Overview of Disco Sound Systems*

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Performance requirements and current techniques for disco sound system installations are described and referred to field experience in building many systems. Quality, reliability, and maintainability are discussed by considering the disco sound system as the key tool with which the club owner invests. While most techniques and equipment are known and readily available, some are not.

0. INTRODUCTION

Discotheques are a natural outgrowth of the demand for low-cost group entertainment and the change in demand from activities in which participants merely observe to activities in which the participants take part. Dancing is the activity. The supply to meet this demand became available when equipment capable of generating high sound pressure levels throughout the audio range, not just the presence range, came onto related markets—equipment good enough to enable the human body to be ensonified, for the senses to be engulfed. Equipment originally designed for home fidelity systems and for high-quality commercial sound reinforcement systems was used, modified in function or form according to the ingenuity of the system installer, to meet the need.

Modern music, created by musicians with electromechanical aids to produce the sound, is now not content to be played casually. For a group of people wanting to dance, the required variety in music cannot be met by one or two live groups. So playing carefully prepared recordings of many artists is a logical and economically sensible alternative. The recording artists themselves, with the help of ambitious producers, have encouraged the use of their recordings by building in elaborate special effects not practical to create during live performances. As long as artists continue to express themselves more effectively recorded than live, the discotheque, under a variety of names, shall remain a practical establishment.

Discotheques began in the late fifties but started to grow in large cities during the sixties. The early ones used low-cost home equipment with the loudspeakers all on one wall. Because no one knew if the interest in discos would go up and how long it would last, the trick was to do it as cheaply as possible. Sound pressure levels rarely exceeded 100 dB, but seemed louder because of the distortion.

Bass was conspicuous by its absence. Hearty loudspeakers capable of absorbing the clipped output of overworked low-power amplifiers enabled the disco to carry on despite many system breakdowns. The surviving establishments had either a reliably installed public-address-type low-fi system or a better one, operating part time with a resident engineer in constant attendance. A typical such installation is shown in Fig. 1.

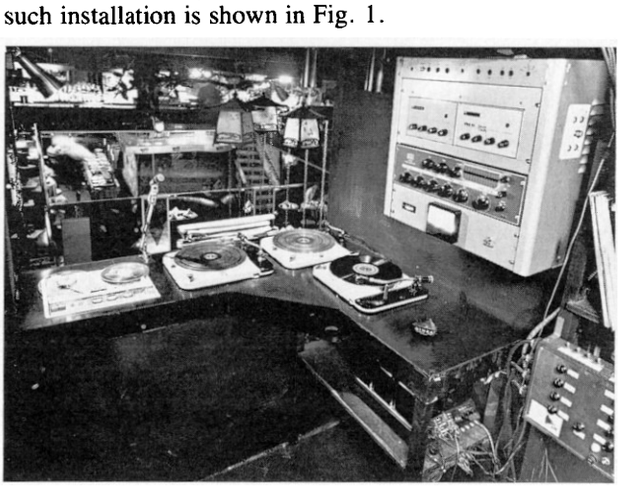

Fig. 1. Control room of a 1966 disco, with a new sound system installed in 1975. It has been in continuous operation since 1965.

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Most serious sound contractors declined to get involved in disco sound systems because of the alien environment. To traditionally conservative engineers accustomed to dealing with professionals, a mix of people from a wide range of socioeconomic backgrounds looked like a roadblock instead of a market—let alone a challenge.

Without feedback from established sound contractors, manufacturers did not know what equipment to make for this growing market. Fortunately our natural scientific and business curiosity won out, and today many sound contractors are getting involved with disco work. Established equipment manufacturers are cautiously slow in responding, but they are responding as the disco boom continues.

1. PERFORMANCE REQUIREMENTS

In the absence of corroborating evidence gathered during scientific tests conducted on humans in similar phases of captivity, the performance requirements summarized here are based on observations during building, improving, and servicing close to 300 different disco sound systems during the past thirteen years of disco evolution.

1) System reliability must be sufficient to keep a major portion of the sound system operational regardless of circumstances, except for a power failure.

2) The system must be capable of accurately and repeatably blending between program sources such as two records.

3) A sound pressure level of between 115 and 120 dB of full frequency range sound with minimum distortion, evenly distributed over the entire dance floor area, should be capable of being sustained for hours. ±3 dB uniformity is excellent, with ±5 dB being acceptable. The frequency response should favor the bass and very high end slightly.

4) Strong, fundamental bass, originating low to the ground, is needed to vibrate the dancers' legs and pelvic area. The system should be able to reproduce 40-Hz information at 120 dB on the dance floor.

5) Controllable bursts of high frequency energy, without harshness, must be evenly dispersed over the dancers' heads. A live tambourine or cymbal crash is not harsh, so its reproduction must not be either.

6) Complete control over the intensity of at least three portions of the sound frequency spectrum must be available.

7) The system is to be maintained by either a trained sound technician or an interested disc jockey, depending on specific circumstances.

