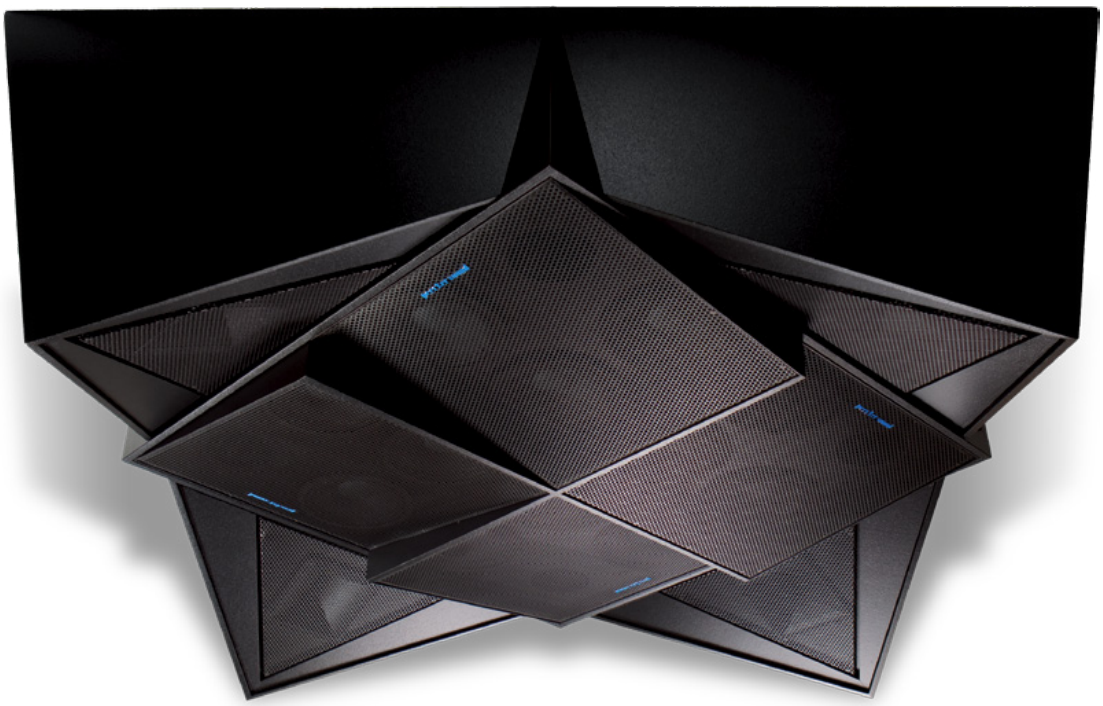
DOUBLE ARRAY

USER'S MANUAL



peecker sound®

SOUND REINFORCEMENT | CONTROLLED RADIATION | ACOUSTIC RESEARCH

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1. PROJECT PHILOSOPHY

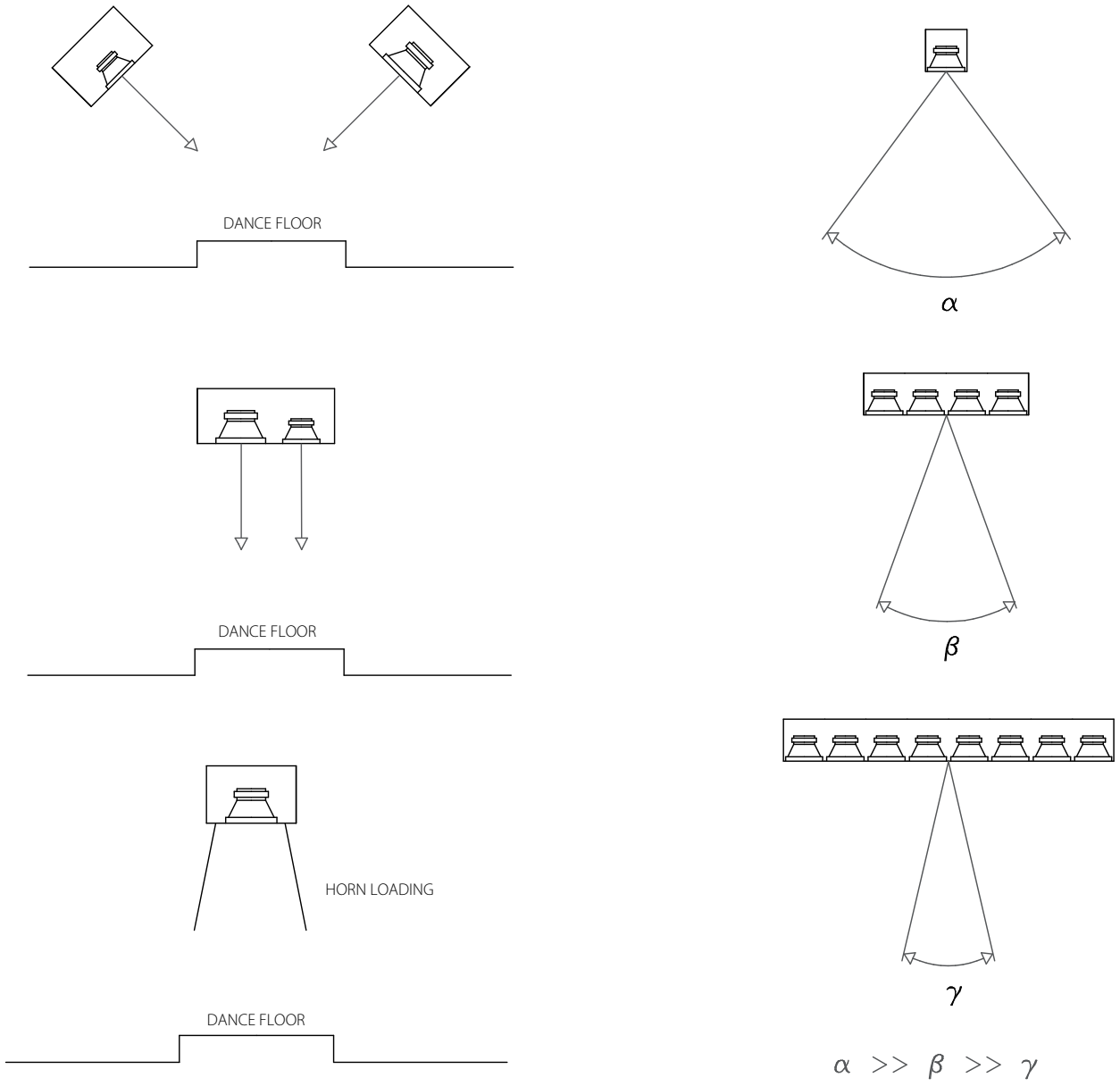
The main problem with sound reinforcement systems has always been to concentrate sound where it is actually needed and lower it perceptibly elsewhere.
Unfortunately, sound waves, by their very nature, are a serious hindrance to the achievement of this goal since they tend to be fairly directional at mid and high frequencies, while at low frequencies they remain omnidirectional. This phenomenon becomes immediately apparent when we move around any speaker. As we move away from the axis, we will notice a progressive lowering of the sound of voices and solo instruments, while the sound of the keyboard and electric bass guitar will remain unchanged.
Even if we try to concentrate sound by aiming the speakers towards the dance floor, or by suspending them from the ceiling, low frequencies will still produce high decibel values at a considerable distance from the dance floor, potentially causing serious problems of compliance with the noise pollution regulations.

If we try to channel sound to the dance floor by means of horns positioned inside or in front of the speakers, we will only make matters worse, as the sound quality will deteriorate unacceptably.

