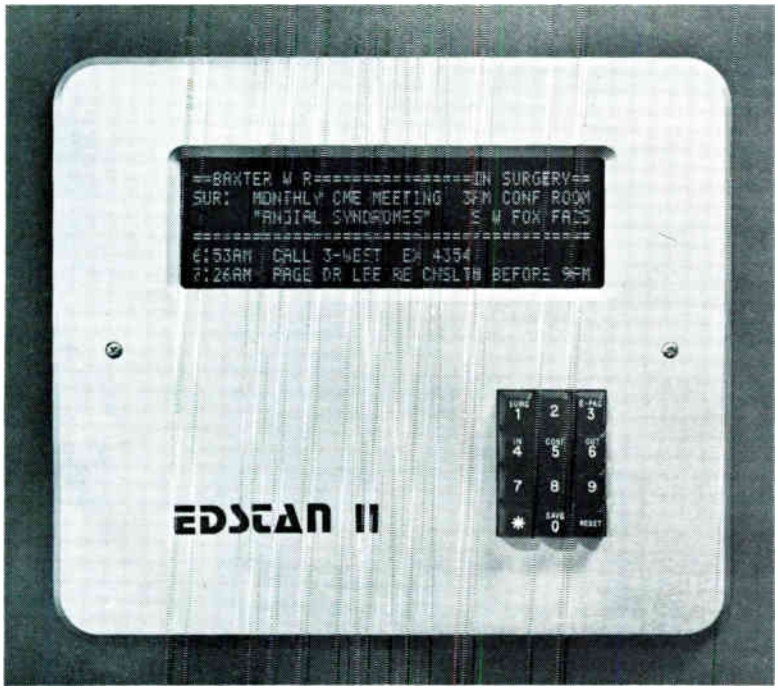
Co., Dallas. Both Shuler and Spoonts will have completed two three-year terms and are thus ineligible for reelection at present.

Nominated to succeed themselves on the board are Eugene B. Chaiken, a distributor, president of Almo Electronics in Philadelphia, Jack Kirschbaum, president, Cole-Flex Corporation, and Frank Vendely, Director of Field Sales, Mallory Distributor Products.

The Nominating Committee's slate will be presented to the Member-Exhibitors at the Annual Meeting, to be held at 2 PM on May 7th. The Nominating Committee is normally composed of the senior elected officers of the Show's three sponsoring associations. This year, this group included Vendely, chairman of EIA/DPD; Marvin Perkel, QAR Industrial Electronics, Mt. Vernon, New York, president of NEDA, and Bruce Anderson, Sumer, Inc., Rolling Meadows, Illinois, president of the Electronic Representatives Association.

Shuler said that the Nominating Committee this year fulfilled a mandate from the Board of Directors to fill vacancies with the best qualified people, taking cognizance of the particular need to have the Show Board represent the full diversity of the industry. "Only thus can we be sure that appropriate voices will be heard to maintain the relevance of the Show to *all* industry segments, from high technology industrial to general line and commercial sound," Shuler said.

The new Directors will take office at the conclusion of the 1981 EDS Show. They will be involved in planning the 1982 Show, to be held in New Orleans, and will also participate in long range planning, dealing with locations and formats for shows for the next decade.



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Atlantic City, NJ – May 19-21, Booth 6

E. New England Hospital Assembly
Boston, MA – March 30-April 1, Booth 1108

F. Ohio Hospital Association
Columbus, OH – April 6-8, Booth 119

G. Texas Hospital Association
Dallas, TX – June 8-10, Booth 337

H. Association of Western Hospitals
Anaheim, CA – April 27-29, Booth 723

* **Hospital Engineering Exposition**
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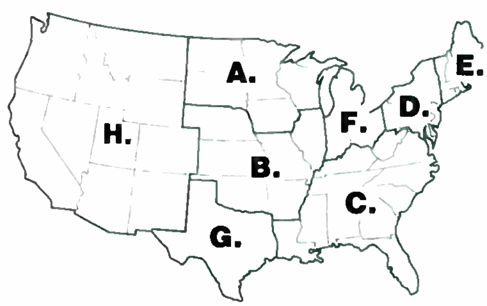
** **American Hospital Association**
Philadelphia, PA – Aug. 30-Sept. 3, Booth

Also:

New England Hospital Telecommunication Association, Providence Marriott Inn
Providence, RI – April 6-9

California Society for Hospital Engineers
Sacramento, CA – April 21-24



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SSB & Mobile Radio

by P. J. Garner

Introduction

It has been proposed that SSB operation of land mobile radio systems with 5-kHz channel spacing would offer considerable advantages over the current AM and FM systems which require channels of 12½ kHz or 25 kHz. The chief advantages claimed for SSB are those of decreased mean transmitter power (approximately one quarter the power for the same range as for FM or AM) and a much reduced channel width. Doubts concerning the relevance of the second of these claimed advantages have been raised.

In mobile radio systems not only is the channel width important but so is the minimum permissible distance between transmitters operating on the same channel: the minimum re-use distance. If a channel can be re-used often, that it may be a wide channel may not matter. It has been claimed that since FM exhibits a capture effect and SSB does not, the minimum re-use distance for FM will be much less than that for SSB and more than compensate for the wider channel. Calculations based on models assuming neither fading nor shadowing have led their users to the above conclusion. Dr. R. C. French of Philips Research Laboratories has calculated the minimum re-use distances in the presence of fading and shadowing for specified values of protection ratio and percentage usability of the channel. The new model predicts a marked increase in the re-use distance for FM when compared with that predicted using an over-simplified model.

