# 1984: 76th AES Convention

At the 76th AES Convention in October 1984 in New York, Dr. D'Antonio presented three important publications. The first description of the RFZ/RPG control room design, which became the de facto standard to this day, the first experimental time and frequency domain measurements of the RPG Diffusor and suggested applications for diffusors in a variety of applications.

Abstract for RFZ/RPG design:
"A design for implementing a LEDE control room is proposed. The dead end is achieved by creating a reflection-free zone (RFZ) by flush mounting the monitors as close to a trihedral corner as is physically possible and splaying the absorbent side walls and ceiling to minimize interfering reflections at the mix position. The live end is achieved by positioning RPG diffusors on the rear wall in such a manner as to reintroduce the energy passing the mix position, after an initial delay, temporally and spatially diffused. The approach leads to accurate monitoring, with a stereo image which is maintained across the entire width of the mixing console and in the rear of the room."

THE RPG REFLECTION PHASE GRATING ACOUSTICAL DIFFUSOR: EXPERIMENTAL MEASUREMENTS — 2158 (H-6)

Peter D'Antonio and John Konnert
RPG Diffusor Systems, Inc.
Largo, Maryland

Presented at
the 76th Convention
1984 October 8-11
New York

AUDIO AES

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AN AUDIO ENGINEERING SOCIETY PREPRINT

THE RFZ/RPG APPROACH TO CONTROL ROOM MONITORING — 2157 (I-6)

Peter D'Antonio and John H. Konnert
RPG Diffusor Systems, Inc.
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AN AUDIO ENGINEERING SOCIETY PREPRINT

THE RPG REFLECTION PHASE GRATING ACOUSTICAL DIFFUSOR: APPLICATIONS — 2156 (H-7)

Peter D'Antonio and John H. Konnert
RPG Diffusor Systems, Inc.
Largo, Maryland

Presented at
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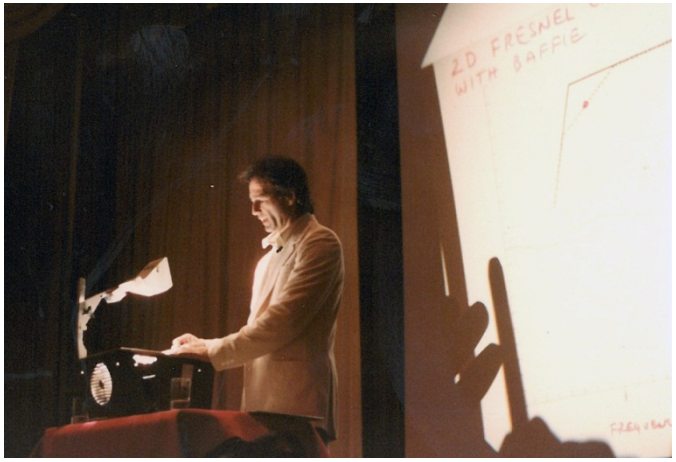
AN AUDIO ENGINEERING SOCIETY PREPRINT



# 1984: First Mix Magazine Article

Mix Magazine's August 1984 special issue on Studio Design, the RPG Reflection Phase Grating Diffusor was featured, exposing RPG's emergence on the scene to the entire music industry. There was a very enthusiastic response to this article.

## The RPG Reflection Phase Grating Acoustical Diffusor

Many approaches have been used to improve the diffuston of sound in critical listening environments. Room dimensions have been optimized, ceilings have been inclined and walls splayed. Room surfaces have been covered with geometrically irregular shapes, polycylindrical columns and/or alternating reflecting and absorbing panels. These conventional diffusors have limited application, however, because they do not simultaneously scatter uniformly over a wide enough range of frequencies and directions necessary for good diffusion. The RPG is a new reflection phase grating acoustical diffusor which offers a novel approach to providing sound diffusion over a broad frequency bandwidth with uniform wide angle dispersion. An incident wave is scattered into many wavelets having equal energy over a wide angular range (half space). In addition, this polar energy response is practically constant over a broad, designable range of frequencies. In essence, the RPG's highly diffusing surface provides efficient backscattering over a broad range of frequencies with wide angle coverage.