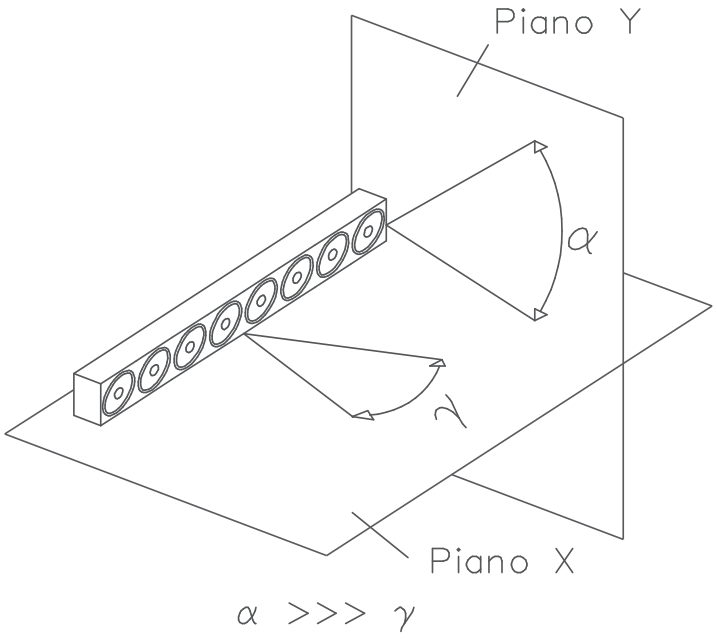
2. A NEW CONCEPT OF SOUND

Looking at the polar diagrams of an individual speaker at low frequency, we will see almost omnidirectional radiation (i.e. the same radiation in all directions). However, a considerable reduction in sound dispersion at various angles can be achieved simply by positioning *four* speakers in a line.
As we increase the number of speakers, the sound emission angle will increasingly narrow.
Note the significant effect of *eight* sources set in a line in the drawing below.

It should be noted, however, that the effect achieved by narrowing the sound beam will only occur along the axis on which the speakers are positioned, while on the perpendicular axis no change will occur by doing this as compared to using just a single transducer.



Dwg 1. Dispersion angle differences between standard horn-loaded speakers and line arrays (4 and 8 elements)



Dwg 2. With a single line array (positioned on plane X) the sound beam is very narrow in the horizontal direction, but it remains very wide in the vertical one

3. THE PEECKER SOUND DOUBLE ARRAY

The Peecker Sound research engineers have designed an exclusive system where loudspeakers are positioned *on a double line*, thereby reducing the radiation along the two axes. This arrangement of transducers, called Double Array (hence the name of the series), produces a sound beam with a strong concentration along the axes perpendicular to the plane on which the loudspeakers are positioned.
The invention refers to sound systems with controlled and delimited diffusion, in which the many different sound sources, such as cone loudspeakers, are arranged sometimes in *double array* formation (hence the name of the series - **Double Array**), sometimes suitably spaced out from each other according to pre-established and differentiated steps, with a level-plane, concave dome-shaped, trunk-conical layout or according to some other configuration.
Such sources – the cone loudspeakers – are, preferably but not exclusively, fixed to support trusses or rigging systems that can have reticular, panel or continuous form and essentially delimit the sound reinforcement systems. With the systems configured in this way, the cone loudspeakers are positioned at the same distance from each other or at variable distances and in a specific way according to the reduction of sound diffusion one is aiming to achieve in the adjoining peripheral areas. With reference to the well-known physical laws regarding the diffusion of sound waves in the air and the interference phenomena occurring between the selfsame sound waves emitted by more than one adjoining and/or combined source, it can be noted that, based on the sources' distance from each other, their direction and sound pressure, it is possible to add, subtract, direct and/or alter their overall sound effect.
From these preliminary remarks, putting what can be gleaned from the textbooks on Acoustical Physics in simple and intelligible language, we can state that by aligning several sound sources, **it is possible to alter the dispersion angle of every sound source and achieve an overall irradiation effect of the whole set that is narrower and more targeted towards a desired direction.**
The Double Array Series systems aim to exploit this principle in order to design **sound systems with controlled and delimited radiation** with the following requirements:
- sound sources (the cone loudspeakers) are fitted out on continuous panels or are profiled on rigging systems or truss structures with level-plane, concave, trunk-conical or different layouts, according to double arrays, namely several essentially parallel line arrays;
- audio systems formed in this way can be used in wall applications for a specifically and/or particularly oriented sound reinforcement, for overhead or ceiling applications and for delimited sound diffusions.

Advantages achieved using sound systems with Double Array Series loudspeakers essentially consist in obtaining:
- greatest sound intensity, available power being equal, in the area facing the systems where sound reinforcement is asked;
- easiest intelligibility of acoustic signal in the area included in the cone/cylinder of sound irradiation;
- extreme reduction of sound level in the zones adjoining the systems, outside the cone of sound irradiation;
- maximum abatement of environmental noise pollution.

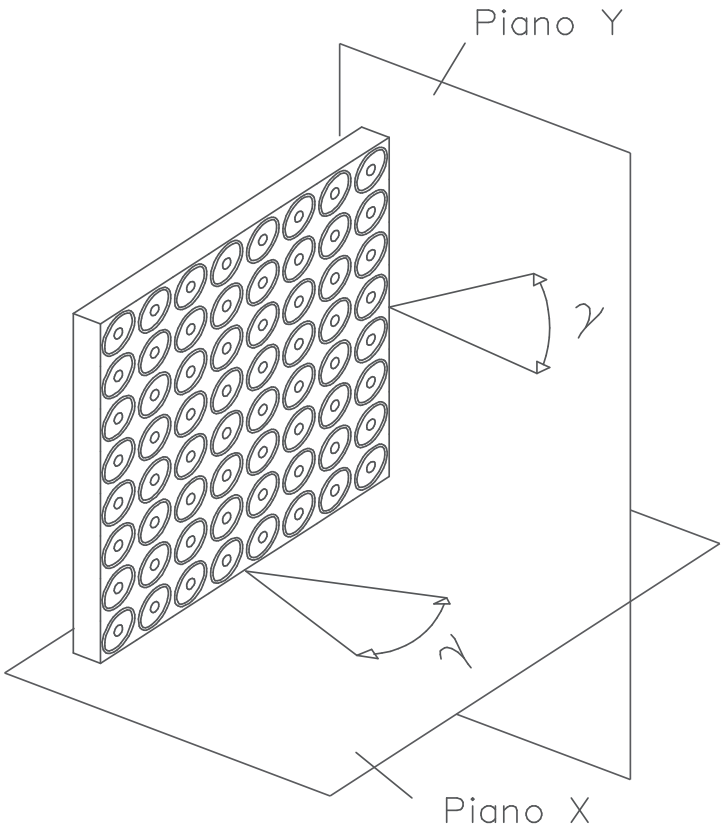
For instance, a 105 dB average intensity of sound emission, for standard systems for public dance entertainment places (dance clubs, night clubs, music pubs, etc.), corresponds to a noise value generically included between 80 and 85 dB, in the zones surrounding the dance floor.

A peripheral sound decrease can be achieved, both around the floor and in the surrounding zone, with a controlled and delimited diffusion Double Array Series sound system, for example hanging from an about 3,5 m height ceiling over a dance floor, with a remaining noisiness included between reasonably bearable 65 and 70 dB. In this way, the area of highest acoustic power is only for dancing patrons.