The first part of our work was aimed at establishing acceptable protection ratios for FM and for SSB. The protection ratio may be defined as the difference in the mean signal levels of the wanted and the unwanted signals in a co-channel system to give acceptable quality and intelligibility of the wanted signal. The tests were carried out in a moving vehicle, so as to include the effects of fading.

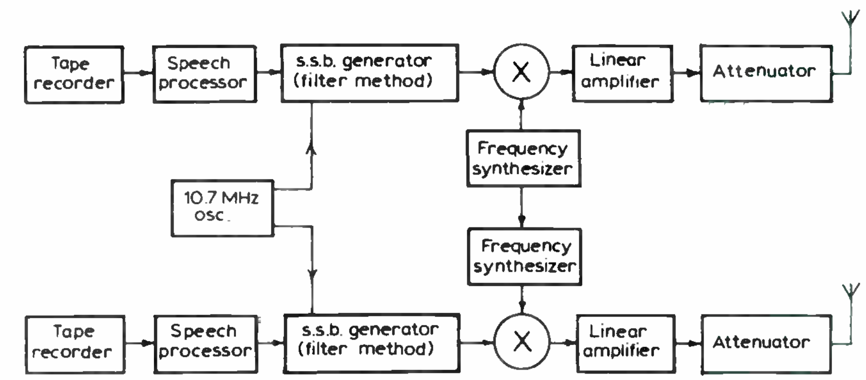

Figure 1. Block diagram of s.s.b. transmitters used in the field trials.

Another area of interest is the relative performances of FM and SSB under "quasi-synchronous" conditions. This occurs with a mobile receiver in the overlap area of two transmitters, both radiating the same information on almost the same carrier frequency.

Experimental Equipment

To perform both the co-channel interference and the quasi-synchronous tests, we used two FM transmitters, two SSB transmitters, and one FM and SSB receivers, see Figures 1 and 2. The transmitting aerials were secured at the same height above the ground and separated by thirty-five wavelengths at the transmitting frequency of 167.2 MHz. The receivers were located in a van which was driven around a test loop close to the laboratories. We

Mr. Garner is with Philips Research Laboratories, United Kingdom.

measured received signal strengths on the test loop and used these to calculate the cross-correlation coefficient of the two transmitters. Although the separation of the two transmitting aerials was low, there was little short-term correlation along the test loop between the signals received from the two transmitters, i.e., the fading of the two transmissions was nearly independent.

We chose as the FM receiver, a high quality mobile transceiver from a leading American supplier. This was designed for 25-kHz channel spacing and was fitted with a pre-i.f. noise blanker. The FM transmitters were two Marconi TF2020 frequency synthesizers feeding purpose built linear amplifiers. The front-end of the FM receiver was also used as the front-end of the SSB receiver to ensure that both receivers had front-ends of similar performance. A block diagram of the SSB receiver is shown in Figure 3.

Care was taken to ensure that the audio responses of the FM and the SSB receivers were the same and that the SNR (signal-to-noise ratios) of the receivers were close to theoretical predictions.

For the co-channel interference tests, the wanted signal consisted of a twenty-five-minute tape recording of a series of numbered statements spoken by a male speaker. The "unwanted" interfering signal consisted of a three-minute continuous-loop recording containing both male and female voices. The "statements" recording was used for both channels in the quasi-synchronous transmission tests.

Signal level recordings were made frequently during recording sessions to ensure that the mean received signal level was correct.

Subjective Assessment of Received Signals

While travelling around the test loop, audio information from across the loudspeaker terminals of the radios was recorded on three-minute loop cassettes. This was slightly less time than the time taken to travel once around the test loop.

Batches of recordings were played to listeners who were asked to assess the quality of the recordings and score them against the following

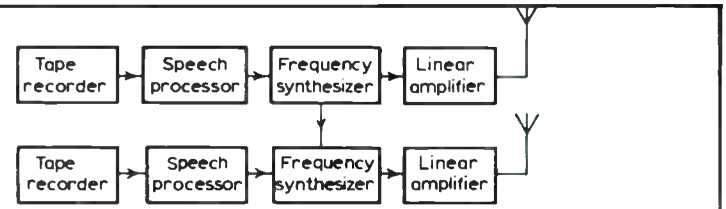

Figure 2. Block diagram of f.m. transmitter.

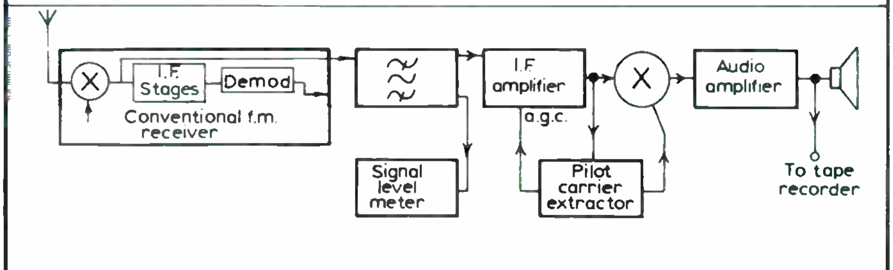

Figure 3. Block diagram of s.s.b. receiver.

scale:

5) Excellent
4) Good
3) Fair
2) Poor
1) Bad

Each subject was asked to score a set of about twenty recordings on the basis of a fifteen-second sample from each. The recordings were presented to each subject in a different random order. Consecutive subjects heard consecutive fifteen-second segments from the three-minute loop recordings. Thus, twelve subjects were required to assess the complete recording.

Co-channel Interference Tests

For these tests, both the wanted and the unwanted signals used the same modulation type.

