AUDIO engineering society, Inc.

CENTRAL EUROPE SECTION

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HIGH-INTENSITY, MODULAR TRI- & QUAD-AMPLIFICATION LOUDSPEAKER SYSTEMS

Paper of the Convention '72
14.-16.3.1972 Munich / Germany

HIGH-INTENSITY, MODULAR, TRI- & QUAD-AMPLIFICATION/LOUDSPEAKER SYSTEMS

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SPECTRA SONICS

INTRODUCTION

High-intensity, power amplifier/loudspeaker systems that simultaneously provide high quality, reliability, flexibility and meet practical business objectives are outlined. These operating systems recently have been made feasible at a competitive cost by a unique development in the power amplifier field. A single, modular, plug-in power amplifier* with related electronic crossovers, and common card holder/power supply installation system provide the practical solution.

When utilized in conjunction with the proven principles of bi-, tri-, and quad-amplification, this versatile system assures an overwhelming RMS power (measurable in kilowatts), wide dynamic range, high-intensity acoustic output, low distortion, and improved transient response. And finally, it realistically meets practical business requirements such as competitive cost and flexibility.

PLUG-IN, BUILDING BLOCK APPROACH

After considerable development, a modular "building block" approach was selected and based on:

1. A plug-in power amplifier module which may be used singly for low power or in pairs for high power.
2. Plug-in electronic filter/stereo crossover modules to permit bi-, tri-, and quad-amplification.
3. A versatile pre-wired master card holder to hold combinations of the above plug-in modules.
4. A regulated power supply to power a complete card holder of the above plug-in modules.

More specifically, the actual building blocks are as follows:

Model 700 Power Amplifier: This solid state unit is manufactured in modular, plug-in, printed circuit card format (2½" x 10" x 2"). A single amplifier will deliver 25 WRMS or greater to an 8 ohm load. For maximum versatility, two of these modular amplifiers may be used together in a bridged (push-pull) configuration to deliver greater than 100 WRMS to an 8 ohm load. The amplifiers may be loaded with from less than 4 ohms up to infinity (open circuit), to power varying transducer loads. They are completely stable under reactive load conditions. As a protective feature, each plug-in power amplifier module is individually fused on its output. This provides a dual safety feature for the amplifier module plus each individual loudspeaker component.

*Patent Pending

The outstanding typical performance of this modular plug-in power amplifier is:

Continuous Power Output	60 watts RMS, delivered to a load. In bridged configuration (2 amplifiers) 120 watts RMS.
Power Response	Within ± .1 dB DC to 20 kHz, into 8 ohms at full output.
Total Harmonic Dist.	Unmeasurable--less than 1/100th of 1%, DC to 20 kHz, at full output.
Intermodulation Dist. 60 Hz & 7 kHz, 4:1	Unmeasurable--less than 5/100ths of 1% (test equipment residual) at full output.
Signal-to-Noise	Better than 100 dB below 30 watts, unweighted, 20 Hz to 20 kHz. Typically better than 120 dB.
Overload Recovery Time	Less than 1 microsecond for up to 1000% overload.
Slewing Rate	Better than 10 volts/microsecond.
Phase Shift	Less than 5° from DC to 20 kHz.
DC Temp. Stability	Unconditionally stable (stability factor = 1).
Maximum Ambient Temp	Up to 100°F without forced air cooling.

Model 505 Electronic Filter/Stereo Crossover: Each of these plug-in printed circuit card modules (2½" x 10" x 3/4") contain two line level electronic crossovers. For convenience, these solid state units are in the same format as the above power amplifiers. The electronic filters are available in a wide range of crossover frequencies to satisfy high pass, low pass and band pass applications. Some typical standard values are 800 Hz/800 Hz for two channel bi-amplification, 800 Hz/2500 Hz or 800 Hz/7000 Hz for single channel tri-amplification, etc.

The use of an active filter with separate buffer amplifiers to energize the various loudspeaker drivers alleviates problems caused by: passive crossover impedance mismatch, varying loudspeaker impedance with frequency, amplifiers and crossover loading requirements, etc.[1] Furthermore, these low level, active crossover units eliminate the need for large passive crossover iron-core inductors, resistive, and capacitive circuits between the power amplifier and individual loudspeaker voice coils. Thus, the rate at which the high level power amplifier energy can be transferred directly to each voice coil (transient response) is greatly improved.[2,4]

Model 202PC Card Holder: This unit provides a complete rack mounting installation system for up to 8 amplifier and/or crossover printed circuit card modules. The card holder provides complete bifurcated card connectors pre-soldered to a master printed circuit board, single bi-, tri-, quad-amplification configuration via simple strapping, PC mountings for two input transformers, eight balance/level potentiometers, output screw terminals, and most important, an excellent, continuous-plated, ground reference plane.

Model 403RS Regulated Power Supply: This heavy duty supply provides ± 25 VDC, 6 amperes maximum and many circuit protection features. It will power approximately one Model 202PC Card Holder rack full of Model 700 Power Amplifiers and/or Model 505 Electronic Filters. The supply is well regulated from no-load to full-load conditions. Rapid temporary increase in lighting demands, air conditioner loads, etc., often cause the AC line voltage to drop during special portions of a performance. This regulated power supply eliminates the significant 20% power loss which occurs with unregulated systems.

In total, these flexible building blocks may be arranged easily for:

1. Low power single amplifier systems.
2. High power bridged amplifier pairs.
3. High-intensity bi-, tri-, or quad-amps with kilowatt ratings.
4. All combinations of the above.

Following are a few typical installations which illustrate the varied flexibility and quality obtainable with this "building block" system approach.