8) A pleasing appearance and organized layout of the control room equipment will enable the disc jockey to efficiently control the system.

2. HOW THE REQUIREMENTS ARE MET

1) In no area of entertainment are the consequences of system unreliability as disastrous as in a disco. The disco experience may be visualized as a chariot racing across the desert in wartime. In such a case the rules are that the chariot must not stop under any circumstances. To do so will invite disaster from all quarters. Suitable precautions must be taken, therefore, during the building and outfitting of the chariot, to assure that the required operating conditions are met. This means multiple wheels on each side so that one getting split will not affect progress. It also means enough horses up front so that should one get tired or trip, he gets cut loose while the chariot continues. A spare horse behind or a spare wheel decoratively displayed won't do because hitching time is down time and pit stops are not acceptable during the journey.

When the sound system fails in a disco, patrons leave in an unhappy frame of mind and are not likely to return—ever. If the crowd is worked up enough at that moment there exists potential for a riot. These considerations merit heroic measures which always cost money to implement. There are no shortcuts.

System reliability is accomplished by using many shared components of the best available quality. It means using many medium-power amplifiers as opposed to one monster. It means using many loudspeakers working below their maximum capability; it means carefully installed and properly supported cables and tight connections, and it means a trained disc jockey. Finally, it means that if required, the installer must be available to help nights and weekends on very short notice, and he must stock replacements for the installed components.

2) Blending between records is accomplished by means of a stereo mixer–preamplifier and two high-torque turntables having adjustable speeds around the playing speeds of 33⅓ or 45 r/min. The output of one turntable is lowered as the output of the second is raised, the second having been synchronized as to speed of the dance beat during the cueing procedure just before. Some systems, like many radio stations, blend a general atmosphere and not a specific beat. In these systems adjustable turntable speed is not required. The turntables need to be acoustically isolated from the system's bass energy at resonant frequencies. Overcoming acoustical feedback and susceptibility to external shock is a major technical problem plaguing most disco sound systems. Feedback picked up at the turntables is nature's way of cautioning us to use good sense in not playing the system too loudly and endangering our hearing. If it were not for acoustic feedback, the average level of disco sound systems would be 6 dB higher. There are several techniques for reducing this problem, and none used so far works in every installation. Solutions range from bolting the turntable solidly to a rigid counter to very soft spring suspension and foam rubber supports in isolated stages.

3) To meet the sound-pressure-level requirement, a large number of efficient loudspeakers and amplifiers are needed. Correct power calculations are essential to ensure that the components operate below their peak capability most of the time to meet the reliability criterion of item 1.

4) The large amounts of bass energy needed are available using efficient bass horn designs, large-diameter loudspeaker drivers, and high-power amplifiers—equipment which is readily available, though not so much of it is specifically designed for disco use. A system deficient in bass lacks reliability because it gets pushed too hard. Fig. 2 shows a scaled up version of a conventional bass horn, camouflaged by mirroring its surface.

5) Bursts of high-frequency energy are generated using omnidirectional arrays of high-frequency transducers mounted above the dancers' heads. Horn-loaded compression drivers do this job mainly. They may be crossed over above 6 kHz. A typical array is shown in Fig. 3.

6) Control over at least three portions of the audio frequency spectrum is accomplished using an active electronic crossover network with front-panel-adjustable gain of its output. An alternative is to adjust the individual gains of the various power amplifiers, but this turns out to be not as practical to do.

7) The system components must be installed keeping in mind that they will need to be serviced regularly for various reasons. Components, no matter how good, fail occasionally and require repair or replacement in the system. The dusty, humid disco environment does not help. Sometimes, there is an accident. So they must be removable without taking the building apart or breaking up half the system. Components as well as interconnecting cables should be clearly labeled. Cables should have slack, strain relief, and protection from radio-frequency interference picked up from nearby lighting circuits.

8) The control room needs to be solidly built to minimize acoustic feedback. It must be organized to give the disc jockey ready access to all operating controls and provide good visibility of the dance floor area. Figs. 4 and 5 show typical control room setups. The disc jockey must have visual indicators, such as LED indicators or VU meters, telling him the condition of the system and how loud he is playing. Most importantly, he must be able to hear a proportional slice of what is happening on the dance floor. Although lighting, particularly special effects lighting, is a different discipline, the sound system installer should always provide proper turntable illumination as part of the sound system. Finally, the control room needs to be kept clean by operating personnel and periodically cleaned by the attending sound technicians.