When co-channel interference occurs in practice, it is unlikely that the two transmissions will be exactly on the same frequency. The tolerances on the transmitter frequencies are about 150 Hz and 1 kHz for SSB and FM respectively: typically values about one-half of the maximum are likely. For these tests, we made recordings with frequency differences between the wanted and interfering transmitters of zero and 75 Hz for SSB and zero and 500 Hz for FM. Other offset frequencies within the tolerance range were judged to degrade the receiver performance by no more, and usually by less, than the values selected. Received signal levels of 3 μV and 10 μV (mean for FM; peak for SSB) were used. 3 μV is a low signal level; 10 μV, a good signal level.

Two types of subject were used for the subjective assessment of these recordings. First, colleagues from our laboratories who were not used to mobile radio and, second, experienced radio users from the Surrey Police Force, were employed. No significant difference was found between the scoring of the two groups.

Co-channel Interference Results

Figure 4 is a histogram of the gradings given for SSB and FM with zero offset frequency and at a received signal level of 10 μV. Figure 5 shows histograms for received signal levels of 3 μV and 10 μV and offset frequencies of 75 Hz for SSB and 500 Hz for FM. In the case of SSB, the signal level refers to the peak signal level, the average level being somewhat less, whereas for FM the signal level of interest is the mean signal level. The results are plotted in graphical form in Figures 6 and 7. Approximately 80% of results lie within the shaded bands.

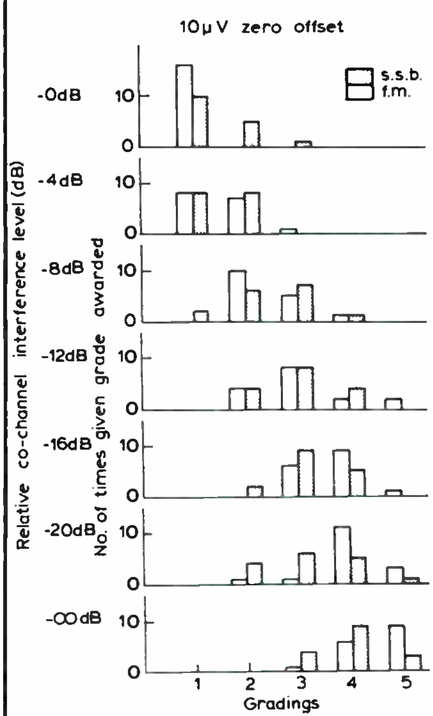

Figure 4. Histogram of results of subjective testing of s.s.b. and f.m. with zero offset frequency.

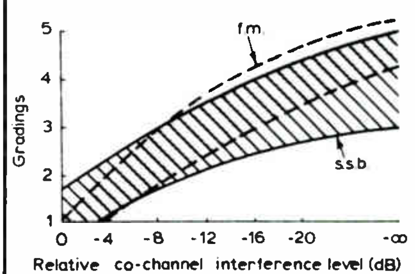

Figure 6. Comparison of the co-channel performances of s.s.b. and f.m. with zero offset frequency and at a received signal level of 10 μV.

The large area of overlap of the bands show the performance of SSB and FM in a moving vehicle to be very similar in the presence of co-channel interference. The protection ratios of the two systems and, hence, the minimum re-use distances, will be the same.

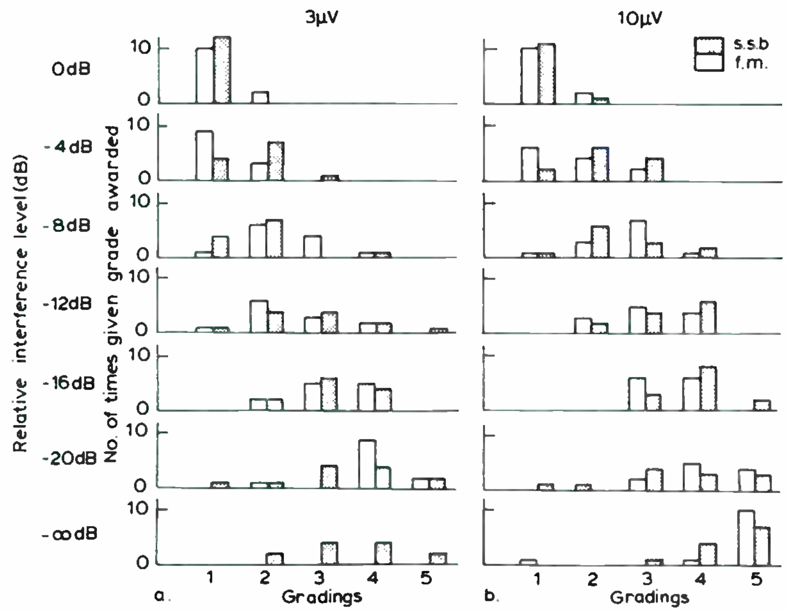

Figure 5. Histogram of results from subjective testing of s.s.b. and f.m. with offset frequencies of (a) 75 Hz and (b) 500 Hz.

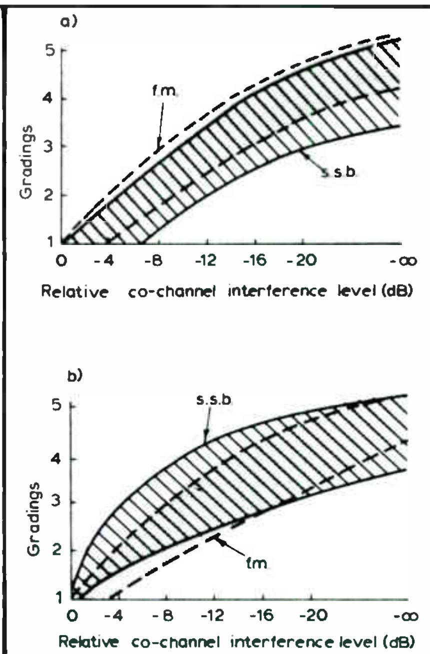

Figure 7. Comparison of the co-channel performances of s.s.b. and f.m. with, respectively, offset frequencies of 75 Hz and 500 Hz at a received signal level of 3 μV (a) and 10 μV (b).