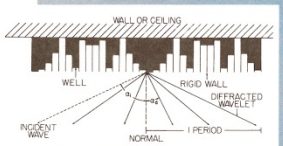



*Figure 1: Scaled top view cross section of a QRD-17 has two periods with 17 wells per period.*

The one-dimensional diffusor consists of a periodic grouping of an array of wells of equal width, but different depth, separated by thin and rigid walls (Figure 1). The unique properties of the RPG result from varying well depths, determined by quadratic-residue (QRD™) or primitive-root (PRD™) mathematical number sequences—the Fourier transform of the exponentiated sequence values is of a nearly constant magnitude. This insures equal energy in all the scattered directions.

PRD diffusors are characterized by a unique energy dip in the specular reflection direction. For a one-dimensional, laterally diffusing RPG (wells running vertically), the scattered energy is concentrated into a hemidisc whose thickness is proportional to the specifically to absorb sound over a wide range of frequen- thickness increases, as does the coverage. This hemidisc can be conveniently directed by orienting the diffusor or source. Two-dimensional models using either sequence are also possible. These diffusors spread the scattered energy into a hemisphere.

**APPLICATIONS**

**Audio recording, radio and television studios:**

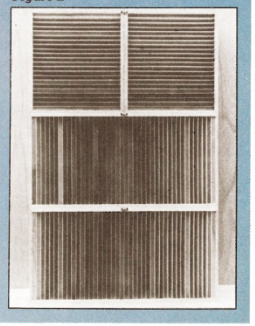
The acoustics of the studio can be tailored to provide the necessary early reflections and dense diffuse sound field, with a uniform decay time over the full frequency spectrum, which provides a spacious sound with the sweetening of a concert hall. The RPG can also be used as a movable gobo, allowing the acoustical characteristics of selected "live" areas, to be easily altered. The spatially diffuse reflections from the RPG arrive over a sound field, providing an open, airy sound. With appropriate microphone techniques these diffuse reflections can be used to "thicken" the sound of acoustic and amplified tracks.

**Voiceover rooms, drum booths, isolation rooms, mobile studios and acoustic reverberation chambers:**

The RPG can be used to psychoacoustically create the impression of a much larger room, by positioning the diffusors to adjust the arrival time between the direct sound and the spatially and temporally diffuse early reflections. This significantly reduces the "boxy" sound character and adds ambience and body to the sound. The RPG provides

—PAGE 76

*Figure 2*



through multiple impedance (material) changes.

Many studios in metropolitan areas are not on ground floors, and pouring a concrete slab on high floors presents several problems. One is that the load bearing limits of many buildings will not support a 50 lb/ft² floor slab in addition to the normal load found in a studio. The other complication is that concrete weighs a great deal more wet than dry and may strain the buildings limits dangerously during construction. If the weight is not a problem, the cost of transporting the concrete to a high floor site may be. Concrete is a very cost-effective sound barrier when it can be poured easily and directly into place; the cost of moving it any distance from a truck can make it quite expensive.

Sound absorbing materials used in studios for the control of excessive reverberation and the uneven build-up of sound have tended in the past toward the unattractive and harshly functional. This was due, in part, to the scarcity of absorption test results. If the performance of a material was unknown the safe course was to use something familiar, even if it was less than desirable esthetically. Here too we often find a misleading one-number rating, the NRC, specified by manufacturers. Since the performance of a material at each octave band is critical in calculating quantity and placement, the sound absorption coefficient must be used. Today, there is information on the sound absorbing qualities of many common materials, and a growing number of proprietary products, that allow the designer much more freedom in planning a room.

Sound absorbers fall into two general categories: ***absorptive,*** which includes soft, porous materials; and ***resonant,*** which includes membrane and Helmholtz absorbers. The first group, which takes in building insulation, foams, Sonex and other manufactured absorbers, exhibits an absorption curve that falls off considerably at low frequencies. The thicker the material, the better the low frequency absorption; low frequency performance is also improved by spacing the material out from the mounting surface. The layer of air takes the place of additional material and is much cheaper. Membrane absorbers—large, thin sheets of a hard substance mounted over a cavity—offer fairly broad low-frequency absorption. Tuned absorbers deal with narrow frequency bands and are generally used where unavoidable build-ups of sound have been caused by less-than-ideal room dimensions.

There are a number of products manufactured specifically to absorb



—FROM PAGE 74, RPG

early reflections which fatten drum tracks and both enhance and complement the reverberant sound from plate or digital reverberation units added in post processing. Customarily, absorption has been used to reduce the acoustic disadvantages of mobile studios. The RPG offers a complementary surface treatment with a sense of openness in this restricted space. Live acoustical reverberation chambers can be designed or modified to provide a diffuse sound field with a natural buildup and decay.