4. A PRACTICAL EFFECT

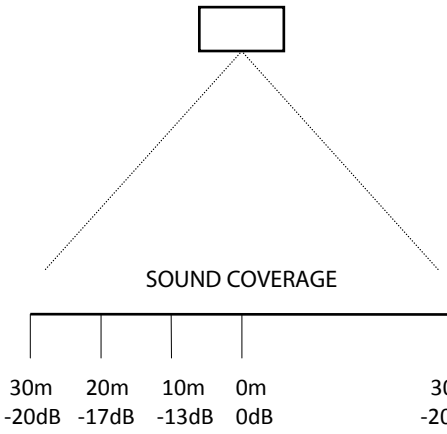
Placing one Double Array speaker above a dance floor can result in lowering the sound outside the floor **from 10 to 30 dB**!

This means that in a venue where the sound level with a standard system is 105 dB on the floor and 80 dB in the perimeter outside the venue itself, adopting a Double Array sound system can reduce the outside level to just 60-70 dB.

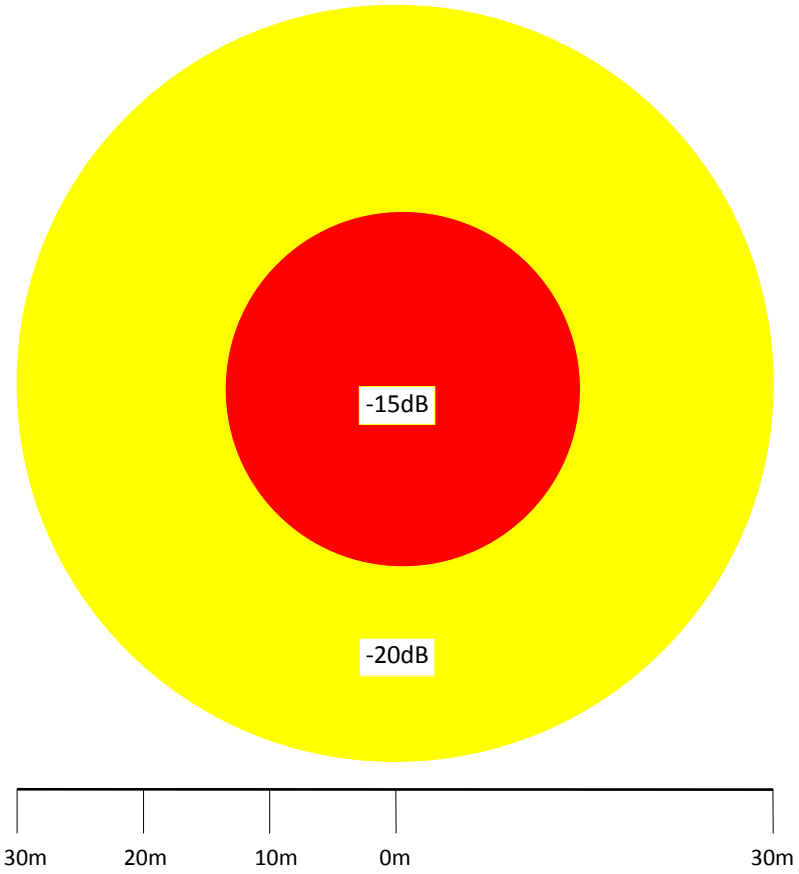


Dwg 3. With Peecker Sound double array the sound beam gets thinner in both directions

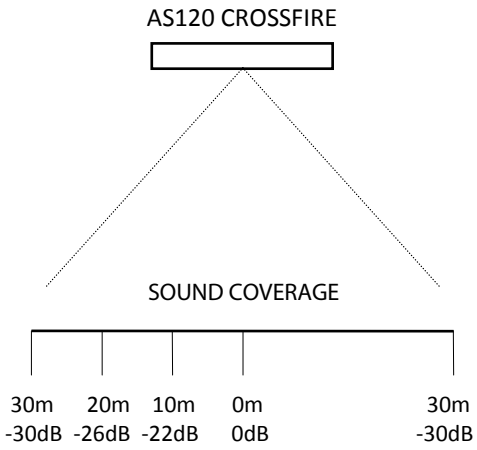
STANDARD LOUDSPEAKER SYSTEM



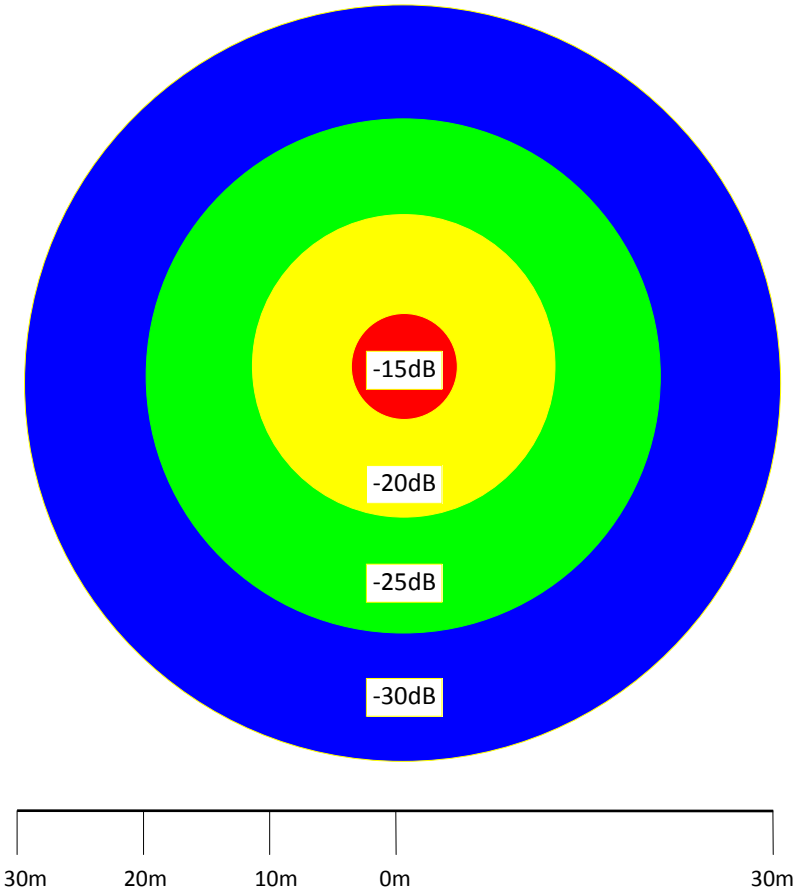
With a standard loudspeaker system, the sound level at 10 metres from the centre of the floor drops by just -13 dB and at 30 metres by -20 dB.