Quasi-Synchronous Transmission Tests

For the quasi-synchronous transmission tests, the same audio information was fed to the two transmitters. Audio delays, though, could be included to simulate, for example, different telephone line delays to the transmitters. One transmitter could be given a small offset frequency with respect to the other. Recordings of the received signals were made and assessed in the same way as for the co-channel interference tests.

Mixed Co-Channel Interference

If SSB is accepted for use in mobile radio communications, it will have to be used in the presence of SSB interference on FM and FM interference on SSB. One might expect the latter type of interference to be worse than the former, because the average transmitted signal is

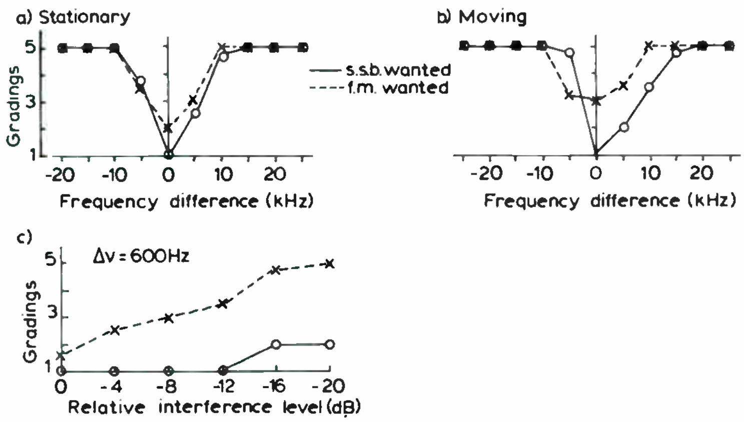

Figure 8. Results of mixed interference tests (f.m. signal: 10 μV, s.s.b. signal: 10 μV peak).

much higher for FM than for SSB. Both bench and field trials were performed. For most of the tests the carrier frequencies were spaced by an integer multiple of 5 kHz. This was to access the effects of putting an SSB signal into a 25-kHz FM system. To date the recordings have been assessed by the author only. The results, Figure 8a and b, show that generally FM is more tolerant of SSB interference than SSB is of FM. However, providing the FM signal is more than about 10 kHz away from the SSB signal, little interference is experienced. Not surprisingly, SSB suffers more interference when the FM signal is higher in frequency than the SSB signal compared with when the FM signal is lower in frequency. This is due to more energy from the FM signal being present in the SSB passband when the FM is high in frequency than when it is low.

If the interference is true co-channel, then the offset frequency will be much less than 5 kHz. In practice an offset frequency of 600 Hz was judged to be the worst case for both SSB and FM. Figure 8 shows the performance obtained; again the author only has assessed these recordings. SSB is seen to be badly affected by FM interference.

Conclusions

1) The performances of FM and SSB in a moving vehicle in the presence of co-channel interference with the same type of modulation, are very similar.

The oft quoted advantage of FM over SSB was not observed. Thus, the re-use distances for the two types of modulation will be the same. To obtain a quality/intelligibility rating of three (fair) both modulation systems require the interfering signal to be (12-14) dB below the wanted signal. SSB, of course, has a power and channel width advantages over FM.

2) SSB interference on an FM signal is less objectionable than FM interference on an SSB signal. This is thought to be due mainly to the higher power content of the FM signal.

3) SSB channels may be located less than 25 kHz away from a 25-kHz FM channel. Under equal signal strength conditions, a 10-kHz separation gave a quality/intelligibility rating of three (fair). □

INTERCONNECT LINES

A NEW PRICING SCHEME BY AT&T FOR ITS WESTERN ELECTRIC ADVANCED LINE OF PBXS HAS SURFACED. IT REPLACES THE BELL SYSTEM'S 5-YEAR OLD 2-TIER RATE STRUCTURE ON CUSTOMER PREMISE TELEPHONE EQUIPMENT. The pricing plan includes a Variable Term Payment Plan, a mixture of fixed monthly rates, short-term payback periods and uniform tariffs among the Bell System operating telephone companies.

AT&T's movement from conventional leasing plans and 2-tier pricing to the Variable Term Payment Plan is expected to pose new financial ground rules for the Bell System's existing and future PBX subscribers, as well as to alter marketing strategies among interconnect equipment manufacturers and distributors competing against the carrier.

Central to the Variable Term Payment Plan, along with discounts said to reach 10% on some longer-term contracts, pricing is said to offer stable monthly tariffs for PBXs on 1-month, 48-month and 72-month leases, compared with the older 2-tier pricing scheme in which prices often varied from state to state. In addition, it incorporates changeable maintenance and overhead charges and offers payment plans that could be stretched out over a maximum of 144 months.

It is believed that although some upfront charges and monthly rates are higher under the Variable Term Payment Plan than 2-tier, long-term charges for PBX users will be less expensive, allowing Bell to protect its base from competitive inroads.

Also, there is speculation that discounted 4-year or 6-year leases under the Variable Term Payment Plan may lock-in users until the Bell System unveils a new generation of customer-premise switches and that the Variable Term Payment Plan is the key element in AT&T's migration strategy for attracting customers from the old to the new phone equipment.

TIP & RING

—ROLM CORP. and NORTHERN TELECOM began shipping their respective hardware and software packages that support non-voice applications for digital PBXs. The products—Rolm's electronic message system (REMS), add-on voice and data switching systems by Northern Telecom and InteCom integrated exchange—are believed by both makers to be the first step toward data transmission directly from station to station.