QUAD-AMPLIFIED, HIGH-INTENSITY, COLUMNAR LOUDSPEAKER SYSTEM

Over 1.6 kWRMS of conventional power (single amp with passive crossover) per section is available with the 400 WRMS quad-amp/electronic crossover configuration shown below. This startling 4 to 1 available power increase is provided by the quad-amp. In total, both sections shown in Figure 1 provide 3.2 kWRMS of available peak power.

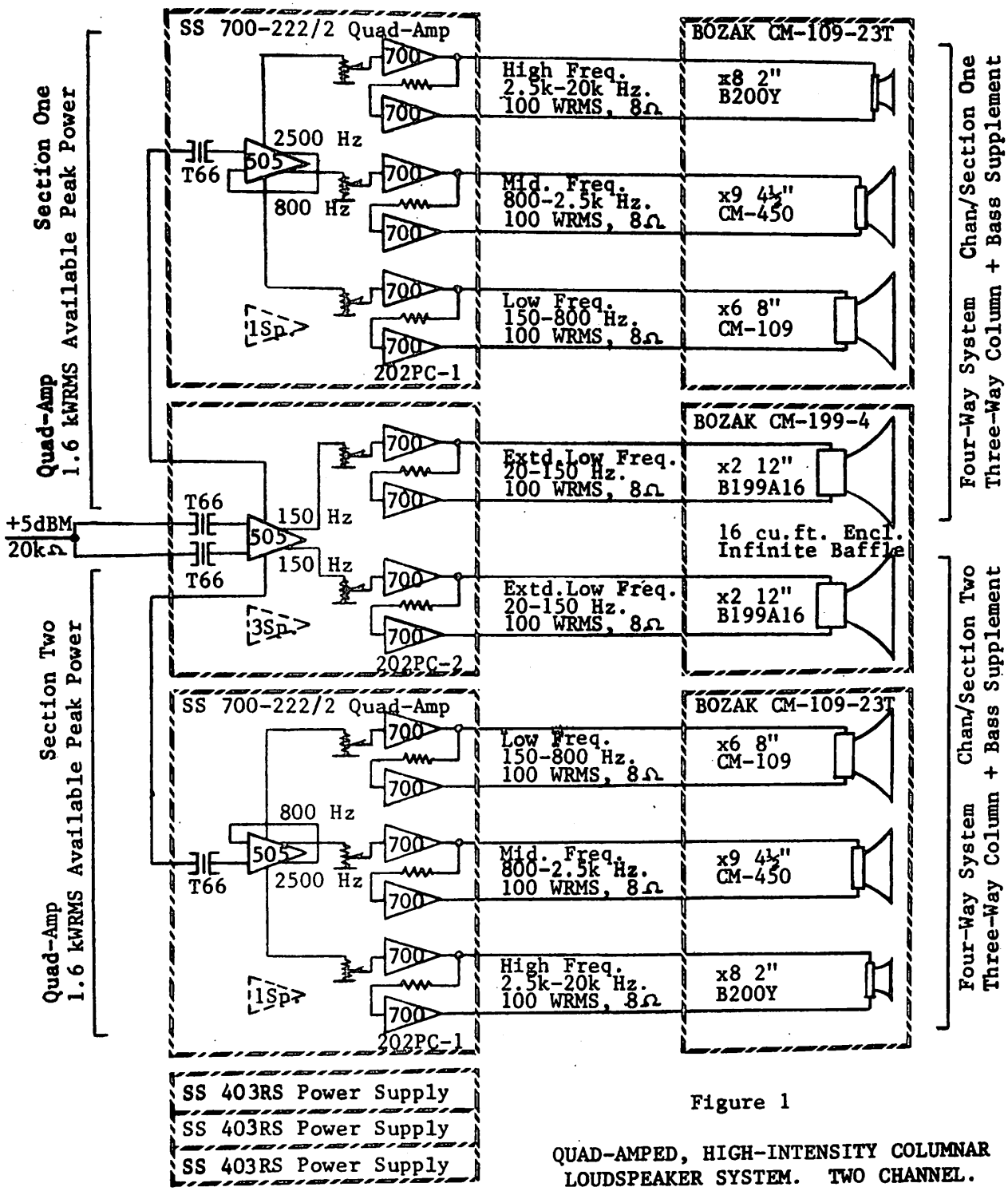

Figure 1

QUAD-AMPED, HIGH-INTENSITY COLUMNAR LOUDSPEAKER SYSTEM. TWO CHANNEL.