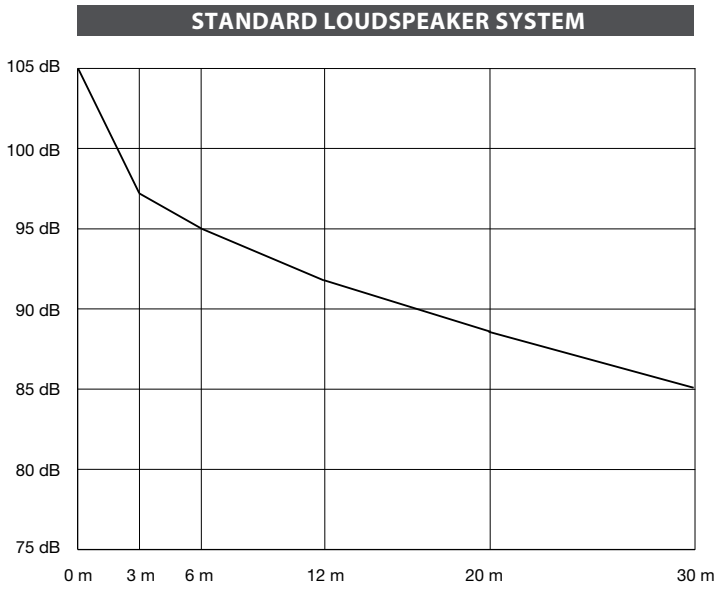


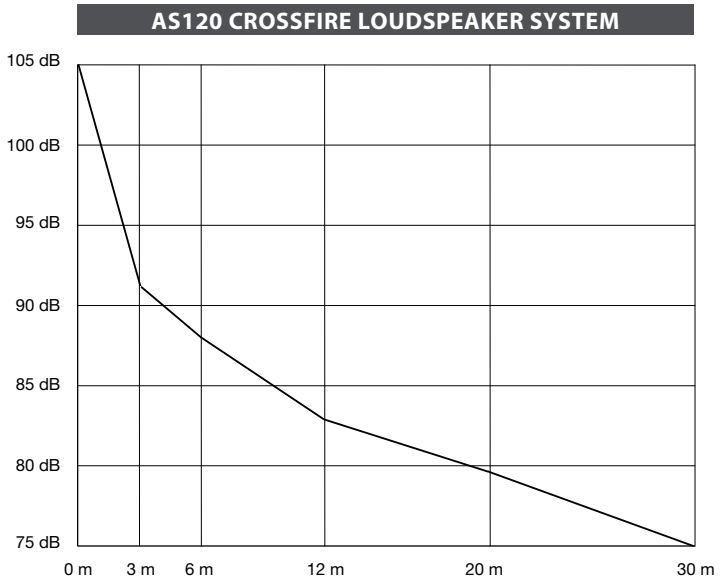
AS120 CROSSFIRE



With the revolutionary AS120 Crossfire system, the drop in sound level at 10 metres from the centre of the floor is already **-22 dB** and at 30 metres can be as much as **-30 dB**.







The above diagrams clearly illustrate the significant reduction in sound level that can be achieved outside the floor by using the AS120 Crossfire system instead of a traditional speaker.
Measurements by STUDIO ESA (Florence)

5. CERTIFICATIONS

UNIVERSITY OF PARMA - DEPARTMENT OF INDUSTRIAL ENGINEERING
Testing was conducted according to the following two different methods:
1) measurement of the polar dispersion diagrams (directivity curves) in a simulated free field, using a turntable and the MLSSA system of analysis;
2) measurement of the sound level spectrum produced at 1.5 metres from the ground by the **AS120** speaker mounted in operating position (suspended at 3.5 metres from the reflecting floor and pointing downwards) along two orthogonal directrices.

The first measurement makes it possible to quantify the speaker's directive emission properties: such data, for example, is required when using acoustics simulation programs for indoor venues.
The second measurement, on the other hand, enabled experiments to be carried out to verify the speaker's behaviour in real-life operating conditions, taking into account, among other things, the reflection of the floor.

The outcomes of these tests clearly show the outstanding ability of the AS120 Crossfire system to control acoustic energy in a well-defined area.

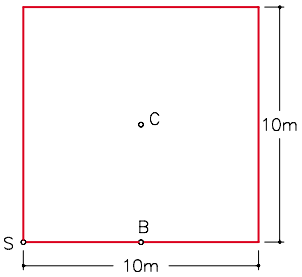
STUDIO ESA - FLORENCE
Testing was performed by installing an AS120 Crossfire speaker system and a standard system in an outdoor dancing venue. In both cases under investigation the speakers were suspended from the ceiling, 3.5 metres above the ground, and testing was conducted at 1.5 metres from the ground.
The investigation showed that the AS120 Crossfire system produced a significantly greater reduction in sound pressure levels outside the dance floor than the standard system.

CENTRO ACUSTICO DI PROGETTAZIONE AMBIENTALE (ACOUSTIC CENTRE OF ENVIRONMENTAL DESIGN) - REGGIO EMILIA
The numerous tests conducted in the relevant environment clearly showed that the AS120 Crossfire system has a greater ability to concentrate sound emission than any other standard speaker.

THE DOUBLE ARRAY SYSTEM IS COVERED BY INTERNATIONAL PATENT No. 01280080

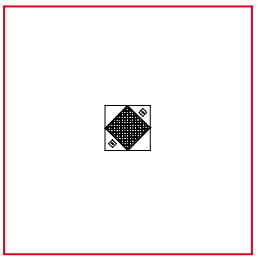
5.1 Measurements and tests on AS120 speaker

HYPOTHETICAL FLOOR 10x10m (100 mq)



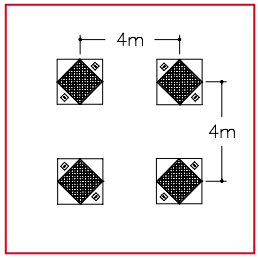
A) Single AS120 speaker in the middle of the floor;

P_{max} (C) = 105 dB
$P_{floor\ edges}$ (B) = 90 dB
$P_{corners}$ (S) = 87 dB



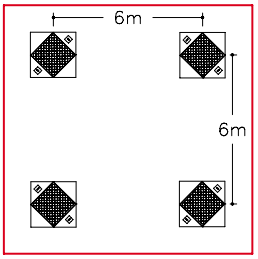
B) Four AS120 speakers at 4 metres;

P_{max} (C) = 105 dB
$P_{floor\ edges}$ (B) = 97 dB
$P_{corners}$ (S) = 93 dB

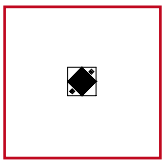


C) Four AS120 speakers at 6 metres;

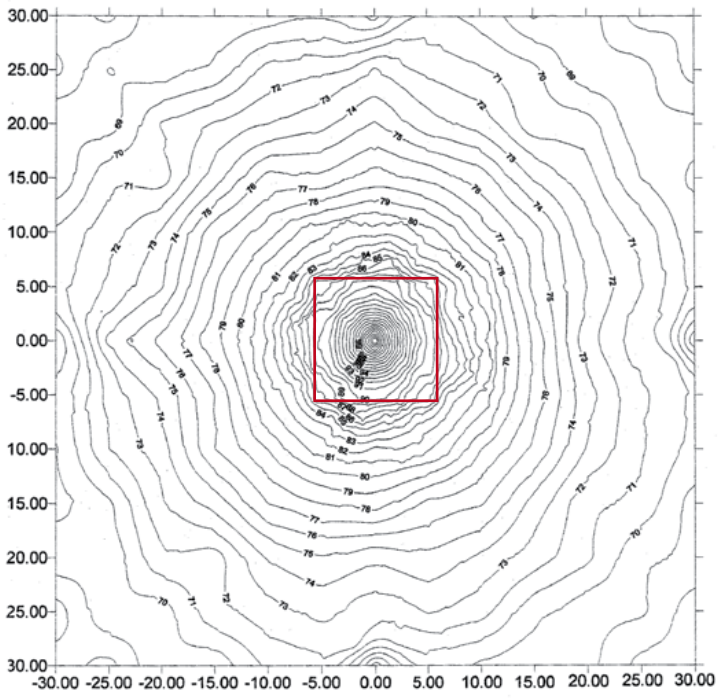
P_{max} (C) = 105 dB
$P_{floor\ edges}$ (B) = 98 dB
$P_{corners}$ (S) = 95 dB