—NEC TELEPHONES INC. has appointed Edward F. Eddy President, succeeding Kazumsa Yoneyama. Yoneyama continues as senior vice-president of NEC America. Eddy comes to NEC Telephones after having served as president of the Communications Systems Division/ITT. Eddy holds a B.A. in marketing from Duquesne University and an M.L. in marketing from the University of Pittsburgh.

—TIE/COMMUNICATIONS INC. has opened a new sales office in Atlanta, Ga. under the direction of Joseph Privitera. The new facility will be a full-service office with regional sales support, customer service representatives and technical service engineers. Meanwhile, TIE/

COMMUNICATIONS has entered into an agreement to exclusively distribute in the U.S. and Canada phone equipment made by Jeumont-Schneider S.A. of France. It is a 7-year pact between these two firms. The initial product covered under the agreement is a new computerized hybrid PBX/key system, known as the Ultracom 7VDX-144.

—ELECTRONIC INDUSTRIES ASSOCIATION'S TR-41 COMMITTEE, successor to the FCC's "PBX Advisory Committee" which has been supplying the interconnect industry with performance standards for voice terminal equipment in the U.S. and Canada, has named Victor Boersma and James "Jay" Gwatkin to the new subcommittee. Boersma of Bell-Northern Research has been designated chairman of the keyphone subcommittee, while Gwatkin, Manager of Subset Design, ITT Telecommunications, has been named head of the TR 41.3 telephone committee.

—RCA SERVICE COMPANY is now marketing the Model 43 Telex, made by Teletype Corp. The Model 43 Telex features keyboard dialing and 8K memory with full text-editing capabilities.

—DIGITAL TELEPHONE SYSTEMS/HARRIS CORP. and EXECUTONE, INC. have jointly announced that their distribution relationship for the D1200 family of PBXs will be modified to a non-exclusive agreement. Executone will continue to market the D1200 PBXs under the Executone D-1000 proprietary trade name, and Harris Digital Telephone Systems will continue to supply and service Executone. However, the agreement was modified to serve both companies' growing customer needs, enabling Executone to expand its product line while, at the same time, free Harris to make arrangements with other interconnect companies, to broaden the distribution of its PBX products.

—ACTON CORPORATION HAS ACQUIRED THE ASSETS AND BUSINESS OF TELE/RESOURCES, INC. Acton Corporation, through its subsidiaries, has a base of over 9,000 interconnected telephone systems, including National Telephone Company, 45 cable TV systems and a radio station, and applications are before the FCC to purchase two TV stations and one radio station.

—PACESETTER COMMUNICATIONS CORP. vs. TELECOM EQUIPMENT CORP. (and NEC), the anti-trust action, has been settled. Telecom, 14.04% owned by NEC Telephones, Inc., said that the settlement provided for its payment of an "unsubstantial sum of cash" to Pacesetter, and for the discontinuance of Pacesetter's action with prejudice—elimination of future suits based on the same grounds. Attorneys for both sides said that a notification of a "stipulation of discontinuance" has been filed with the U.S. Southern District Court. Pacesetter had charged NEC and Telecom Equipment with an "unreasonable restraint" of commerce by using various means to exclude other distributors and dealers from the interconnect PBX and keyphone marketplace. NEC and Telecom both denied Pacesetter's charges and made counterclaims in court against the company. Pacesetter had asked for $1 million in punitive damages and restraining orders against the companies. A spokesman for Telecom Equipment said the settlement called for a payment to Pacesetter in "five figures only."

PABX Switching

The following article is an adaptation of a paper delivered by Robert Kennedy, Vice President/Telecom Equipment Corporation, Long Island City, New York, before a Communications Seminar sponsored by Salomon Brothers, New York investment bankers, in Hyannis, Mass. Other guest speakers included the Chairman of Northern Telecom, the President of AT&T, and the President of Datapoint.

The seminar was devoted to the trends and directions in telecommunications, as seen through the discerning eyes of vested interest experts.

My fellow panelists have addressed themselves to data communications networks, and how data and telecommunications coalesce in the broad spectrum of communications.

Since my company, Telecom Equipment Corporation, is a purveyor of communications systems which incorporate the products of a variety of manufacturers... promoting, selling, designing, installing and maintaining the telecommunications system... I deemed it appropriate to talk about PABX switching. Why talk about PABX switching at this juncture? Because we must understand the realities of the available and evolving technologies, and we must know what are the real priorities in design selection. It is we, the systems marketing people, who are the surrogates of the end users in influencing the manufacturers' design criteria.

What are the future needs of the office environment? I quote the following from the May, 1980 announcement of a special PABX report in Communications News.

"The PBX will be the central and unifying element of the office of the future...the heart or brain of the office, providing universal network access and making possible the harmonious interaction of all office systems. The PABX is obviously emerging as the pivotal switching element for whatever communications devices are on the desk of the future. Recent FCC rulings, along with development of electronic mail, intelligent terminals and communication word processors, heighten interest in new PABX developments... "

Another quote, from a special report in the April, 1980 issue of Electronic News, states:

"PBX suppliers, their parents, and distributors handling key lines have been the targets of aggressive companies eager to position themselves in future data and office equipment markets in which the PBX is expected to play a pivotal role."

A corporation's internal telecommunications network is unique. It transcends departmental boundaries and reaches all corporate personnel, on any level or with any specific functions.

The purpose of a PBX is to provide a movable connection. It permits a terminal to be connected to one of any number of other terminals upon command. Having accomplished a desired connection, the switching matrix is ideally transparent to the flow of information between the two terminals, imposing no limitations on what might be transmitted through it, and without distortions or losses.

There are no features associated with the switching matrix, only transmission characteristics, and traffic capacity. For features we must look to the control portion of the PABX. In the crossbar systems, this control was an electromechanical processor which was generally known as a marker.