9) To integrate the sound system with the physical environment requires early coordination with the club's designer, who must be made to see that the sound system is an important tool and not a necessary evil for his otherwise beautiful space. Figs. 6–9 show two such integrated systems. In discos already standing, camouflage may be the

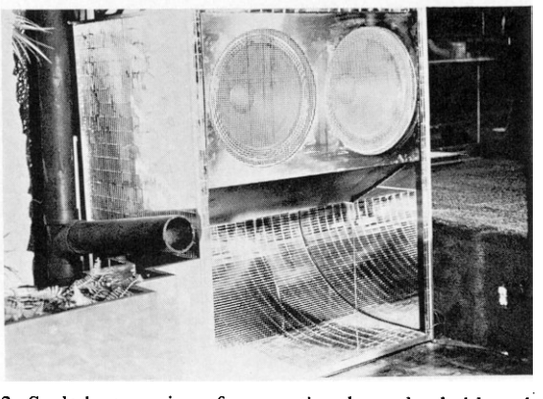


Fig. 2. Scaled up version of conventional rear-loaded bass horn camouflaged with mirrors.

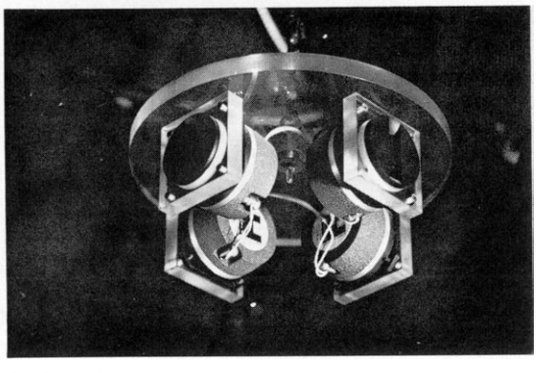


Fig. 3. Omnidirectional tweeter array using four horn-loaded high-frequency transducers in acrylic mounts developed in 1973. A protective capacitor is installed in series with the line from the power amplifier to stop low frequencies which sometimes develop during turnon.

Fig. 4. Turntable counter showing control mixer with electronic crossover network next to it. Counter is elevated on poured concrete foundation especially made not to touch the dance floor and outer protective partition, at left. Amplifiers and tape recorders are mounted in two floor-standing rack cabinets behind the disc jockey, to the right of the picture.

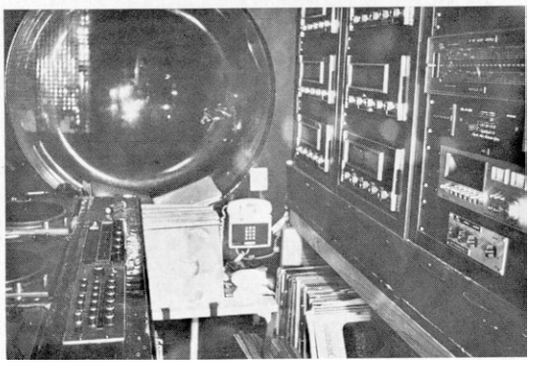


Fig. 5. Amplifiers are built into three table-top rack cabinets which are recessed into back control room wall.

only effective remedy. Sometimes clever use of lighting can hide the ugliest loudspeakers. An example of this is shown in Fig. 10.

3. EQUIPMENT REQUIRED

At this writing, there is not one definitive disco turntable on the market, regardless of price, which has the needed features. If it has isolated suspension, it lacks the torque. If it has both, it lacks adjustable speed, and so on.

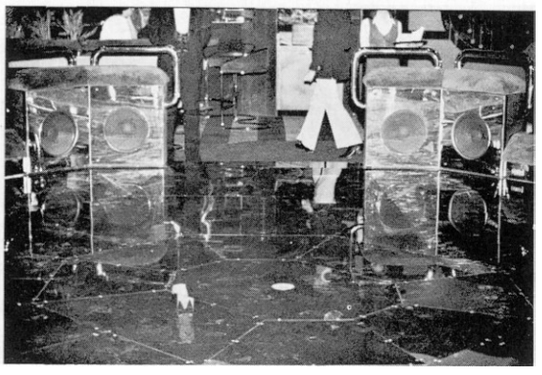


Fig. 6. Eight 15-inch (0.38-m) bass drivers are built into custom loudspeaker enclosures surrounding the dance floor. The front panel is a sandwich of two ¾-inch (19-mm) plywood panels and a ¼-inch (6.3-mm) mirrored acrylic plus an aluminum screen. The cabinets extend down below the dance floor.

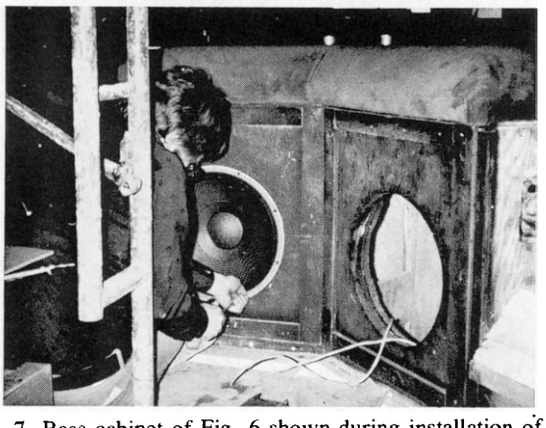


Fig. 7. Bass cabinet of Fig. 6 shown during installation of the loudspeakers. The enclosure is an infinite baffle design, lined with fiberglass on three interior surfaces.