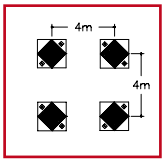


SOUND REINFORCEMENT | CONTROLLED RADIATION | ACOUSTIC RESEARCH

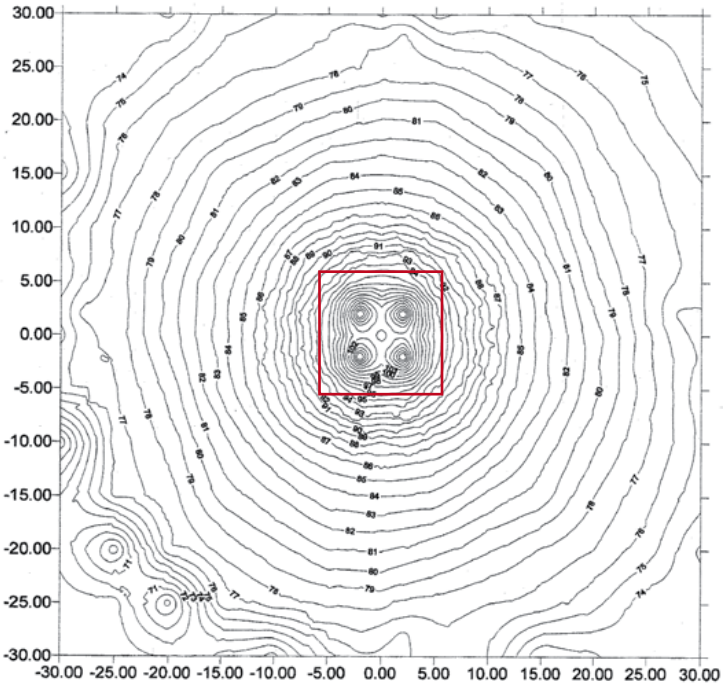


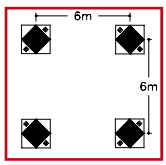
A) Spectrum measurement of the sound level produced at 1.5 metres from the ground by one AS120 speaker mounted in operating position at a height of 3.5 metres from the reflecting floor, pointing downwards.



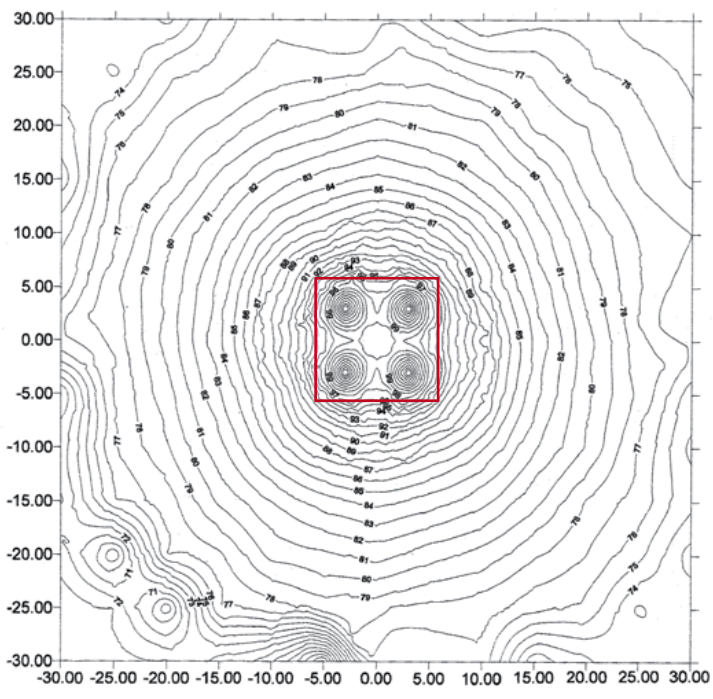


B) Spectrum measurement of the sound level produced at 1.5 metres from the ground by four AS120 speakers mounted in operating position, 4 metres from each other, at a height of 3.5 metres from the reflecting floor, pointing downwards.





C) Spectrum measurement of the sound level produced at 1.5 metres from the ground by four AS120 speakers mounted in operating position, 6 metres from each other, at a height of 3.5 metres from the reflecting floor, pointing downwards.



We notice that four speakers produce a much more homogeneous sound distribution across the floor. Placing the speakers at 6 metres from each other reduces the difference from the centre to the edge of the floor from 15 dB to just 7 dB.

Since four AS120 speakers are too many for a 100 m^2 floor, the same effect can be achieved with AS60 speakers.

6. THE DOUBLE ARRAY SERIES INNOVATION PROCESS

6.1 A market niche

In early summer 1996, Peecker Sound counted more than 100 fixed installations in Italy and abroad at different hangout spots including dance halls, night clubs, lounges, bars, etc... In summer, these typical venues offer visitors a thriving night-life and the possibility to dance and have fun outdoors. So, as at the beginning of each new season these hotspots reopened and Peecker Sound's technicians and engineers were to provide their usual, yearly Customer Service activities, they kept on struggling to handle two thorny problems:
1) owners complaining about poor sound pressure levels around the dance floor area with dissatisfaction of both the resident deejays spinning at the club's and of the paying visitors who were still used to the loudness of the large audio systems installed at "indoor" winter spots;
2) steamed managers who were to handle an upset neighbourhood relentlessly complaining about the loudness of the audio system causing nuisance and annoyance to the people living nearby. The neighbourhood was quite rightfully making appeal to the *Italian Piece of Legisltion No. 477* on acoustic pollution (and the following enforcement acts) implemented in October 1995 to control the maximum noise emission levels by establishing mandatory values that were very restrictive for those playing music efficiently.
This scenario had come to a critical level when the managers decided to take the following compromise solutions to lessen the problems:

1. Installing short-throw, traditional, "forward firing" loudspeaker systems that are with their axis parallel to the floor (see Fig. 1); this arrangement, however, involved some inevitable phase shifts due to the different acoustic paths of the sound reproduced by the loudspeakers, especially in the mid-high range;

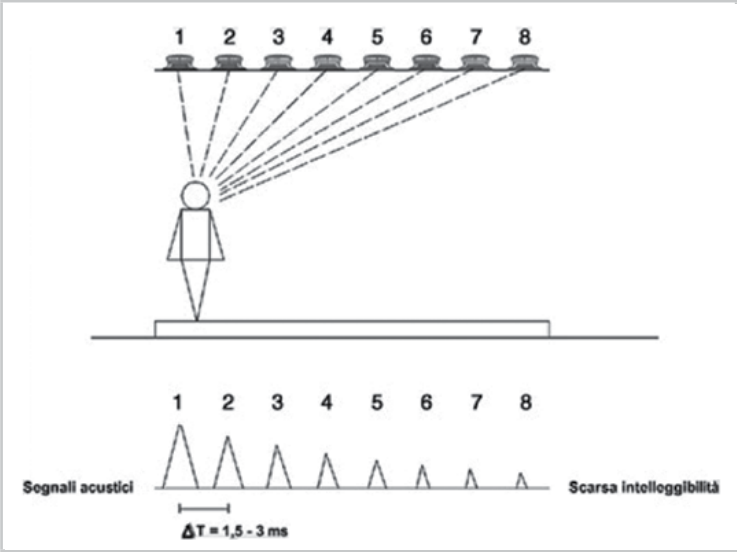


Figure 1. Layout scheme of forward firing loudspeakers

2. Giving up subwoofers for the reproduction of low-pitched audio frequencies to deejays' great disappointment;

3. After long consultancy studies, implementing acoustic barriers out of insulating and sound absorbing material (i.e. *Celenit*, *Eraclit*, *Calibell*) to the owners' malcontent due to the high workmanship costs;

4. Setting up adequate loudspeaker system suspending/rigging structures in highly soundabsorbing electro-acoustic materials (as for instance reinforced concrete) to the dissatisfaction of the architects who felt these structures were detrimental to the typical summer vocation of the clubs.