In ESS switching systems, the electromechanical processor gave way to the much faster electronic processor. This change permitted substantial cost reductions in larger systems, notably central offices, where multiple markers could be replaced by a single electronic processor. This in turn made possible a whole new array of operating features. With the rapid evolution of computer technology and large scale digital device technology, it only took a few years for stored program controlled ESS machines to displace the earlier wired logic products.

When we speak of digital PBX switching, there is a widespread misconception that the subject relates to the digital computer technology used in the control. Just as ESS refers to the electronic control of an undefined switching matrix, the term digital switching refers specifically to the matrix. It also does little to define the design characteristics of the control, or to delineate the feature capabilities.

The evaluation of a PBX must separately consider the control and matrix functions.

Although features have considerable impact on economics through the computer's provision of cost control and system management, we have been taking advantage of these things for some three to five years. The evolution of the microprocessor, and low cost large scale integrated circuits, have been making these benefits economically available in smaller and smaller sized machines.

As we view what is happening with the "office of the future," what is new about the PBX is not the stored program control, but the broad-band switching matrix, and the ability to provide a very broad range of switching capabilities with a very high degree of parts and service commonality over the whole range of products.

The industry has been advancing rapidly in the application of increasingly sophisticated computer controls to the PBX functions and we talk about entering the age of software, where the major new requirements will be served with new software. Because of the very high costs and complexities of software, however, we are trending toward the solutions via the additions of hardware. We talk of adding sub-systems to provide the ancillary functions of electronic mail, word processing, data switching, etc., and having them communicate via a dial up connection through a PBX. Gone are the projections of the large supermachines that would handle everything from payroll to telephone calls. We are entering the age of the big, distributed processing networks with the PBX tying the entire package together.

Referring back again to the earlier referenced April 21st article in Electronic News, the author included a quotation, part of which is:

"The data processing and communications areas are tending to merge. The modern PBX essentially is a computer driven device and anyone with such capability would probably find a place in the market if they have motivation and equipment."

The implied conclusion that computer technology is the dominant factor in the generation of a successful PBX is misleading. When the PBX was a separate, stand-alone switch, interfacing to an analog network, comprised of hard copper paths, the statement was far more representative of the real world. Now, however, successful participation is unlikely without strong capabilities in computer switching, traffic, transmission and device technologies.

A digital transmission medium ceases to differentiate between voice and data. If we wish to transmit data at economically meaningful rates, we must have a digital transmission design that provides that capability at an acceptable error rate. When we want to use these paths for voice, which requires much less of a "bandpass," we trade the bandpass for an increased number of voice paths.

Returning to the original premise, the primary purpose of a PBX is to provide movable connections, in adequate quantities, which become transparent to the transmitting and receiving terminals. How shall we now evaluate the switching matrix when the terminals are transmitting something other than voice grade analog signals, and the "electronic matrix" is no longer the equivalent to a pair of copper wires?

If we are to be transparent to the switched network, and the network is distributing information via T1/D3 format PCM transmission lines, we need to effectively be directly switching T1/D3 transmissions. If we have other than an internal matching format, then we must introduce black boxes to convert the information. If we are tandem switching, that is, switching it back out over another trunk to another switch location, then we must do this twice. Black boxes mean more parts, which means statistically reduced reliability. Depending on the nature of the conversion, it could mean losses and/or distortion, both of which result in increased error rate, the solution for which is generally a reduced data transmission rate.

With increasing corporate communications requirements, corporate networks are rapidly growing. In the future, as we develop multilocation networks that will be interconnected by the tandem T1 switching function of the PBX, we have to be concerned that expensive leased transmission facilities are not blocked by local traffic in the switching PBX. This is part of the traffic function referenced above. We want to configure traffic per station in an economically feasible manner, being able to protect higher traffic areas where appropriate, while at the same time providing fully non-blocking tandem switching of 2-wire or 4-wire trunks, either analog or digital.

Because traffic is important, we cannot ignore this aspect of the control processor function. If the computer control is too busy to establish and supervise the connections we want, it matters little how many paths are available. As indicated above, the original cost effectiveness of the electronic control was through displacement of hardware, because we never need more computers, just a more powerful one. At some point we can even afford the second one for redundancy. This evolutionary process accounts for most existing systems' use of the redundant monoprocessor control.

One of the problems with the use of the monoprocessor, with its full duplication for redundancy, is that it becomes cost effective over a somewhat narrow range of application. The recent introduction of electronic telephones requires memory, space and processor time. Station lines now require more memory space, because of the amount of tabular data that must be maintained per station, as a result of increased features. Traffic activity uses a high degree of real time capacity. As traffic increases, the ability to address tabular instructions, look up tables, electronic telephones, diagnostics, and current PBX activities diminishes, because of the number of functions that must be performed on a closely controlled real time schedule.

What we really need in order to be prepared for the "office of the future" is the ability to grow the real time capacity of the processing function as the demands on the system grow, and as the matrix grows. The obvious approach to accomplishing this end is the application of distributed processor control. This means the provision of a computer function at the point where the work is to be done. It also means the load sharing of centralized common processing functions that cannot otherwise be distributed.

What we see here as the trend, is the appearance of "families" of machines that minimize the impact of growing over a wide range of size and traffic configurations. It is also the provision of a flexible switching function that can remain transparent to the evolving North American T1 digital transmission network, one that can provide a highly controllable traffic distribution while maintaining a truly non-blocking tandem function. It means the inclusion of the "stored program control" with "modular expandability" for PBX growth.