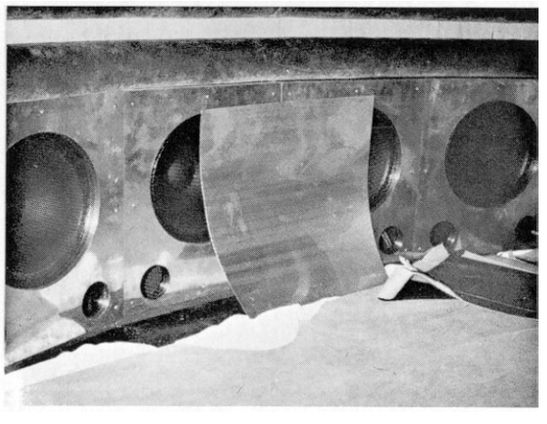


Fig. 8. A bass reflex enclosure design using four 18-inch (0.38-m) drivers in each of two such units, finished in brass and upholstered on top. The brass rail above the enclosure is not shown.

Some turntable manufacturers are working on the problems and we will most likely have such a turntable by next year. Meanwhile manual turntables designed for the home are used with special adaptations to comply with the system requirements.

With regard to control mixer–preamplifiers, there are several specially designed for the disco market. Most are unreliable, unable to pass even a spilled drink test. The rest lack the required operating features. Only one or two do the job at present, and barely. The area of electronic crossover networks and other signal-processing equipment is wide open for innovation. Perhaps some recording studio console designers will be inspired to come up with practical disco consoles and crossovers. Meanwhile we either modify available equipment or inefficiently make our own.

The amplifier area is in good shape. Lots of reliable designs abound. Loudspeakers are another story, however. Home systems are too inefficient. Sound reinforcement loudspeakers are not configured in ways practical to install in available spaces. A great deal of custom building is still needed in adapting available loudspeakers for disco use.

Some new loudspeaker manufacturers are rising to meet the demand, particularly for budget systems, but while their products look good on paper, they do not perform as

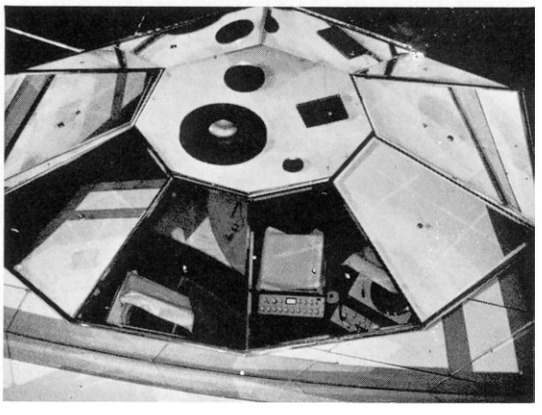


Fig. 9. Midrange and high-frequency loudspeakers built into mirrored ceiling.

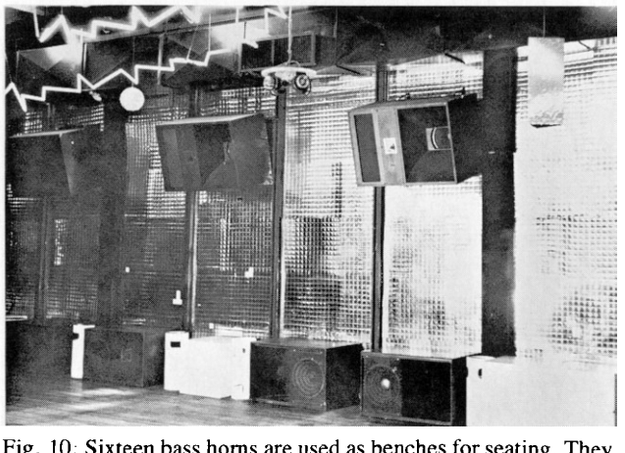


Fig. 10. Sixteen bass horns are used as benches for seating. They surround the dance floor. The midrange cabinets, painted flat black, disappear between the mirrored surfaces and special-effects lighting fixtures.

needed. We are confident that the major loudspeaker manufacturers will eventually fill the gap. What we can do to help, meanwhile, is to tell them what we need.

Finally, there are small items like cueing headphones which also are not available as needed. Headphone manufacturers will have to close that gap.

4. A TYPICAL HIGH-PERFORMANCE DISCO SOUND SYSTEM

A typical high-performance disco sound system may be installed in a space of 6000 ft² (558 m²) with a 12-ft (3.6-m) high ceiling, having a dance floor of 25 × 45 ft (7.6 × 13.7 m). In such a system the midrange two-way loudspeakers M are suspended around the dance floor, as shown in Fig. 11. The locations of the floor-standing bass loudspeakers and suspended tweeter arrays are also shown in Fig. 11. Fig. 12 shows a typical rack cabinet housing the power amplifiers.