This is why our Top Management decided that a deep change was required and a unique, fully innovative system had to be worked out in order to clear all foregoing problems. Eventually, the solution came and consisted of a controlled radiation system conceived to concentrate the sound pattern within an extremely limited and restricted space.
By so doing, the Company Management aimed at designing a product with a triple target:
- Number one: getting finally rid of all afore said conflicts and meet with the expectations of a large number of peecker sound customers (as numerous "summer hotspots" managers were also owners of "traditional" indoor dancing rooms);
- Number two: accurately complying with the applicable, yet very strict standards on acoustic pollution;
- Number three: hopefully acquiring a market share associated with the new generation trend of dine&dance restaurants, hotels with an own night club up to those cruising boats whose entertainment hall was close to the cabins (although the latter was not in the original picture!).

We will read later how all three targets were reached and a product (**AS120 Crossfire**) was developed and later contributed to consolidate Peecker Sound ranking among the leading manufacturers in the field of sound entertainment.

6.2 "Music inside, silence outside"

The final aim of this Peecker Sound project was to bring forth an audio system with highly dynamical levels on the dance floor, medium levels in the adjacent surrounding area and low *Laeq* (i.e. *equivalent A-weighted sound pressure level*) on the club walls. While initially these systems prevalently came into question for outdoor spots, they are presently increasingly required also for indoor places in order to provide compliance with most recent regulations enforcing very strict sound level limitations.
Everywhere in the world, all loudspeakers are constructed to provide a fairly good sound directivity in the mid and high range frequencies (voices and solo instruments), but nearly no directivity at all in the low frequency range (from 20 through 500 Hz). Low sound frequencies radiate in any direction without any apparently possible control. If you stand behind a subwoofer, you would still hear the same basses at the same distance in front. For this reason, the traditional sound systems for dance halls feature a really small difference between sound levels on and off the dance floor thus obliging the inspectors to decrease the volume. The longterm effects of this intervention can turn to a real disaster with people no longer visiting dancing clubs, because they miss the physical sound pleasure and discos being deserted because of abiding the rules!
How the sound can be DIRECTED?
The only, very old method for controlling sound waves radiation is – as usual – to design a sound guide of adequate size in front of the audio driver. While all the experts know about acoustic horns, the concept of "adequate" size makes it a bit more buzzing. In fact, if a good performance is achieved at 1500 Hz with a 13 cm long horn with a 48 cm mouth, a similar device performing at even 150 Hz only will be 10 times bigger than that!

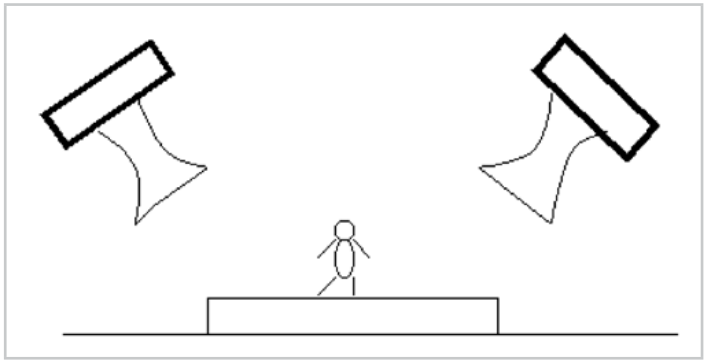


Figure 2. Layout of a traditional loudspeaker arrangement

Figure 2 above shows a dance floor with horn-loaded loudspeakers.

As one can see, the only way to send sound to the floor is to adjust the horn devices by a suitable radiation angle "α" between normal at ground and the loudspeaker centre of gravity. It may be hard to believe, but this was the only method used to direct low sound frequencies to the dance floor until short ago.
What about today? We presently offer **Double Array Series** (**AS6** - **AS60** - **AS120** - **AS180**): after many years of specifically focused research, these loudspeakers have been tested on tens of different outdoors and indoors installations in all European countries and actually brought forth a revolution of the very sound texture concepts.
They provide a real absolute innovation in the field of acoustics because they completely turn around the whole classical thinking of traditional technicians.
The new concept consists of a *double array* of throughout same loud speakers designed to shift the phase off the axis so to provoke at least 10 dB damping of sound variations in foreign areas while maintaining an unaltered sound volume and feeling on the dance floor.

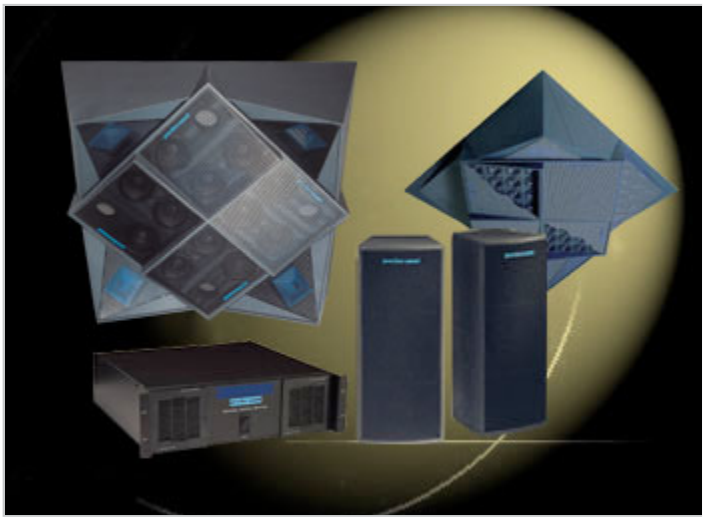


Figure 3. The Double Array series

6.3 Double Array Series engineering

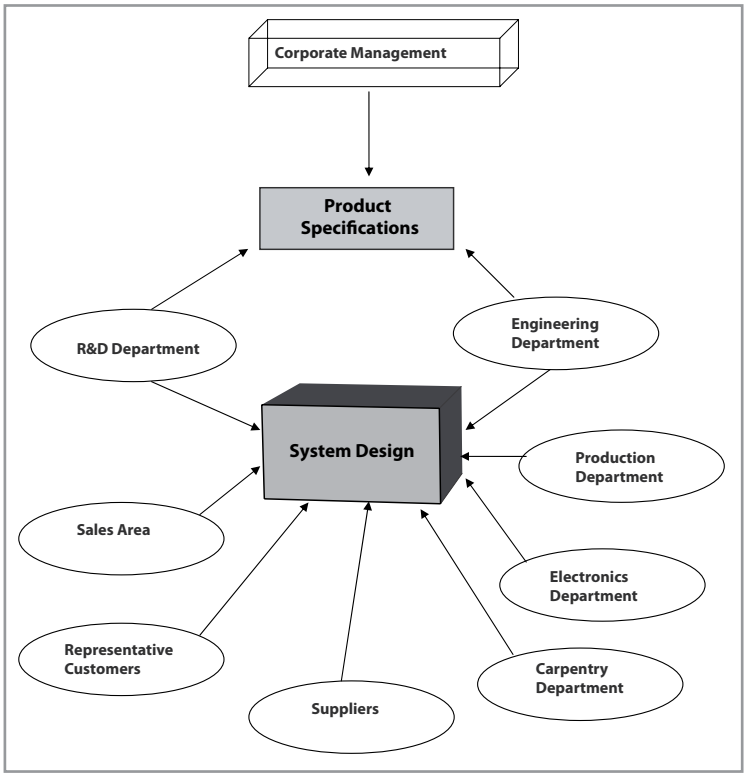
The company's Management, having accurately detailed the requirements of this market niche, called a project-meeting to launch the engineering of an innovative system suitable to orient and concentrate sound radiation to the dancing floor, without causing any annoyance outside and keeping well within the strict limitations established by the applicable law provisions (as already explained above).
At that time, the company's Top Management grasped at once that such a hard engineering and design process could never be carried out and successfully completed by sticking to the traditional design concepts that had been applied so far. This prompted the company to involve in the project a variety of different parties from inside and outside the company to collaborate and give their contribution at all main steps of the design process from the early definition of the product specifications.
After exchanging views with the Engineering Department, the company's Management decided that for the first time in its life, Peecker Sound would have led and supported the design, the engineering and the production of a new system by a *project-wise approach* instead of assigning the design and production tooling tasks to the Engineering Department as it always happened before. All parties who normally acted in production cycles needed to be involved and collaborate (including company's functions that would normally not interact with a product design project, raw material and component suppliers up to final customers).