**Recording, broadcast, disk mastering and film mix control rooms:**

The RPG acoustical diffusor can be used to provide the necessary diffusion in conventional and LEDE™ recording control rooms to enable more accurate monitoring. In a LEDE room the RPG provides the required diffusion in the live end and helps maintain a uniform stereo perspective and spectral balance across the entire width of the mixing console. The accuracy of the stereo image is increased because the listener is immersed in a diffuse sound field, which increases the dissimilarity of sound reaching each ear and aids the binaural aspects of music perception. We recommend stacking the modular units into clusters in the live end of the LEDE rooms. A typical cluster would consist of two QRD-43 units atop one another, with two QRD-23 units above these, making a panel 48-inches wide and 73-11/16 inches high, as shown in Figure 2. The QRD-43 units cover the horizontal plane and the QRD-23 units provide dispersion in the vertical plane. In conventional control rooms, the QRD-43 diffusors can be mounted above and to either side of the console to provide the necessary early reflections and uniform coverage over a considerable area, including both the mix position and the producer-client position.

**Auditoria, performing arts facilities, theaters, churches, convention centers, clubs, and orchestral shells:**

The RPG can be used to increase the lateral diffusion in these large rooms, immersing the listener in a diffuse sound field with a high degree of binaural dissimilarity. This low interaural coherence increases listener preference by providing an improved stereophonic experience. RPG can be effectively coupled with sound reinforcement systems to help provide uniform broad bandwidth, wide angle coverage, which minimizes acoustic hot spots and voids. The RPG can be used to create effective orchestral and choral shells, affording performing artists a heightened sense of ensemble playing and pitch control.

*—Peter D'Antonio and John H. Konnert*

cies; many are already finished with a choice of fabrics and trim and can be very attractive. Most of these are fairly expensive and require skilled installation. One very cost-effective alternative is the use of compressed fiberglass building insulation (Owens Corning 703, for example) covered with a stretched fabric. There are numerous fabrics that will work effectively this way and finding an inexpensive example is not usually difficult. Ordinary speaker grill cloth is eminently suitable since it allows virtually all sound striking it to pass through to the absorbent material. It is commonly available in wide rolls at very reasonable prices. The fiberglass insulation is also very cheap and easy to install.

> Wood has long been the mainstay of studio design and with good reason. It has a nice balance of reflective and absorptive qualities and can assume almost any appearance that might be needed.

A popular technique for this sort of installation is to attach several inches of fiberglass to a wall between wood lath the same thickness, on 2-foot centers. Fabric is then stretched over the fiberglass and attached to the lath. The fabric can be stapled and the seams covered with moulding or trim. There are also "seamless" systems using plastic track and splines that produce a finished appearance close to a continuous wall of fabric. These systems must be installed by a firm specializing in such work, however, as the technique is tricky.

Expanded metal grills can also be used as wall coverings providing the area of metal is not too great compared with the open area. Careful calculation of the proportion of metal to open area would be required here, since the hard metal would act as a reflector at high frequencies. Metal wall coverings are very rugged however and are suitable for many locations where fabric would be too delicate.

Wood has long been the mainstay of studio design and with good reason. It has a nice balance of reflective and absorptive qualities and can assume almost any appearance that might be needed. Installed in slats, it can be spaced to allow absorption of sound by a soft backing material. Large thin sheets can be mounted on lath with an air space behind; this membrane will act as a broad-band low-frequency absorber. Although good quality hardwoods are quite expensive, construction grade plywood can be covered with hardwood veneers relatively cheaply. If the job is done carefully, the results can be impressive.

Finally, one of the most important factors in keeping costs down in a construction project, is a careful and thorough design. This may sound simplistic, but I bring it up because I have seen so many jobs bogged down in on-site design decisions or changes. These can be costly and result in compromises that affect acoustical performance or appearance. They can also be avoided by a design that encompasses all aspects of the construction stage. For example, interior and acoustic designs should not be considered separately as they are integrally related. In the same way, incorporation of the mechanical systems—lighting and air conditioning—into the initial design will allow better use of available space and coordination of all the visual elements. Soffits tacked on to cover A.C. ducts, or lighting systems hung in awkward places take away from the smooth visual flow that characterizes a good design. It's no different than a home or office building; good architecture makes a statement by its apparent effortlessness. I'm not suggesting that the only way to build a successful studio is to hire a world famous architect. A large part of good design is common sense, careful planning and skillful use of space; many laymen have an instinctive talent for design. And no project can be successful without a clear definition of the goals for the space—determinations that can only be made by owners and users.