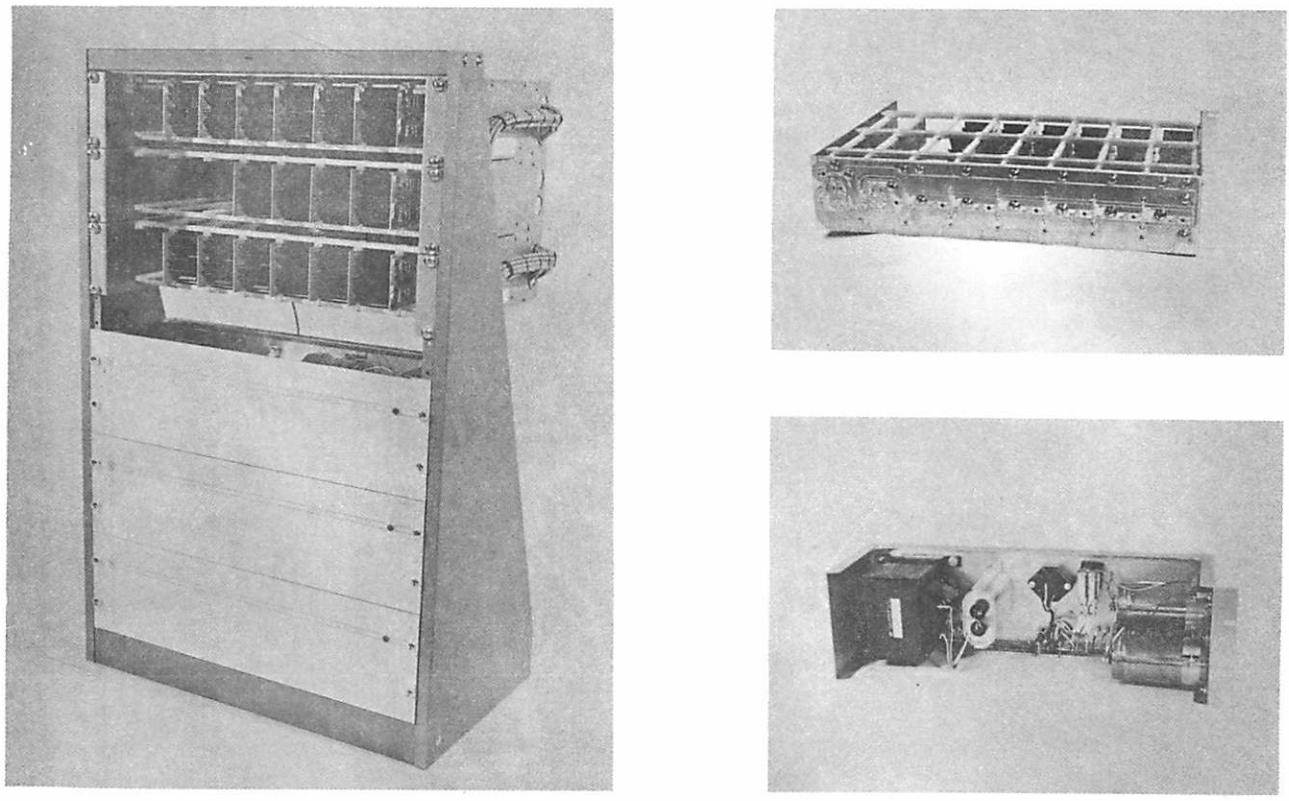

Figure 2

ELECTRONICS FOR TWO CHANNEL QUAD-AMP SYSTEM, FIGURE 1, PROVIDE 3.2 kWRMS AVAILABLE POWER. SEPARATE 202PC CARD HOLDER & 402RS POWER SUPPLY COMPONENTS SHOWN ON RIGHT.

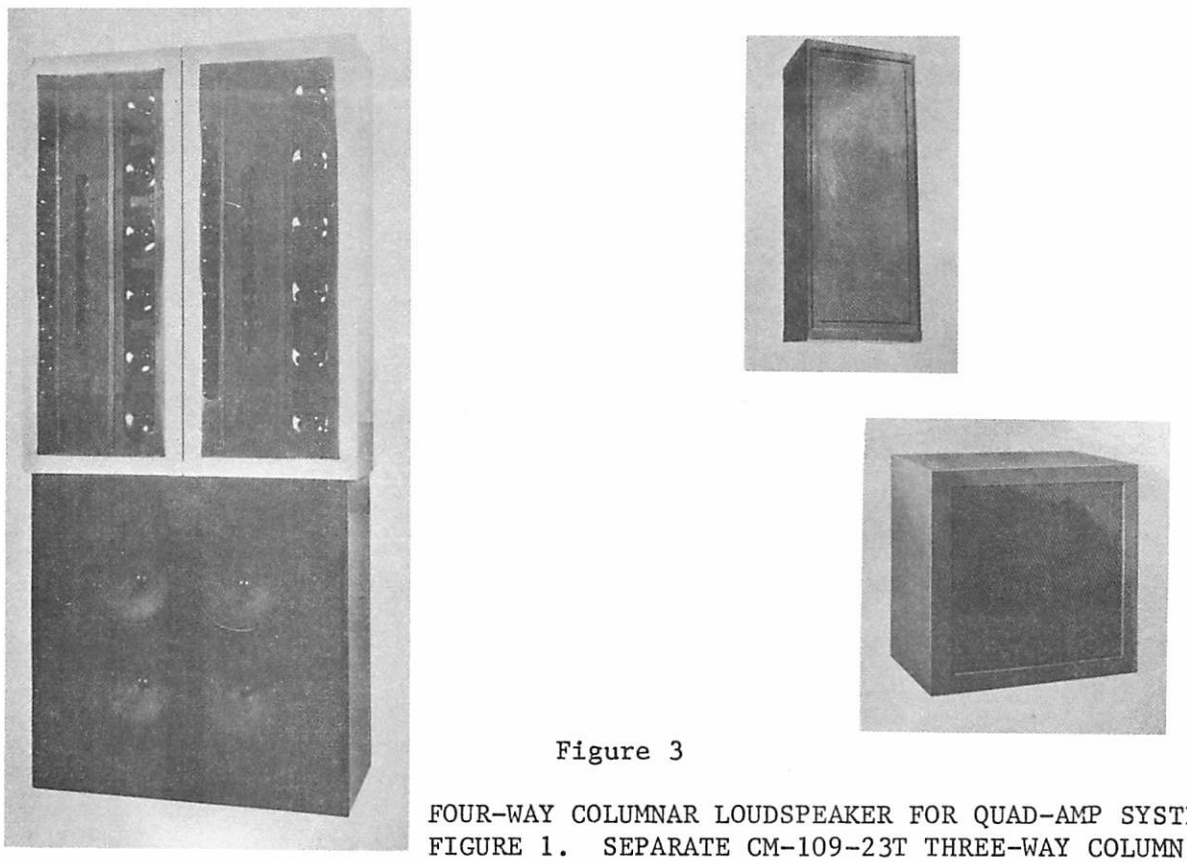

Figure 3

FOUR-WAY COLUMNAR LOUDSPEAKER FOR QUAD-AMP SYSTEM, FIGURE 1. SEPARATE CM-109-23T THREE-WAY COLUMN & CM-199-4 EXTENDED BASS COMPONENTS SHOWN ON RIGHT.