The die was cast: the corporate Top Management took immediate action at company's internal levels by means of direct, informal contacts and a staff motivation action aimed at raising awareness for the new product. On company's external levels, the Management set off to drag in the project team some outstanding actors selected among the most representative and influent suppliers and customers.

So the Company's Management immediately set about shortly defining all organization and logistic details:
1) It was resolved that the new sound texture project had to have its own venue and for this reason a 250 sqm area was made available at the premises in Reggio Emilia where all project-dedicated equipment would be installed and where the prototypes would be assembled and tested;
2) Responsible staff members out of all corporate functions were selected and assigned to project execution, while *G. Gandolfi* (R&D Division) was appointed as project leader with the task of supervising the works and informing the Management about the progress of the project by means of periodical meetings;
3) It was established that all corporate functions, whose part of staff was assigned to the new project, would rearrange themselves so that they would not longer need to distract the transferred people from the mission of the new project (which was possible thanks to the proximity of the locations);
4) Contacts were taken with the most representative suppliers and customers in order to "recruit" them into the project: suppliers promptly turned out quite ready to collaborate with the new system design (some of them had even already considered similar projects within their companies). Attracting and sensibilizing customers was indeed a more difficult task and one can really say that this particular mission succeeded just because of the nearly intimate management relationship with the most "important" customers;
5) A maximum project deadline (12 months) was established;
6) After a consultation with the financial managers and diverse meetings with field operators (banks and investment companies), a maximum project budget (1.5 billion "old" *Lira*) was allocated in compliance with the company's resources.

In summary, the *project team* was made up of:
- the entire corporate Engineering Department;
- all staff of corporate R&D Department;
- *three* members out of the corporate Sales Division;
- *two* internal Production members;
- *one* engineer and *two* technicians of the corporate Electronics Department;
- *two* of the best people in the internal Carpentry Department;
- *one* person from each Supplier of: a) raw materials, b) components (horns, loudspeakers,..), c) grids and suspension systems
- *two* members of the corporate Management of two of the most prestigious clubs already equipped with a peecker sound audio system.

Moreover, the President of the Sound Corporation group, *Mr. Gianni Toschi,* took personally part to the first project workshops attended by internal and external participants listed below.



Here below is a brief description of the design steps and the contributions of the various parties involved in the project:

- After the first meetings, it was decided to "release" the customers, because they already extensively outlined the problem in terms of relationships both with the neighbourhood and with the inspectors (USL agencies) checking on noise emissions. Moreover they all eagerly, already accepted to host and install a zero series of the new product;
- Of course the R&D Department extensively joined the Engineering Department throughout the entire design project and its contribution turned out very conclusive in the selection of the raw materials and above all in the implementation of **controlled-radiation, double-array sound reinforcement system** (an absolute innovation at that time, as the actual state-of-art in the reference field only accounted for single arrays!);
- On the contrary, the contribution of the suppliers continued over a longer period of time and led to the following conclusions.
  For indoor loudspeakers (by CIARE S.r.l.): standard components out of the actual catalogue would have been used.
  For tweeter horns (by B&C SPEAKERS S.p.A.): bespoke parts and components would have been designed for the new product by means of a special dedicated injection and stamping line.
  For protection grids (by NUOVA LAMM): new custom-made grids would have been designed in accordance with CAD drawings of the new product.
  For the packaging (by TITAN): the project management approved an inhouse make due to the expensive price offered by the supplier.
- A very crucial task was performed by the carpenters in terms of scraps management and selection of the original raw material: marine plywood (a renown, very light and waterproof material largely used in the navy field) was selected and it was decided that the size of the speaker central element (see below) was to be exactly the same as one half of the original raw panel size (so to avoid any complicated and costly nesting of the wood shapes!);
- The staff from the Electronics Department was immediately asked by the project team to develop a dedicated electronic controller for the new-born speaker.
  As a matter of fact, it became progressively clear since the very first work hours that it would have been impossible to accurately reproduce the entire music range (from 30 to 18,000 Hz) for every possible volume level.
  The plan was to design a totally new active crossover that eventually turned out to be our **DP 60-120**;

Figure 4. DP 60/120 processor

- The production technicians, instructed by the Engineering Department, decided that a dedicated line would be installed at the premises in Reggio Emilia where the new product would be assembled.
  It was decided that no additional production machineries would be required, except for electric parts and fabrication tools as for instance drills, screwdrivers, etc… The same production technicians agreed with the carpenters on the correct position of holes on the speaker in order to rapidly achieve an ergonomic placement of electric cables;
- Finally, the sales manager from the Sales Area extensively cooperated with the Design Engineers to provide the lowest possible fabrication costs and to outline an attractive speaker look. In the framework of this collaboration, it was decided that the speaker was to be equipped with some strobe lights in the corner elements without active music components (this was the only suggestion accepted by the project staff among several ones made by the marketing experts!).

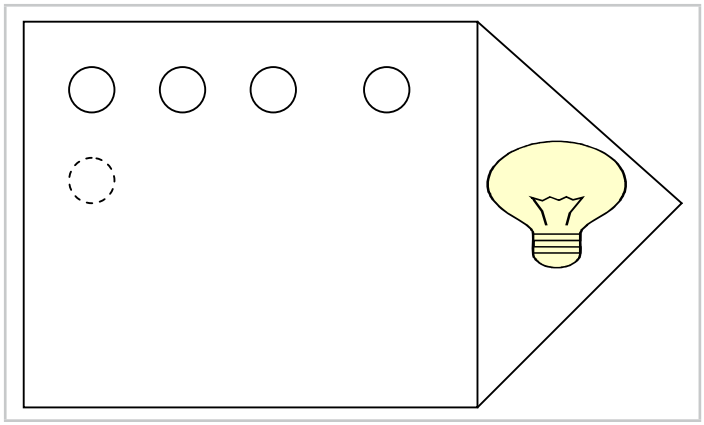


Figure 5. Sketch of the new speaker

At the end of the design process (that lasted approximately 6 months and therefore 6 months well ahead of the expected deadline!) the following specifications had been outlined:

Project team	*Decisions made*	*Specs/Processes*
Engineering Dept.	Management of the project team	System design
R & D	Raw material and array system	/
Production Dept.	Dedicated series	Series tooling
Electronics	Dedicated controller	Totally new design
Carpentry	Chassis - 125x125 cm	No tooling
Grids supplier	Dedicated grids	Design from CAD drawings
Components supplier	Catalogue components	/
Enclosure supplier	Too expensive packaging	"Make" decision
Marketing	Product look and lights	Lights addition
Customers	Availability of the zero-series	/

To great satisfaction of the Corporate Management, the first prototype was ready one month only after defining of the technical specifications and it proved quite positive although the following modifications were decided:

1 Using shorter PVC tubing for playing bass chords;
2 Changing the corners of the tetrahedral elements;
3 Redefining the cutting frequencies of the passive crossover.