We at Telecom feel that we have begun providing all these capabilities in our family of PBX systems. We are currently installing digital PCM switching systems with distributed microprocessor control which provide individual, non-blocking tandem systems, expandable all the way to 12,000 lines and 1920 trunks. We are designing networks that use PBXs with capabilities of 48 lines, 360 lines, 1320 lines and 12,000 lines, all of which utilize common circuit packages and maintenance procedures. This not only benefits the cost of ownership, but greatly facilitates relocation and reconfiguration of individual PBXs in a dynamic multi-location network environment.

In summary, the key trends we foresee in PBX product requirements are:

- *Distributed Processing*—to handle high real time requirements and reliability.
- *Full T1 Digital Compatibility*—to interface with the digital network.
- *Wide Band with Channels*—to handle both voice and data.
- *Modular Expansion* of *Both* Control and Matrix.
- *Full Family Switches*—across the entire product line for commonality of parts and service.
- *Non-blocking Tandem*—Capability for corporate networks.

We feel this is not only the trend in PBX switching, but a very necessary trend if we are to provide that pivotal point for the "office of the future" concept. □

MOBILE COMMUNICATIONS

STATE POLICE IN 21 STATES NOW HAVE DISTINCTIVE CB CALL SIGNS ALLOTED BY THE FCC in recognition of the important role that CB radio plays in public safety. (Distinctive call signs are not authorized for law enforcement agencies at county, city or local levels.)

The distinctive CB call sign consists of letter "K" plus the two postal initials of the state, followed by 911. These call signs, based on the familiarity of 911 as an emergency telephone number, are intended to provide the public with an easy-to-remember number. CB channel 9 is designated by the FCC as an emergency channel. Twenty-one states, the District of Columbia and Puerto Rico have been assigned distinctive CB call signs to date. The states are: Alaska, Colorado, Georgia, Illinois, Iowa, Louisiana, Maryland, Michigan, Missouri, Montana, Nebraska, Nevada, New Hampshire, New Jersey, New York, North Dakota, South Carolina, Tennessee, Utah, Virginia, and West Virginia.

AT&T IS WOOING RCCS TO RESELL ITS 800 MHZ RADIO CAPACITY TO END-USERS. Some RCCs suggest AT&T is "talking vaguely" about potential agreements under which RCCs would act as sales agents for Bell's cellular advanced mobile phone service, now in trial operation in Chicago.

Thomas Lamoureux, executive director of Telocator Network of America, the Washington, D.C. based association of RCCs, commented: "AT&T was making a call for cooperation, saying they just needed help to get things moving and that they and the RCCs should be allies."

AT&T, which is estimated to have spent almost $125 million on cellular radio development, has said it is ready to market the system around the country, pending FCC approval.

The AT&T proposal to the RCCs runs something like this: Bell's AMPS division would own all the radio facilities up to the cellular computerized switching equipment, and would wholesale the radio capacity to the RCCs and AT&T operating telcos at about 20 percent below end-user cost.

Comments from several large RCC operations indicated there was a hesitancy to "fall in" with AT&T, because the wholesale rate is too low for a "must markup" of 40 percent. Further, there seems to be little opportunity for innovation, meaning any new cellular operating area would be added at Bell's discretion, effectively barring an RCC from entering a new market.

Meanwhile, Motorola, the other developer of a cellular system, which has spent almost $50 million, does not see AT&T's actions as threatening, but nonetheless believes Bell is misleading the RCCs. Martin Cooper, vice-president and research/development director of Motorola, believes that the RCCs are capable of owning a cellular system despite AT&T's assertions to the contrary. Cooper said Motorola wants FCC rulings as soon as possible and hopes the agency will allow RCCs as much freedom as possible in the choice of a cellular system. Cooper indicated that Motorola's cellular system is already marketable.

TNA has not taken a position on the AT&T proposal to the RCCs, preferring to await the FCC's ruling on cellular systems, which is expected at the mid-way point in 1981, or thereafter.

USE OF LOW POWER BAND TRANSMITTERS FOR COVERT TRACKING OPERATIONS ARE AUTHORIZED IN POLICE RADIO SERVICE on those frequencies allocated to the Public Safety Radio Service by the FCC. The Commission said that although it restricted the eligibility for trailing device use to the Police Radio Service, all individuals or entities having a valid law enforcement need for such equipment (motor carriers, security companies, railroad motor carriers, railroad security, etc.) could coordinate with local law enforcement agencies their use of automatic radio detection equipment and, with the concurrence of these law enforcement agencies, they may operate such equipment under the authorization issued to the law enforcement agency. This arrangement would still require the law enforcement agency to assume full licensee responsibility for the operation of the trailing device. The Commission said that this permissive arrangement should allow private entities seeking use of beepers sufficient opportunity and flexibility to satisfy their particular need for these devices.

The FCC also adopted the use of spread spectrum techniques as a feasible method of transmitting beeper signals. It noted, however, that since it did not have sufficient information to determine the appropriate technical standards for spread spectrum applications, it would issue a notice of inquiry to invite comment on what technical parameters should be set for the implementation of spread spectrum systems in covert trailing operations.

THE MOBILE COMMUNICATIONS INDUSTRY, WHICH INCLUDES BUSINESS RADIO, aviation & marine, public safety, car telephone, personal communications and paging, is on the threshold of enormous growth in the Eighties, according to David A. Post, president of PageAmerica Communications, Inc. Speaking before a conference on Communications Networks '81 in Houston, Post said that the synergistic mix of newly allocated frequencies, a fluid demand, new technology and techniques and broadening applications will result in unprecedented industry growth.

"One need only look at what happened to CB radio, which grew in 10 years from 900,000 in 1970 to nearly 15 million by 1980," Post added. "This exemplifies the potency of demand for radio in the public sector. Business is just beginning to recognize the benefits of mobile communications and by 1985 the applications will impact broad sectors...