As stated, the effective power increase offered by quad-amplification is much more than just a marginal improvement that only a few select individuals can hear. This intense power availability may be mathematically illustrated as follows:

$$P = \frac{E^2}{R}$$ where, P = Power, watts RMS
E = Amplifier Output, volts RMS
R = Load Resistance, ohms

Referring to Figure 1, let us assume that the demand on this amplifier system simultaneously requires the full 100 WRMS for all four ranges. This may easily occur during a full range loud passage in a musical production or concert. Thus we develop the following amplifier voltage requirement for the individual frequency sections - high, mid, low and extended low.[2,4]

$$E_{High} = \sqrt{P_{High} R} = \sqrt{(100)\ (8)} = \sqrt{800} = 28.28 \text{ VRMS}$$

Similarly E_{Med}, E_{Low}, and $E_{Extended\ Low} = 28.28$ VRMS

Upon entering the terms, the final system equation for the full range quad-amplifier becomes:

$$P_{Total} = \frac{(28.28 + 28.28 + 28.28 + 28.28)^2}{8} = \frac{(113.12)^2}{8} = 1599.5 \text{ WRMS}$$
$$= 1.6 \text{ Kilowatts RMS}$$

Therefore, four 100 WRMS amplifiers in this quad-amplication configuration provide the equivalent peak power of a 1.6 kilowatt RMS amplifier being utilized in the single amplifier configuration. Thus the quad-amp provides a significant increase in available power and dynamic range of approximately 4 to 1!

From a financial/business viewpoint, in many cases the cost of four 100 WRMS amplifiers (8 ohms) will be less than the cost of one 1.6 kWRMS amplifier (8 ohms). Approximate cost of one section, Figure 1 amounts to: 1 ea. SS700-222/2 = $1,650.; 1 ea. CM-109-23T = $700.; 1 ea. CM-199-2 = $250.; which totals $2,600. However, cost of two channels as shown complete in Figure 1 is only approximately $4,750. Fortunately, as system size increases, cost per tri- or quad-amp decreases. This savings is due to fuller utilization of card holder spaces, crossover channels, and power supplies. In addition to the improved performance, the reliability and maintenance advantages of modular component amplifiers over one bulk amplifier are readily evident.

Frequency response of this quad-amp system is from 30 Hz to 18 kHz, very smooth and gradually rolls off at the high end. The system provides outstanding transient response and low distortion. Maximum acoustic output is approximately 127 dB at 10 feet on-axis. Each column provides a 90° horizontal coverage and a narrow 30° vertical dispersion. Polar pattern of the extended bass supplement portion is essentially omni-directional with some increase in level on-axis. Dimensions of this two section loudspeaker unit as shown in Figure 3, measure approximately 8¼'h x 3 3/4'w x 1 3/4'd.

A very large, fine quality quadraphonic four channel system utilizing the above quad-amplification system is in use at HARRAH'S South Shore Room, Lake Tahoe, Nevada. This system utilizes five clusters, each with two of the 1.6 kilowatt RMS sections shown in Figure 4, plus several supplemental systems. This large, busy casino showroom plays host to many major performers and musical production shows. Similar large systems are also used at the new ABC ENTERTAINMENT CENTER, SHUBERT THEATRE, Century City, Los Angeles, California, and the HOLLYWOOD BOWL, Hollywood, California.

TRI-AMPLIFIED, HIGH-INTENSITY, HORN LOUDSPEAKER SYSTEM

Approximately 0.9 kWRMS of conventional power (single amp with passive crossover) is available from the 325 WRMS tri-amp/electronic crossover configuration shown in Figure 4. This is almost a 3 to 1 available peak power increase obtained by the tri-amp!