It is recognized that separating the various drivers by a distance which is large in comparison to the wavelength of the frequencies they reproduce, creates phase discontinuities adversely affecting source localization or preservation of a "solid" source. The penalty for spreading the sources wide is, however, far less than that for not providing the needed coverage and effects. Because of economic and physical space considerations it is not always possible to meet both requirements in an installation. One such system which has both, whose functional block diagram is shown in Fig. 13, has eight full-range biamplified three-way loudspeaker systems built flush into the ceiling 10 ft (3 m) above a 15 × 20 ft (4.5 × 6m) dance floor. Augmenting these full-range systems are two bass horn loudspeakers, floor mounted at one side of the dance floor. The bass units are fed with audio information below 100 Hz. The full-range units in the ceiling get cut off at 18 dB per octave, using the same electronic crossover network at 100 Hz. One of the benefits of this layout is that less sound reaches the outlying area beyond the dance floor, which in this case was a design requirement.

Getting back to the typical high-performance system, the system block diagram of Fig. 14 shows three turntables, two tape recorders, and two microphones as the program sources. The third turntable is optional and serves as a spare should one of the essential two fail. It also comes in handy during on-the-spur-of-the-moment blend ideas involving special sound effect records and/or other third records. It offers added opportunity for creativity to the disc jockey. The tape recorder is used to record the sessions' activities for playback in the future or elsewhere. A

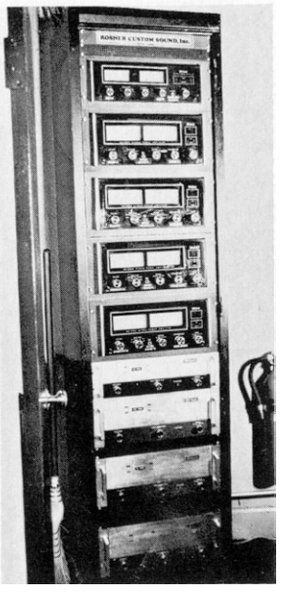


Fig. 12. Amplifier rack cabinet housing power amplifiers. The cabinet sits on wheels so that the rear is accessible for service. It is also oriented so that the disc jockey can see the meter without difficulty.

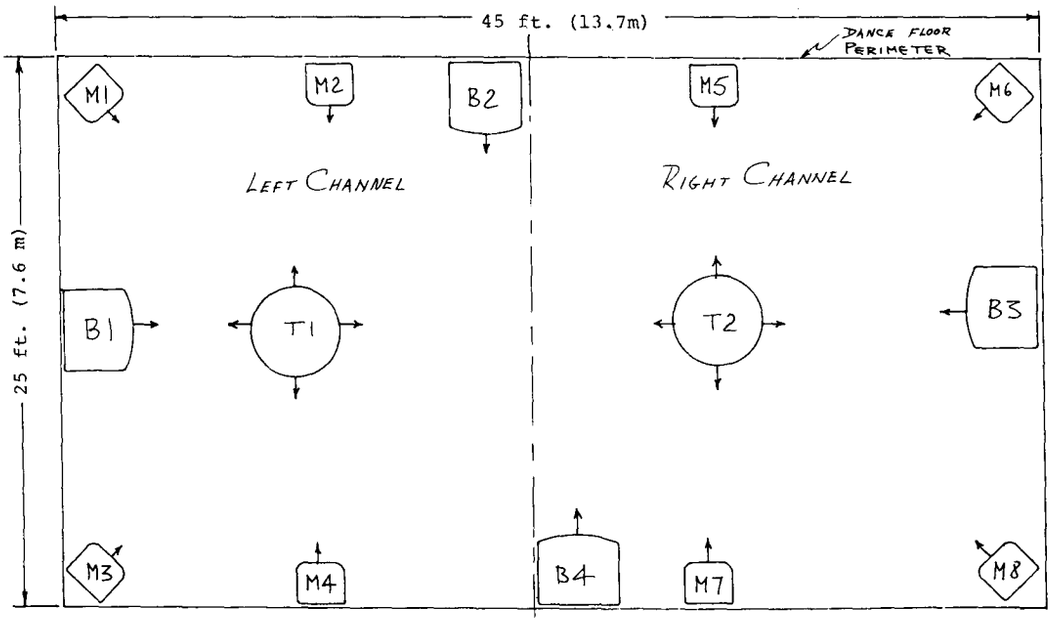


Fig. 11. Plan view of loudspeaker layout in dance floor area of high-performance disco sound system. B — Bass loudspeakers on floor; M — Midrange loudspeakers on wall or suspended; T — Tweeter arrays, suspended.