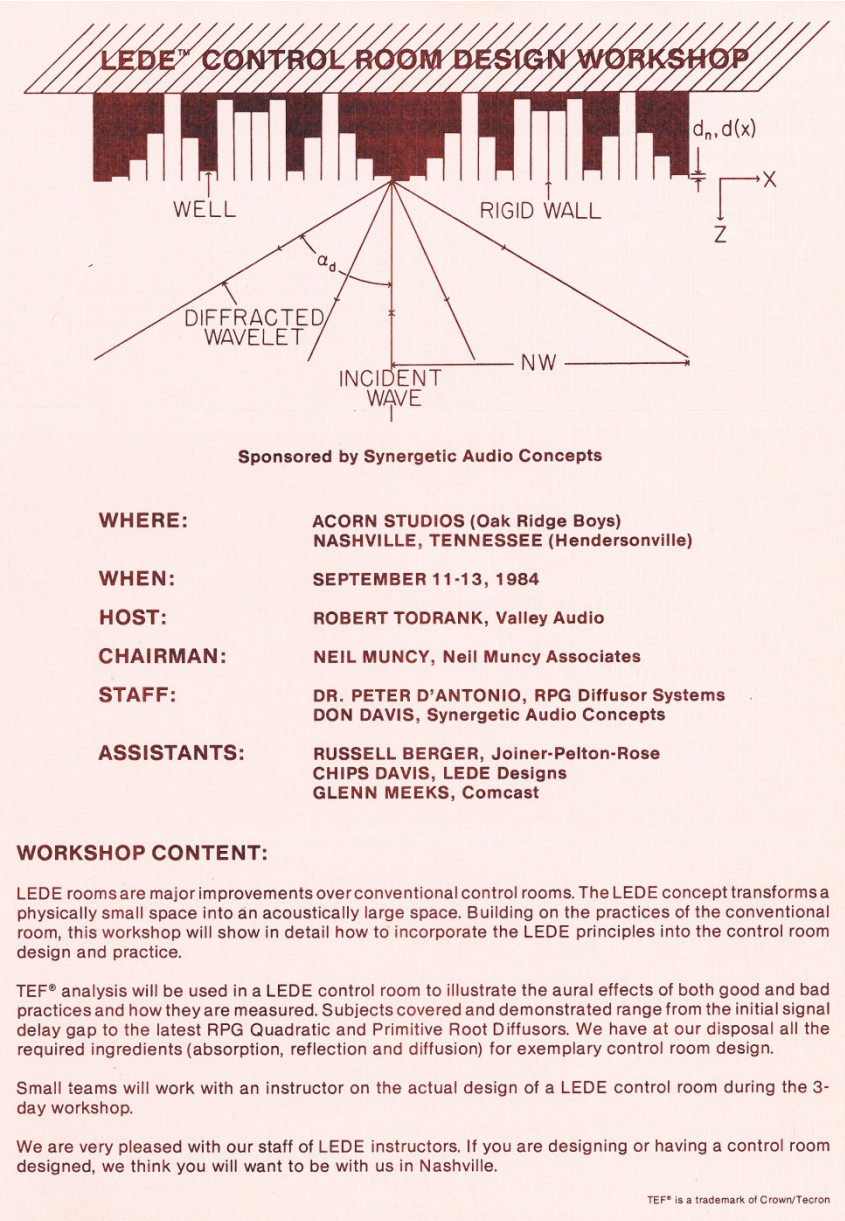
So before you start that new studio, consider your needs carefully; articulate your requirements in as much detail as possible. And remember the Boy Scouts motto (for the sake of those who were too busy learning to play the electric guitar during their scouting years, it's "Be Prepared"). A comprehensive, well documented design that includes all elements of the construction, will produce a better space, allow accurate budgeting, and keep a project on schedule. ■

***Biography: Vin Gizzi is a consultant and designer of audio facilities. He is based in New York City and writes occasionally on audio subjects.***