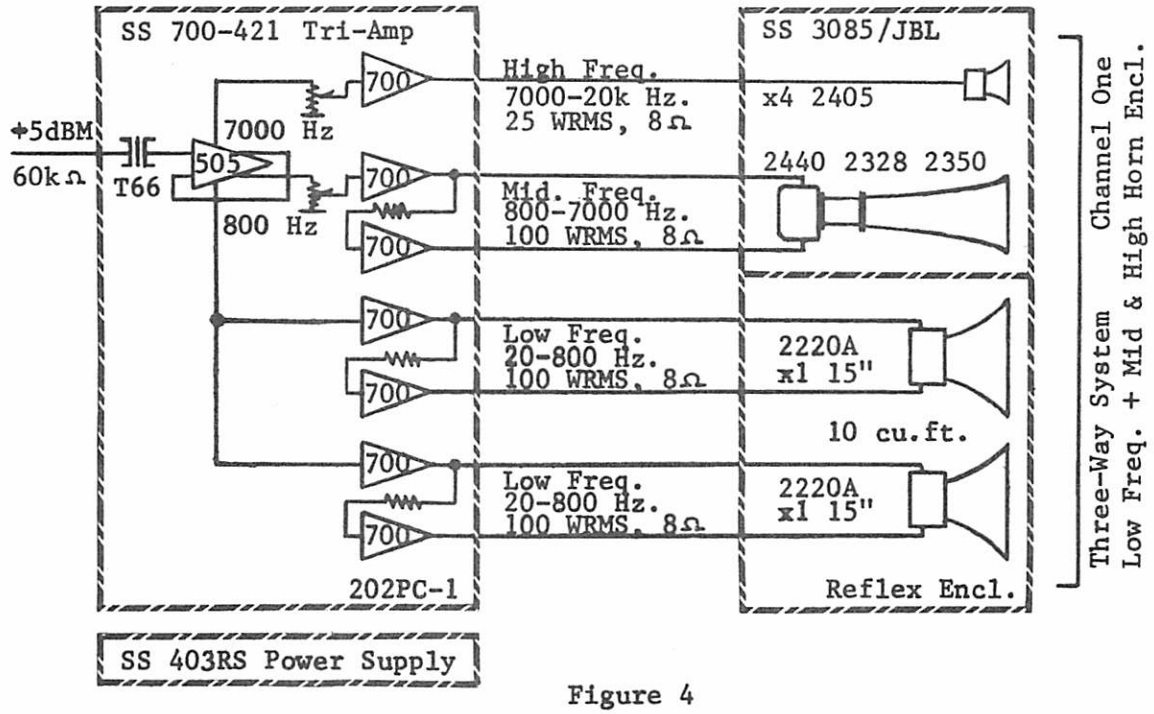

Figure 4

TRI-AMPED, HIGH-INTENSITY, HORN LOUDSPEAKER SYSTEM

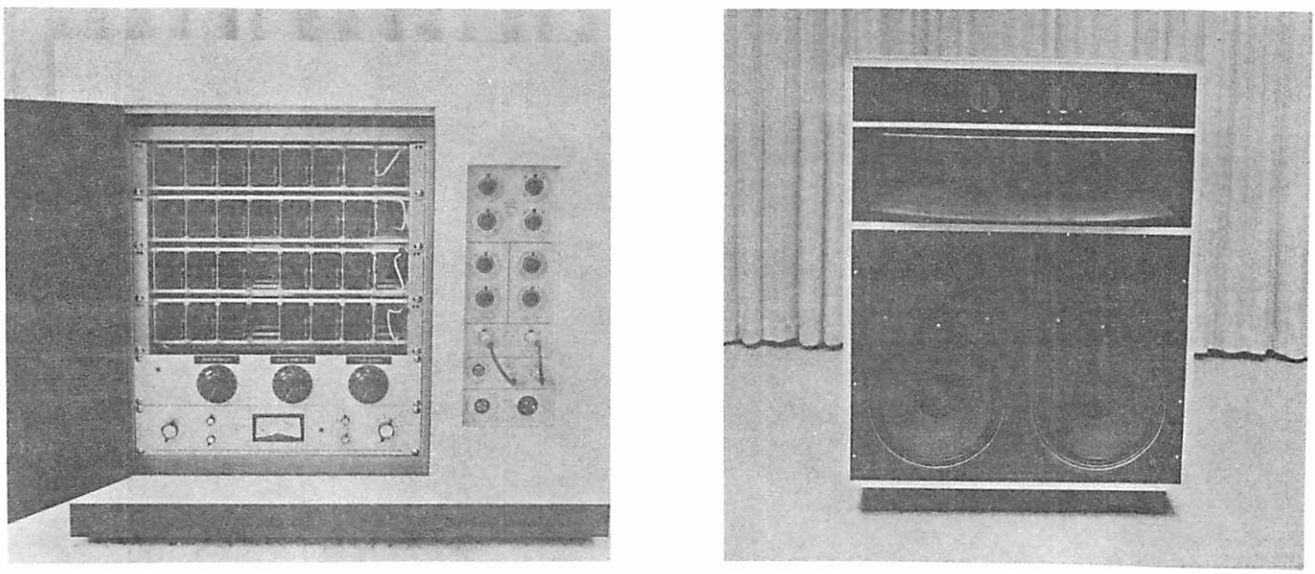

Figure 5

ELECTRONICS FOR FIGURE 4 SYSTEM, PLUS ELECTRONICS FOR AUXILIARY STAGE MONITORS AND STAGE APRON SYSTEMS. AN SS3085 HIGH-INTENSITY LOUDSPEAKER IS SHOWN ON RIGHT.

Approximate cost of one channel, Figure 4, as shown is: 1 ea. SS700-421 = $1,100.; and 1 ea. SS3085 = $1,325. which totals $2,425. Cost of two channels is approximately $4,850.

Figure 5 illustrates more detail of an electronics package, containing tri-amps as shown in Figure 4. The top two card holders are the Model 700-421 single channel, tri-amp systems. The third and fourth card holders are the Model 700-21/21 two channel, bi-amp systems used for two foldback monitors (for performers), and two low silhouette stage apron loudspeaker systems (for front audience fill). The bottom unit is a Model 610 Compressor/Limiter to provide additional power output. This unit establishes a maximum amplitude protection line, and thus a sustained maximum average level may be maintained. The "limiting only" mode eliminates the need for 10 dB (or more) margin conventionally set aside for overload protection.