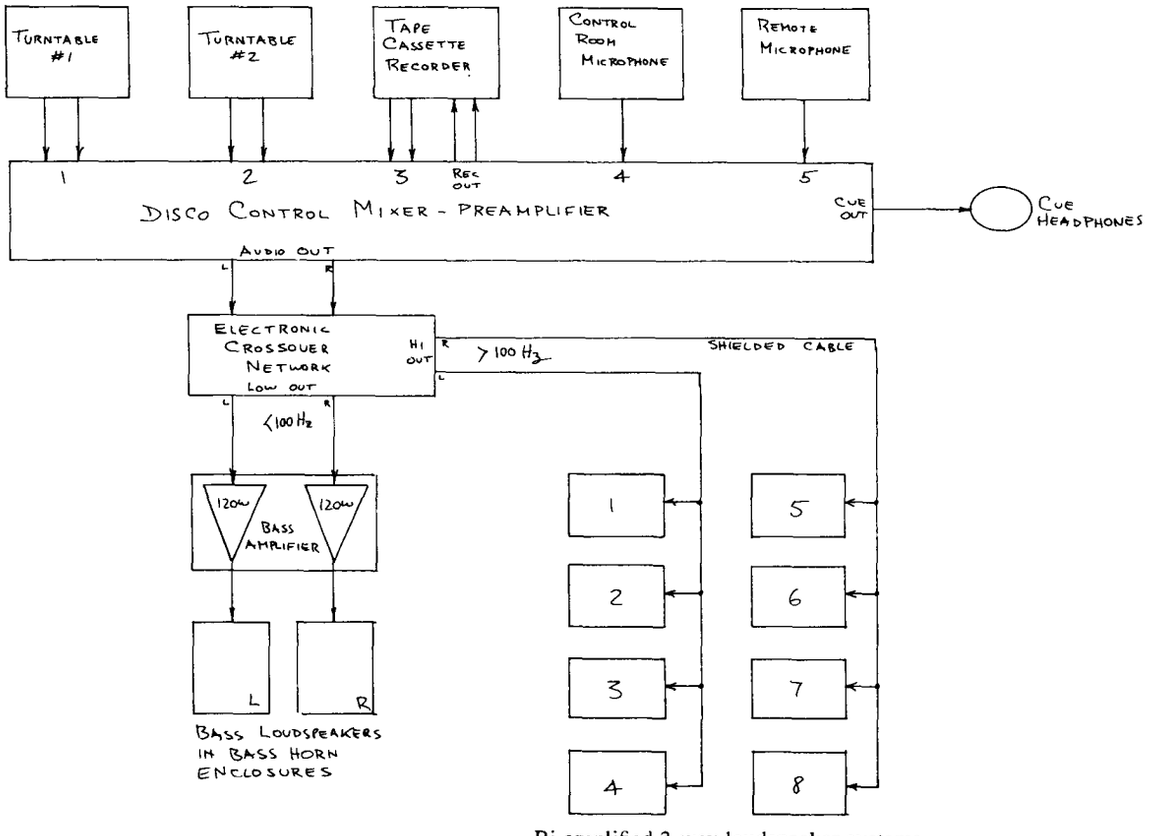
tape cassette recorder does the same thing in a simpler way at some sacrifice in sound quality. Sometimes the tape cassette recorder is used to program a visual slide show. If desired, a synthesizer or rhythmer can also be added to the system, increasing the available sources of sound.

A permanently mounted goose-neck microphone enables the disc jockey to make rare announcements. A remotely located microphone jack makes possible the connection of a hand-held low-impedance microphone or the output of a sound reinforcement control console to the sound system during special events.

The disco control mixer has a cue headphone output, enabling the disc jockey to listen to any of the program sources, regardless of which one is being blended out to the dance floor. The mixer output feeds an active electronic crossover network via a frequency equalizer adjusted for the room, then sealed. The crossover network divides the audio spectrum into four parts at the three crossover frequencies or hinge points. The controls enable the disc jockey to flap around the hinges, thereby creating changes in the quality of the sound he is playing to the involved audience.

The room equalizer is adjusted using acoustical measuring instruments such as a real-time spectrum analyzer, for smooth response in the dance floor area. The response is adjusted for a rising bass and nearly flat high end. The signal from the various frequency sections is then fed to drive the corresponding amplifiers assigned to power their respective groups of loudspeakers. The amplifiers are responsible for continuously delivering their power, yet must protect themselves and the loudspeakers against the effects of being overdriven. No other component in the system chain is in as good a position from which to subdue potentially damaging input signals—regardless where and how they originate. Fortunately amplifiers having built-in limiting circuits that act when the amplifier just begins to distort are readily available from at least one manufacturer. Limiting earlier in the chain before the amplifiers means that the limiter has to be installed ahead of the electronic crossover network, unless more than one limiter is used. In such a case the limiter will have no effect when the disc jockey, in a moment of passion, raises the level controls on the active crossover network. Therefore the inclusion of a limiter there does not provide the needed safety. Which brings us to a discussion of compression, limiting, and dynamic expansion of the signal as applied to discotheques.