Figure 1. Mix Magazine August 1984

# 1984: LEDE Control Room Design Workshop



LEDE™ CONTROL ROOM DESIGN WORKSHOP



Sponsored by Synergetic Audio Concepts

**WHERE:** ACORN STUDIOS (Oak Ridge Boys)
NASHVILLE, TENNESSEE (Hendersonville)

**WHEN:** SEPTEMBER 11-13, 1984

**HOST:** ROBERT TODRANK, Valley Audio

**CHAIRMAN:** NEIL MUNCY, Neil Muncy Associates

**STAFF:** DR. PETER D'ANTONIO, RPG Diffusor Systems
DON DAVIS, Synergetic Audio Concepts

**ASSISTANTS:** RUSSELL BERGER, Joiner-Pelton-Rose
CHIPS DAVIS, LEDE Designs
GLENN MEEKS, Comcast

**WORKSHOP CONTENT:**

LEDE rooms are major improvements over conventional control rooms. The LEDE concept transforms a physically small space into an acoustically large space. Building on the practices of the conventional room, this workshop will show in detail how to incorporate the LEDE principles into the control room design and practice.

TEF® analysis will be used in a LEDE control room to illustrate the aural effects of both good and bad practices and how they are measured. Subjects covered and demonstrated range from the initial signal delay gap to the latest RPG Quadratic and Primitive Root Diffusors. We have at our disposal all the required ingredients (absorption, reflection and diffusion) for exemplary control room design.

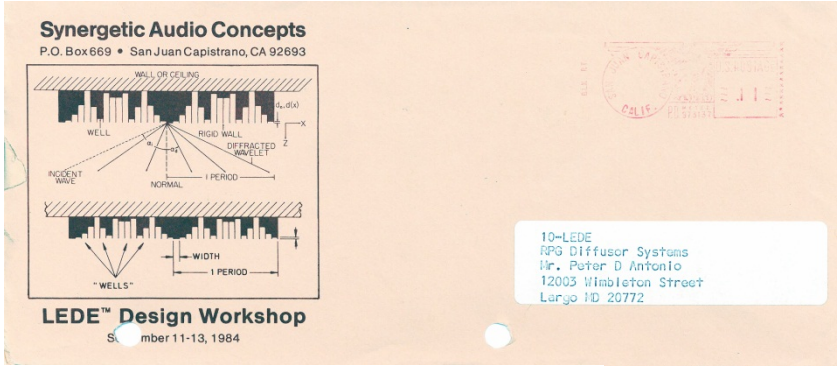
Small teams will work with an instructor on the actual design of a LEDE control room during the 3-day workshop.

We are very pleased with our staff of LEDE instructors. If you are designing or having a control room designed, we think you will want to be with us in Nashville.

TEF® is a trademark of Crown/Tecron

Figure 1. Workshop announcement.

The Syn-Aud-Con LEDE Control Room Design Workshop at Acorn Sound Recorders, Figure 1 and 2, was a wonderful opportunity for Dr. D'Antonio to share his research and experiences with an emerging group, Figure 1, which would become the industry's leading studio designers. This meeting resulted in many life-long friendships with Charles Billelo, Neil Grant and Neil Muncy among others.



Synergetic Audio Concepts
P.O. Box 669 • San Juan Capistrano, CA 92693



LEDE™ Design Workshop
September 11-13, 1984

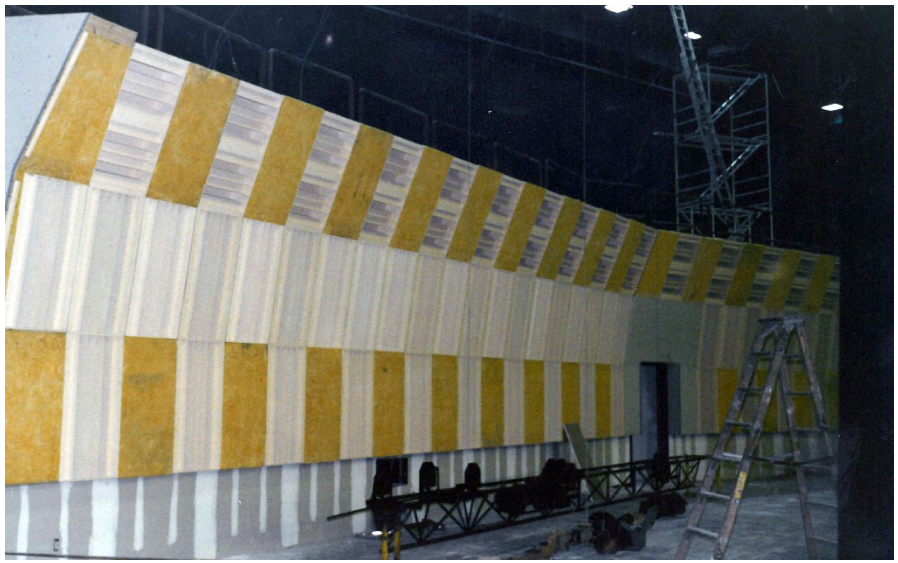
10-LEDE
RPG Diffusor Systems
Mr. Peter D Antonio
12003 Wimbleton Street
Largo MD 20772