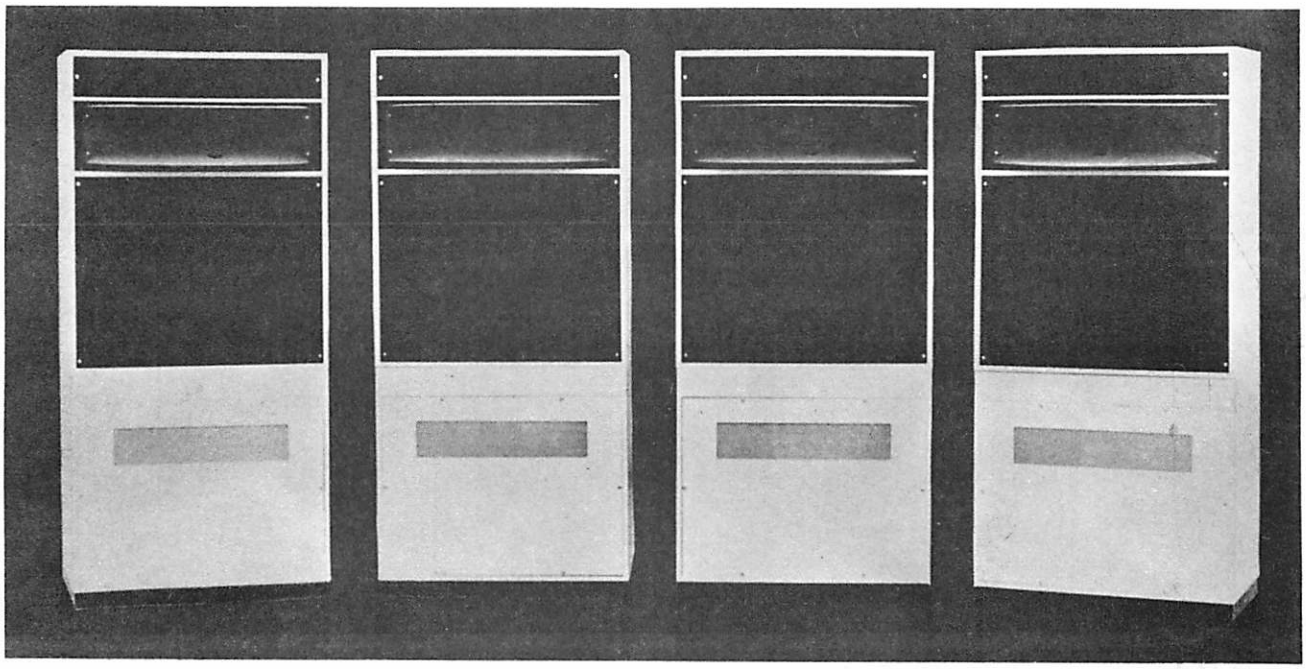

Figure 6

FOUR COMPLETE FIGURE 4, TRI-AMPED SYSTEMS.

Figure 6 shows four of these huge loudspeaker systems mounted on their self-contained electronics. Loudspeaker dimensions of each unit measure approximately 4'h x 3'w x 2'd. The electronics base adds another 3 feet to the height, bringing the total vertical height of each unit to 7 feet. The system is movable, portable, and may be broken down into several smaller systems.

The above high-intensity system provides a full range frequency response from approx. 40 Hz to 22 kHz with very accurate transient response characteristics. Continuous acoustic output is approximately 123 dB at 10 feet on-axis. In a semi-open auditorium, the system will easily maintain a level of 107 dB SPL. It is well suited for performing arts applications and contemporary concert programming. The mid/high portion provides approx. a 90° horizontal, 40° vertical polar pattern, with low bass portion approaching an omni-directional pattern as the frequency decreases.

The above system is located at the BLOSSOM MUSIC CENTER, Cuyahoga Falls, Ohio, for the summer season. During the winter season, it is used in SEVERANCE HALL, Cleveland, Ohio, for the CLEVELAND SYMPHONY OCHESTRA. Several similar high-intensity tri-amplified, horn loudspeaker systems are also in use at the TORONTO PAVILION, Toronto, Canada and at LONDON-DECCA, Vienna, Austria.

TRI-AMPLIFIED, HIGH-INTENSITY, HORN LOUDSPEAKER SYSTEM,
PRIMARILY FOR ROCK CONCERTS

Approximately 1.2 kWRMS of conventional power (single amp with passive crossover) is available from the 525 WRMS tri-amp/electronic crossover configuration shown in Figure 7. This is over a 2 to 1 available peak power obtained by the tri-amp!