Some installers are using dynamic expanders in disco sound systems, and a few equipment manufacturers are beginning to market expanders specifically for discos. The benefits of using expanders in discos are questionable, however, because the dynamic range of most disco record pressings is more than the available dynamic range of a disco sound system when the system is being played in a



Bi-amplified 3-way loudspeaker systems with the amplifiers and electronic crossover network built in

Fig. 13. Functional block diagram of system using full-range biamplified loudspeaker systems above 100 Hz with additional bass horns for the bottom.

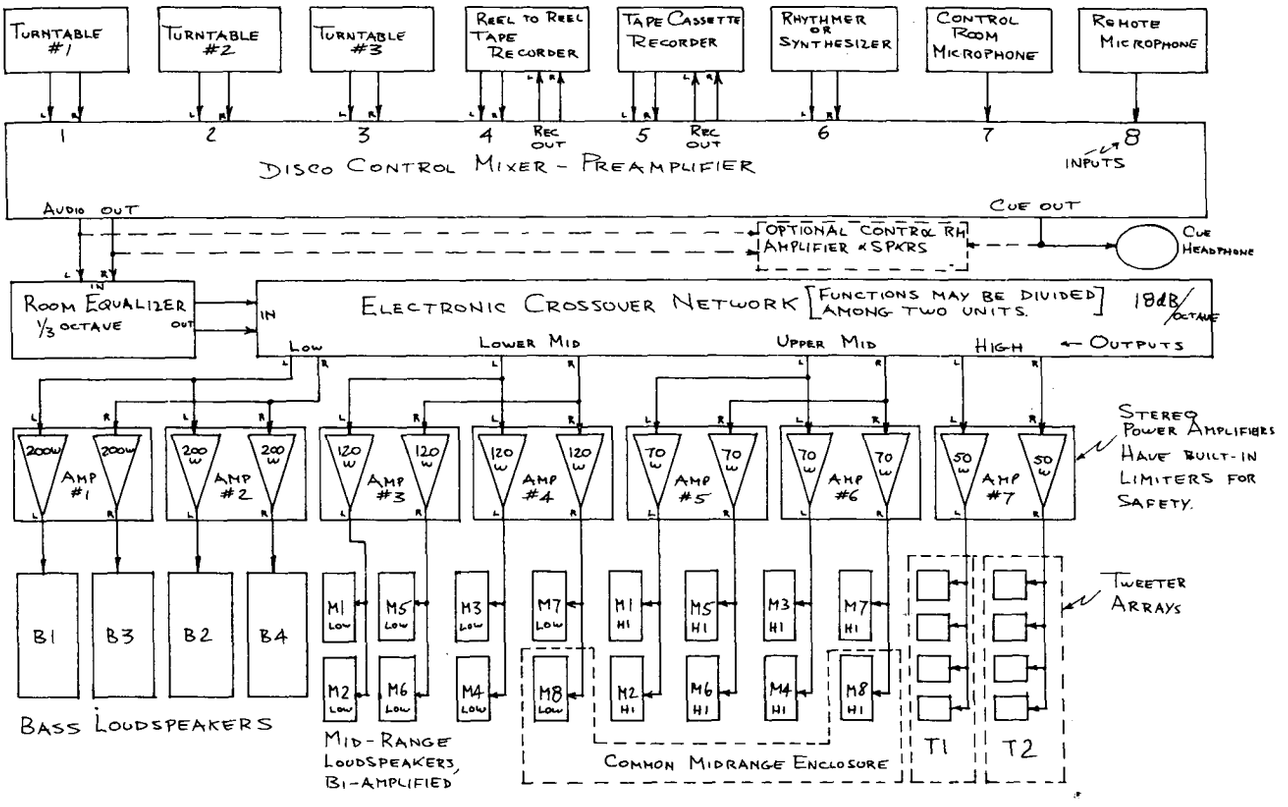


Fig. 14. Functional block diagram of typical high-performance disco sound system.

room full of active people. The high-end limit of the system's dynamic range is fixed by the maximum power the sound system can deliver in the room. The dynamic range expander cannot increase that. The low-end limit is determined by the noise level in the room, which without music is at least 85 dB in most rooms. A 120-dB ceiling, therefore, yields a 35-dB usable dynamic range, regardless of added expansion.

Compression, on the other hand, useful for background music, takes away from the realism here. So we need not fool with the dynamics, except manually to create desired special effects. The recording artists and engineers have already operated sufficiently on the original signal. That signal, such as it is, is preserved in the state they want it. Often an experienced disc jockey makes the final mix for the recording company. Our job, then, is to recreate it as faithfully as possible, with provisions for manual adjustment and special effects, should the disc jockey as artist determine that adjustment is desirable. The sound system, after all, is a tool the disc jockey uses to create effects for the audience. The tool needs to be built using sound engineering principles and in accordance with known and understood laws. Fortunately the state of the art of sound reproduction systems and equipment is sufficiently advanced to make possible high-quality reproduction at the required sound pressure levels, with the needed reliability and desired control flexibility. The wheel need not be reinvented, but we could sure use some sparkling new spokes.