Figure 2. Envelope RPG graphic.

Figure 3. Photo of the Syn-Aud-Con LEDE Design Workshop at Acorn Sound Recorders.

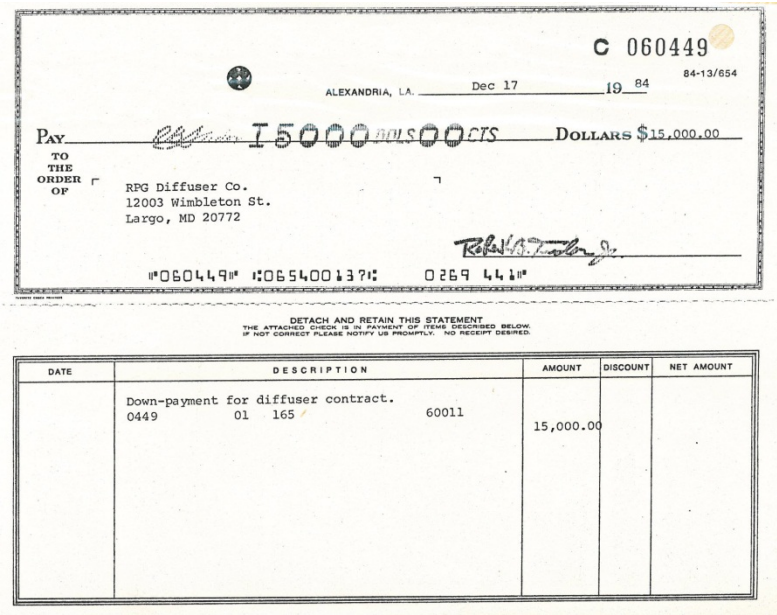
# 1984: First Major Project

RPG's first major project designed by the Joiner Rose Group was the Swaggart World Ministry Center with nearly 600 diffusors. RPG had recently moved from the garage to a 20' x 40' rental area. The diffusors nearly filled the entire volume during production. QRD 734 diffusors filled a couple of trucks. Some of the units were used on the upstage wall as an acoustical shell.



The rest were used in the ceiling.

Since RPG was just moving out of the garage, this project infused welcome capital!



C 060449

84-13/654

ALEXANDRIA, LA. Dec 17 19 84

PAY I5000 DOLS 00 CTS DOLLARS $15,000.00

TO THE ORDER OF

RPG Diffuser Co.
12003 Wimbleton St.
Largo, MD 20772

⑈060449⑈ ⑆065400137⑆ 0269 441⑈

DETACH AND RETAIN THIS STATEMENT
THE ATTACHED CHECK IS IN PAYMENT OF ITEMS DESCRIBED BELOW.
IF NOT CORRECT PLEASE NOTIFY US PROMPTLY. NO RECEIPT DESIRED.

| DATE | DESCRIPTION | AMOUNT | DISCOUNT | NET AMOUNT |
|---|---|---|---|---|
| | Down-payment for diffuser contract.<br>0449 01 165 60011 | 15,000.00 | | |

# 1984: First RPG Publication

Dr. D'Antonio's description of the theory and application of the reflection phase grating diffusor was published in the AES Journal in April 1984.