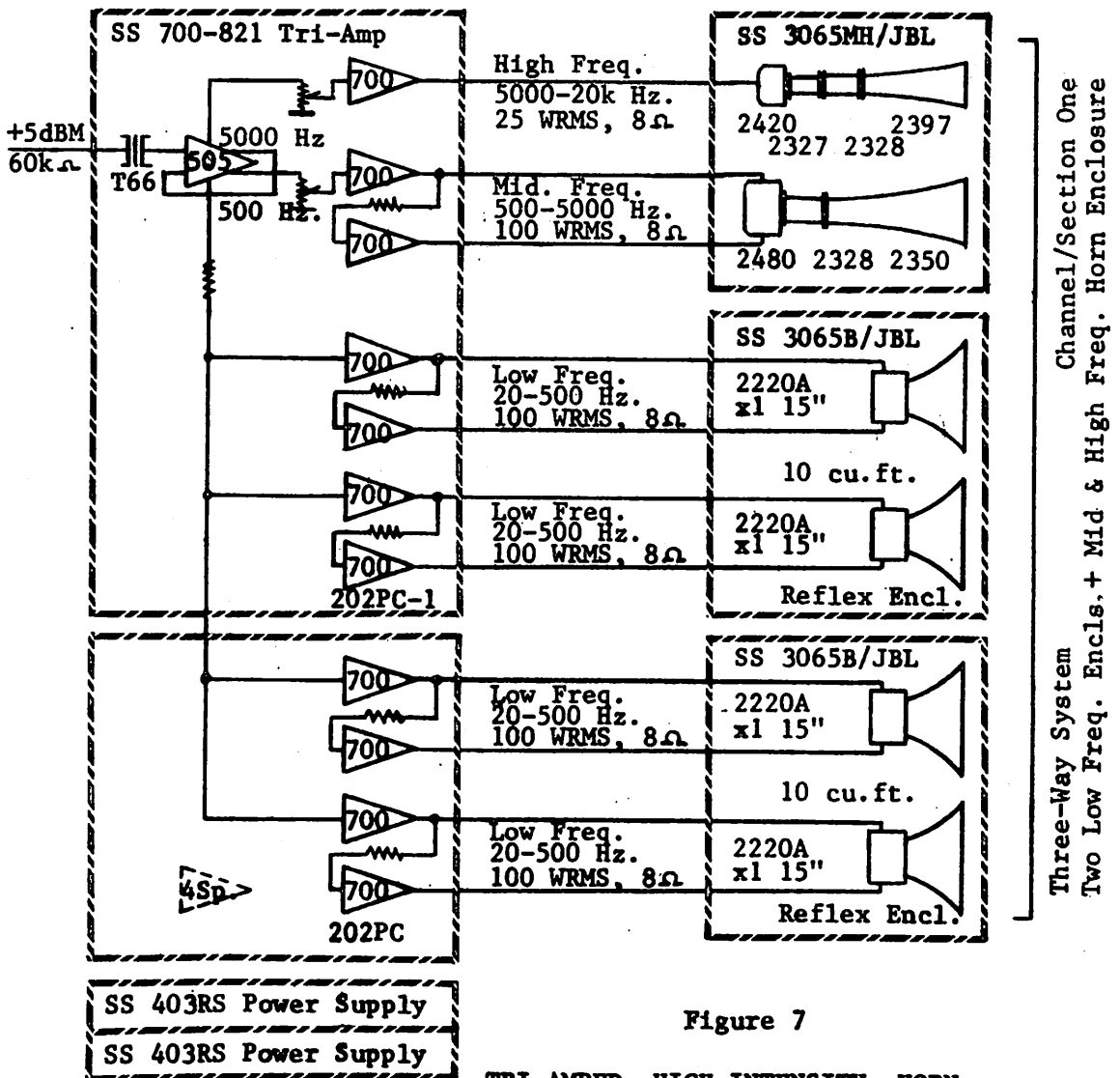

Figure 7

TRI-AMPED, HIGH-INTENSITY, HORN LOUDSPEAKER SYSTEM FOR ROCK CONCERTS.

Frequency response of this system extends from 40 to 15 kHz and gradually tapers off. The system utilizes the very durable phenolic diaphragm mid-range compression drivers specifically suitable for rock music. Continuous acoustic output is approximately 126 dB at 10 feet on-axis per system. Four of the above systems will easily sustain a level of 110 dB SPL within the center of a very large arena. Long throw capability of over 200 yards is possible by arranging the above system for maximum horn coupling, and maximum low frequency "piston size" effect. The mid/high enclosure provides approximately a 90° horizontal, 40° vertical polar pattern. The bass enclosure patterns approach omni as the frequency decreases.

Approximate cost of one channel as shown in Figure 7 is: 1 ea. SS700-821 = $1,750.; 1 ea. SS3065MH/JBL = $900.; and 2 ea. SS3065B/JBL = $850.; which totals $3,500. Fortunately, cost of two channels is only approximately $6,600. Loudspeaker dimensions of one channel measure approximately 6'h x 3'w x 2'd. Two channels are shown on each end of the stage in Figure 8, below.