An area that has been neglected but which will be receiving more attention in the future is room acoustics and corrective treatment of discotheque spaces.

Since the sound system is the most important tool the club owner invests in, it should be the best we know how to make. If we do not know how to make it, we had better learn because the demand is rising fast. In their enthusiasm to sell their sound systems, some installers are overly optimistic about results. A lack of knowledge of elementary acoustics plus unjustified dependence on unverified equipment specifications prepared by optimistic marketing departments results in systems impossible to upgrade without starting almost from scratch. Understandably club owners find this state of affairs hard to accept. Only when their sound system breaks down completely is a logical presentation for upgrading possible. To persevere in such circumstances, the sound contractor has to like what he is doing because there are easier markets to service. While it should by now be obvious, the effect of the sound system on the well being of a discotheque establishment is unfortunately not yet widely understood in a business segment constantly searching for success formulas. For this reason high-quality disco sound systems will not be installed everywhere just yet.

5. MOBILE DISCO SOUND SYSTEMS

In mobile disco sound systems there is the added requirement of portability. Careful design of the equipment housing is necessary. There is a need for quick system connect and disconnect. Sometimes the system operator must set up the system while under pressure and break it down when he is exhausted. Existing mobile systems consist of the necessary components externally connected to

make up the system. Set-up time can vary from half an hour to two hours. A professional mobile disco system consisting of four large loudspeaker systems, amplifier console, and control console can be set up in ten minutes. Such a system can have the same configuration as the four-way system described earlier, or it may be simpler. The components must be protected during moving with reasonable assurance that they will be operational at the next gig. One solution is shown in Figs. 15 and 16. The aluminum-covered cases interlock to form a solid operating base. Multipin connectors are used between the two cases, and illumination for the turntables is provided by means of a pair of goose-neck mounted low-voltage lamps. More elaborate systems can have their high-frequency horns elevated on a pole supported by floor-standing bass horn loudspeakers. Tweeter arrays may be elevated on tripods as well, as shown in the system of Fig. 17. Another kind of mobile system is shown in Fig. 18. This system remains in one location but is used in various rooms having permanent loudspeakers built in.

6. CONCLUSION

The present demand for discotheque sound systems is being met in varying ways by high-fidelity hobbyists, part-time installers, and professional sound contractors. Because of the transient nature of the disco business in general, a minimum investment is desirable, resulting in many low-cost–low-performance and/or low-cost–low-reliability sound systems requiring improvement. Also existing are reliable high-performance sound systems which enable discos to thrive. Some audio equipment

Fig. 15. Mobile disco sound system consisting of two interlocking cases plus four two-way loudspeakers on wheels. A separate dolly helps in moving the system around.

Fig. 16. The mobile system of Fig. 15 closed up ready for travel.

Fig. 17. An older mobile disco system with biamplifiers built into each loudspeaker enclosure and tweeter arrays on adjustable tripods. Lighting controls are built into the control console.

Fig. 18. A formica-covered mobile control console which connects to any of several rooms having built-in loudspeakers. One multiconductor cable does it all.

manufacturers, not having seen the disco demand as significant, were reluctant to tailormake products for the disco market, but they are starting to now. Performance criteria for discotheques are related to other sound system uses that we are all familiar with, so they do not come as a shock. Systems meeting this demand and the criteria are not inexpensive, but easily paid for from profits of a successful club in a relatively short time. There remain lots of challenging opportunities for creative work in new product areas as well as adapting existing products for disco use.

Finally, the pioneering effort is most gratifying. In no other area of sound system design, installation, and servicing does observance of the physical laws and attention to good engineering practice pay off as well as in the area of disco sound systems. The high price of low cost is clearly demonstrable here.

THE AUTHOR

Alex Rosner was born in Warsaw, Poland, in 1935. After five years in various German concentration camps where his and his father's musical talents were chiefly responsible for their survival, he emigrated to the United States at the end of World War II. Unable to read or write in any language, he began his formal education at age twelve.

He attended Brooklyn Technical High School in 1949. At Rensselaer Polytechnic Institute, where he received the BEE degree in 1957, his interest in audio developed. He joined the student section of the Audio Engineering Society and became active in school radio stations, playing accordion, and in hosting a live chamber music program.

Mr. Rosner worked in the defense industry. At Kollsman Instruments he designed ground support equipment for airborne navigation instruments. Three years later he joined the engineering staff of the Sperry Gyroscope Company where he designed factory test equipment for radar and sonar systems. During this time he also continued his studies at night at CCNY graduate engineering and business schools.

His music and audio hobby remained active all during this time and he began helping architect and interior designer friends with their audio installations. He wrote articles for *Audio* magazine as well as equipment reviews.

In 1967 Mr. Rosner founded Rosner Custom Sound, Inc. The company limits its business to high-end installations dealing with sound reinforcement, discotheques, and residences. It also performs laboratory evaluations on audio products for manufacturers, importers, and advertising agencies.

Mr. Rosner is a member of the AES and the IEEE.