## The Reflection Phase Grating Diffusor: Design Theory and Application*

PETER D'ANTONIO AND JOHN H. KONNERT

*RPG Diffusor Systems, Inc., Largo, MD 20772, USA*

The far-field diffraction theory of the Schroeder reflection phase grating diffusor, which provides broad-bandwidth wide-angle coverage, is reviewed. Design parameters are discussed, and theoretical diffraction patterns are presented for a quadratic-residue and a primitive-root example. The diffraction patterns are obtained using a new reflection phase grating program, which was developed to facilitate the design and evaluation of these acoustical diffusors. Experimental energy–time curves are presented and discussed for two models. A few recording studio applications are mentioned, and a recent installation is pictured. Observations in recording control rooms suggest that the reflection phase grating diffusor helps maintain the stereo perspective across the width of the mixing console and adds the sweetening of a concert hall to a treated room.

### 0 INTRODUCTION

Many new and ingenious advances in architectural acoustics have been made in the last decade at the University of Göttingen, Germany, which hold promise for major improvements in the acoustics of sound recording and monitoring environments. Schroeder and his collaborators [1]–[6] have shown that, in addition to reverberation and spectral balance, lateral sound diffusion is a significant parameter which decreases interaural coherence (the similarity of sound reaching each ear) and increases listener preference in concert halls. To increase the amount of lateral diffusion, Schroeder developed a highly diffusing surface, which acts like a reflection phase grating and provides backscattering over a wide range of angles and over a broad bandwidth. With regard to reverberation, Schroeder and Hackman [7] and Gilbert [8] have recently shown that accurate values for reverberation time can indeed be calculated using integral equations for the spatial and temporal energy balance. The calculations reveal the inaccuracies of the classical formulas, which do not include room shape, absorber location, and the state of diffusion.

In an effort to stimulate the application and evaluation of the reflection phase grating diffusor, in acoustic spaces and critical listening environments as one would have in a recording studio and control room, we would like to:

1) Review the far-field Fraunhofer diffraction theory
2) Describe the necessary design parameters
3) Present a quadratic-residue (QR) and a primitive-root (PR) diffusor model example
4) Present calculated far-field diffraction patterns obtained with a new reflection phase grating computer-aided design and evaluation program—RPG[1]
5) Contrast the dynamic interference effects from a QR, a PR, and a cylindrical diffusor as a function of the frequency and duration of the incident sound
6) Present and explain experimental energy–time measurements on a QR and a PR diffusor model
7) Discuss a few applications, installations, and observations.

### 1 THEORY

Many approaches have been used to improve the diffusion of sound in critical acoustic environments. Room dimensions have been optimized, ceilings have been inclined, and walls splayed. Room surfaces have been covered with geometrically irregular shapes, po-

* Presented at the 74th Convention of the Audio Engineering Society, New York, 1983 October 8–12; revised 1984 January 31.

[1] RPG is a registered trademark of RPG Diffusor Systems, Inc.





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### THE AUTHORS

P. D'Antonio

J. Konnert

Peter D'Antonio was born in Brooklyn, New York, in 1941. He received a B.S. degree from St. John's University, New York, in 1963 and a Ph.D. from the Polytechnic Institute of New York in 1967. He has been employed as a research chemist at the Naval Research Laboratory, Washington, DC, since 1967, specializing in the atomic structural characterization of materials using electron, x-ray, and neutron diffraction techniques. In a private capacity, he designed and built Underground Sound Recording Studio in 1974, where he conducts acoustical research and is chief engineer. He is president of RPG Diffusor Systems, Inc., founded in 1983, to develop reflection phase grating diffusors to enhance the acoustics of critical listening environments.

Dr. D'Antonio is a member of the American Crystallographic Association, the American Chemical Society, Sigma Xi, and the Audio Engineering Society.

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John H. Konnert was born in Kingsville, Ohio, in 1941. He received a B.A. degree from the College of Wooster in 1963 and a Ph.D. from the University of Minnesota in 1967. He has been employed as a research chemist at the Naval Research Laboratory, Washington, DC, since 1967 and has developed many techniques for obtaining detailed atomic structural information from electron, x-ray, and neutron diffraction data. At present he is involved with micro- and nanodiffraction using electron microscopy. He is a founding member and vice president of RPG Diffusor Systems, Inc.

Dr. Konnert is a member of the American Crystallographic Association, the American Chemical Society, and Sigma Xi.



Figure 1. First AES Publication: J. Audio Eng. Soc., Vol. 32, No. 4, 1984 April, with authors bio.

At this AES Convention, RPG exhibited its products for the first time. A photo of the first exhibit badge, booth and interested visitor Pat Metheny.