Post cited the paging industry as the example of mobile communications growth in action. In 1970, he said, there were about 60,000 pocket pagers in use. Ten years later, the user population had grown to over 1 million and prospects are for continued growth to 10 million users by 1990.

MOTOROLA, SCHAUMBURG, ILL. HAS REORGANIZED ITS COMMUNICATIONS GROUP WITH THE ESTABLISHMENT OF A "SYSTEMS & PORTABLE" DIVISION, under the stewardship of John W. Battin, former vice president and general manager of the Communications Systems Division. Reporting to him will be the Portable Products Division, the Communications Systems Division and all paging operations.

THE FCC HAS PROPOSED TO MAKE AVAILABLE FOUR PAIRS OF UNASSIGNED FREQUENCIES NOW ALLOCATED TO OTHER SERVICES, TO THE BUSINESS RADIO SERVICE ON A SHARED BASIS WITHIN 35 MILES OF DETROIT. The action results from a petition by the National Association of Business & Educational Radio, Inc., which asked for reallocation of a number of little used frequencies to the business service in the Detroit area. NABER said business service frequencies in the Detroit area are heavily used.

It said Detroit's proximity to Canada denies it the benefits of the Commission's earlier reallocation of TV frequencies to land mobile use in other areas. NABER based its request on a 1977 study showing that there were 76 little used land mobile channels in the Detroit area.

The FCC found that in 1980 there were only four channels which had no base station assignments within 75 miles of Detroit. It declined NABER's request to the extent that it proposed reallocation of frequencies from public safety channels, since it is currently studying alternatives in allocating spectrum and assigning frequencies for public safety and other users in the various Private Radio Services.

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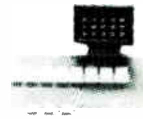

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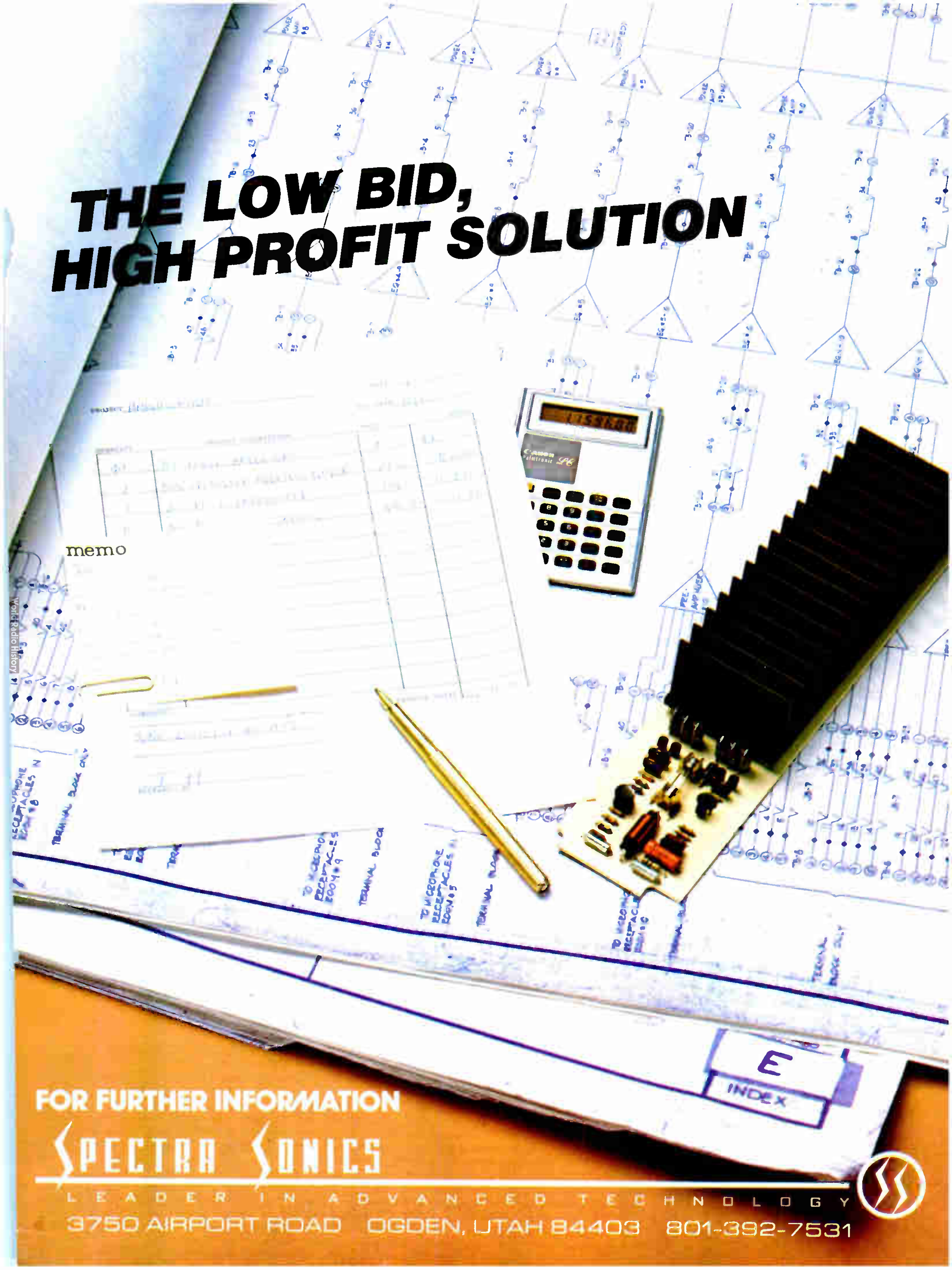
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