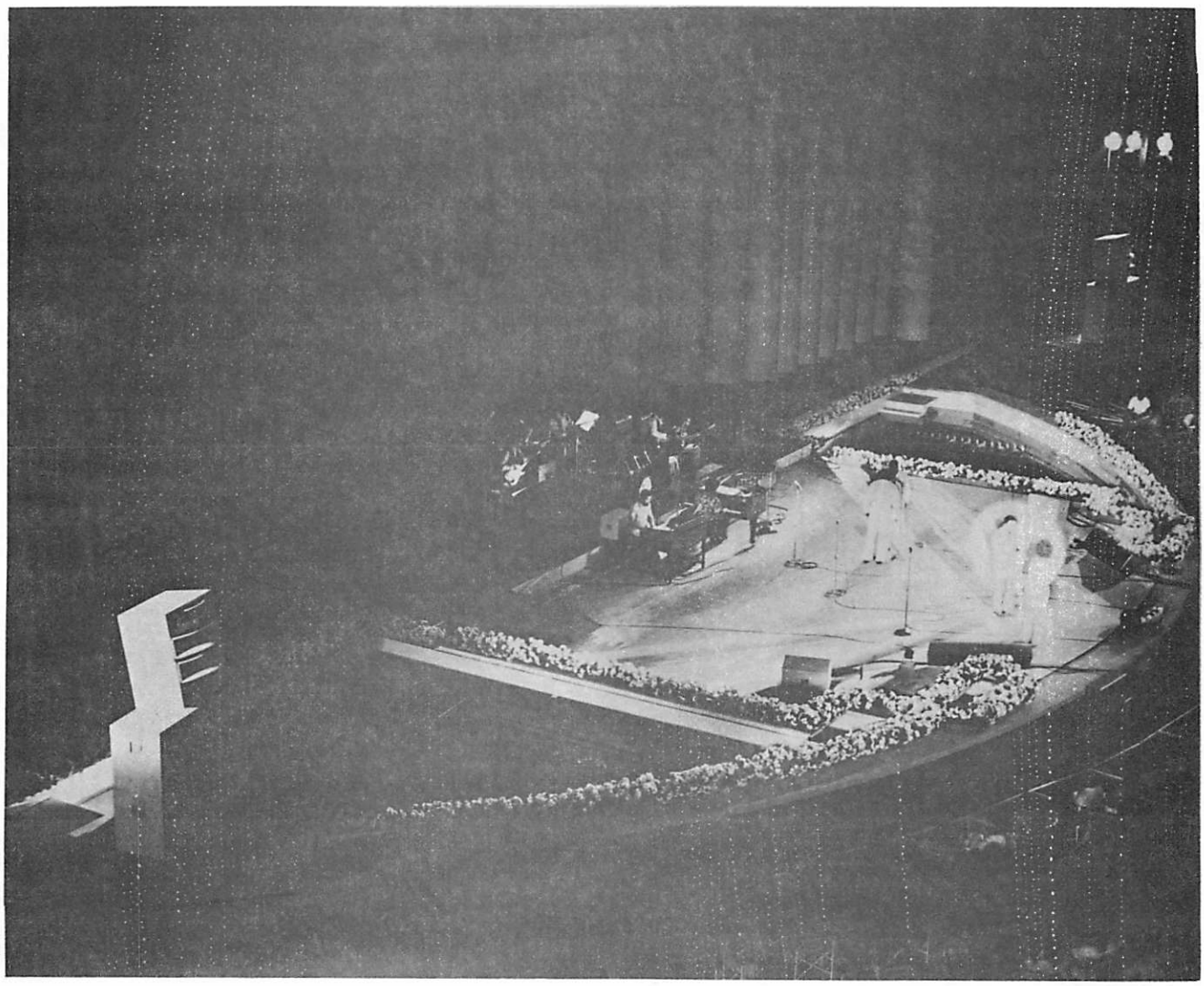

Figure 8

LOUDSPEAKERS FOR FIGURE 7, TRI-AMPED ROCK SYSTEM.
FOUR CHANNELS SHOWN, TWO ON EACH FAR END OF STAGE.

VELVET THUNDER, Hollywood, California, a sound services company, uses several of the Figure 6 systems. These systems have been used for large rock concerts featuring SLY & THE FAMILY STONE, THE OSMOND BROTHERS, etc. at THE FORUM, Los Angeles, California, EMERSON, LAKE & PALMER, THE CARPENTERS, 5th DIMENSION (as pictured above), JACKSON FIVE, etc. at the HOLLYWOOD BOWL, Hollywood, California, the quadraphonic rock opera, "TOMMY", AQUARIUS THEATER, Hollywood, and at many other west coast concerts from San Diego to San Francisco, California.

A similar portable large tri-amplified touring system also is owned by the MIKE CURB CONGREGATION. Their completely self-contained, tri-amplified system is designed to withstand export shipping for their overseas concert schedules.

TWO CHANNEL, BI-AMPLIFIED, HIGH-POWER LOUDSPEAKER SYSTEMS

These systems have been proven in many applications. As an example a 25 WRMS amplifier and a 100 WRMS bridged amplifier in the bi-amp configuration, provide the peak power available with a 225 WRMS amplifier in the single amp configuration. This dramatic 2 to 1 increase in available peak power, plus many other advantages of bi-amplification have been well established in previous writings[1,2,3,4]. A continuous acoustic output of greater than 110 dB SPL at 10 feet on-axis easily can be delivered by such systems. These two channel bi-amped systems have been utilized widely as studio monitors for recording and broadcasting studios, stage/proscenium monitors, foldback monitors, night club show loudspeakers, etc. A typical system is shown on the right.

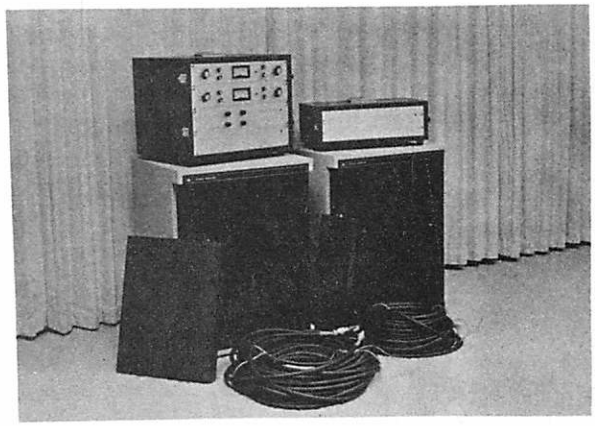

Figure 9

PORTABLE, TWO CHANNEL, BI-AMPED SYSTEM

BUSINESS ASPECTS

In the final analysis, the amplifier building block system described in this paper is particularly feasible, and competitively priced.

The system is expandable; one can start small and build to large. It is flexible; large systems can be re-configured completely by simply restrapping card holders without any loss in investment. There is commonality of product, in that only a single type of amplifier is required for all high and/or low power applications. Simplicity of repair and maintenance is obviously simple due to plug-in format, rather than complete system removal for inspection. Furthermore, immediate substitution is possible without down-time. All these contribute to a very competitively priced system.

SUMMARY

In summary, it's apparent that the approach described in this paper satisfies a wide range of applications, and is as versatile as the designer's imagination. We have shown that via tri-, and quad-amplification techniques, a dramatic increase in peak power and dynamic range is possible. Furthermore, we have briefly mentioned that elimination of the passive crossover permits a better transfer (transient response) between amplifiers and loudspeakers. And finally, the simplicity of the system format holds the cost competitive while assuring maximum quality for the single modular power amplifier and related crossover.

REFERENCES

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[2] Albert V. Siniscal, "Bi- and Tri-Amplification", Recording Engineer/Producer, March/April 1971, pp. 27-29.

[3] "Beyond the State of the Art, Bi-Amplified Monitor System", Spectra Sonics Newsletter 8-70, Fall 1970, pp. 1 & 2.

[4] Allan P. Smith, "Electronic Crossover Networks and Their Contribution to Improved Loudspeaker Transient Response", Journal of the Audio Engineering Society, Vol. 19, No. 8 (September 1971) pp. 674-679.