After saving the modifications in the product folder, the required production tooling was implemented, the final details were defined and the part list was laid out including all outsourced parts.

The first zero series was released after production tooling (8 months after project start-up!) and was installed in a famous club in the district of Modena. The zero-series obtained immediate customers' favour. However, it was decided to hold-on with final production as the Corporate Management first wanted to apply and obtain both *Quality Certification* and *Patent* (finally awarded only 15 months after application) in order to prevent copies or reverse engineering problems (which nevertheless occurred after the large scale success of the Double Array speakers!).

Further collaboration with the *University of Parma* provided measurement of the polar dispersion diagrams and plotting of the speaker directivity curves. In course of an additional collaboration with *Studio di Ingegneria ESA* in Florence, measurement of the sound level was performed at 3.5 m above floor on various installation types with one or more AS120 speakers for different sizes of an assumed dance floor area (please see par. 5).
As a conclusion, after only 15 months from starting of the operations, the project staff had come to the final configuration of the speaker, obtained an international patent (**No. 01280080**, registered at EPO, *European Patent Office*) and launched a mass production of what would have later been one of the biggest Peecker Sound successes with the sale and installation of over 2,000 systems in the following five years.
Upon final validation of the production, after confirming the modifications applied to the zero series, the decision was taken to manufacture the AS120 loudspeaker system with the following final configuration:

- One quadrangular central element accommodating 64 5"-cone loudspeakers for low frequencies reproduction;
- Two prism elements accommodating the tweeters for mid-high frequencies;
- Two tetrahedral elements accommodating, on request, eventual strobe lights to improve the overall look.

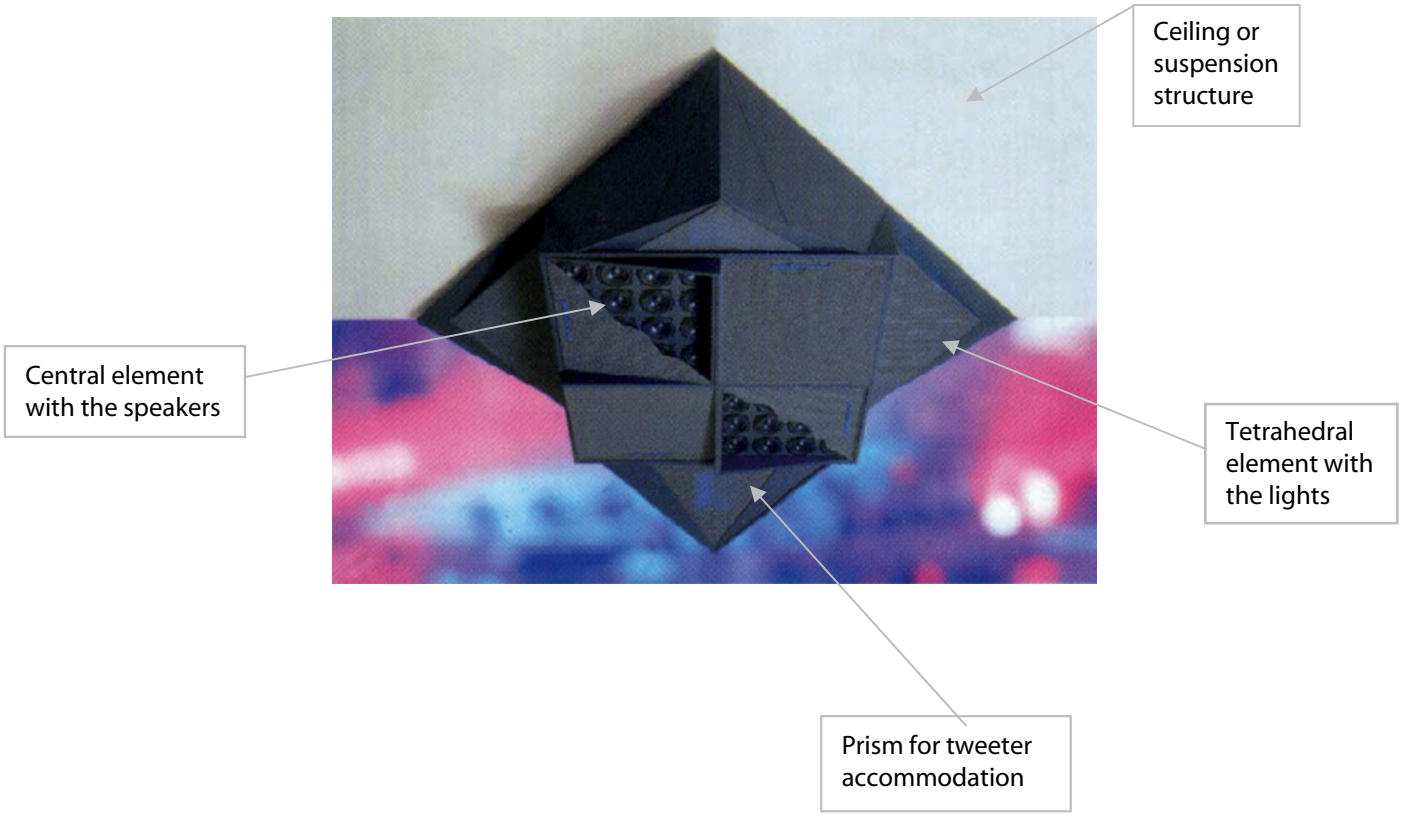
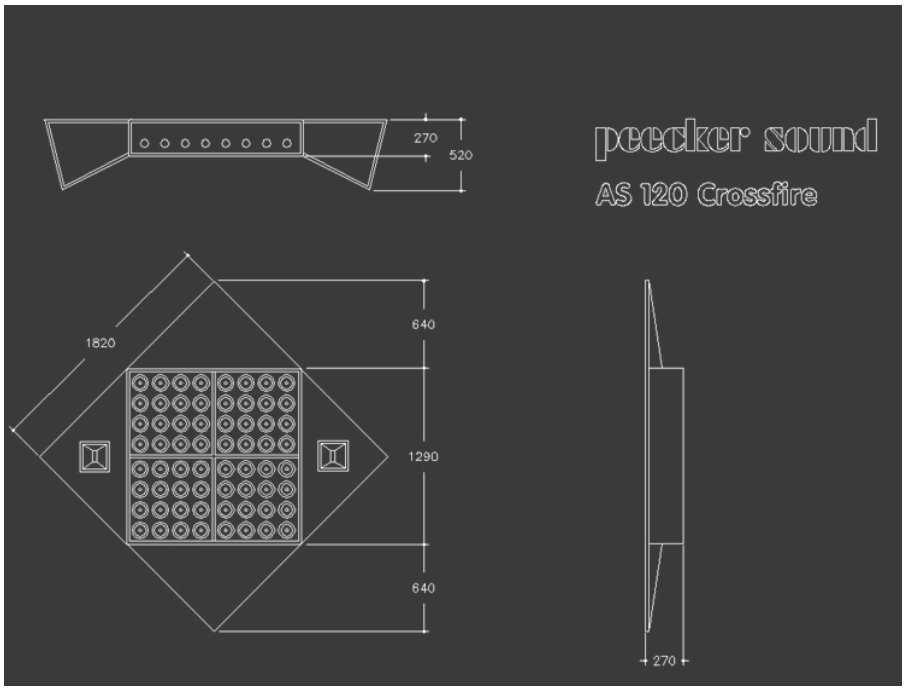
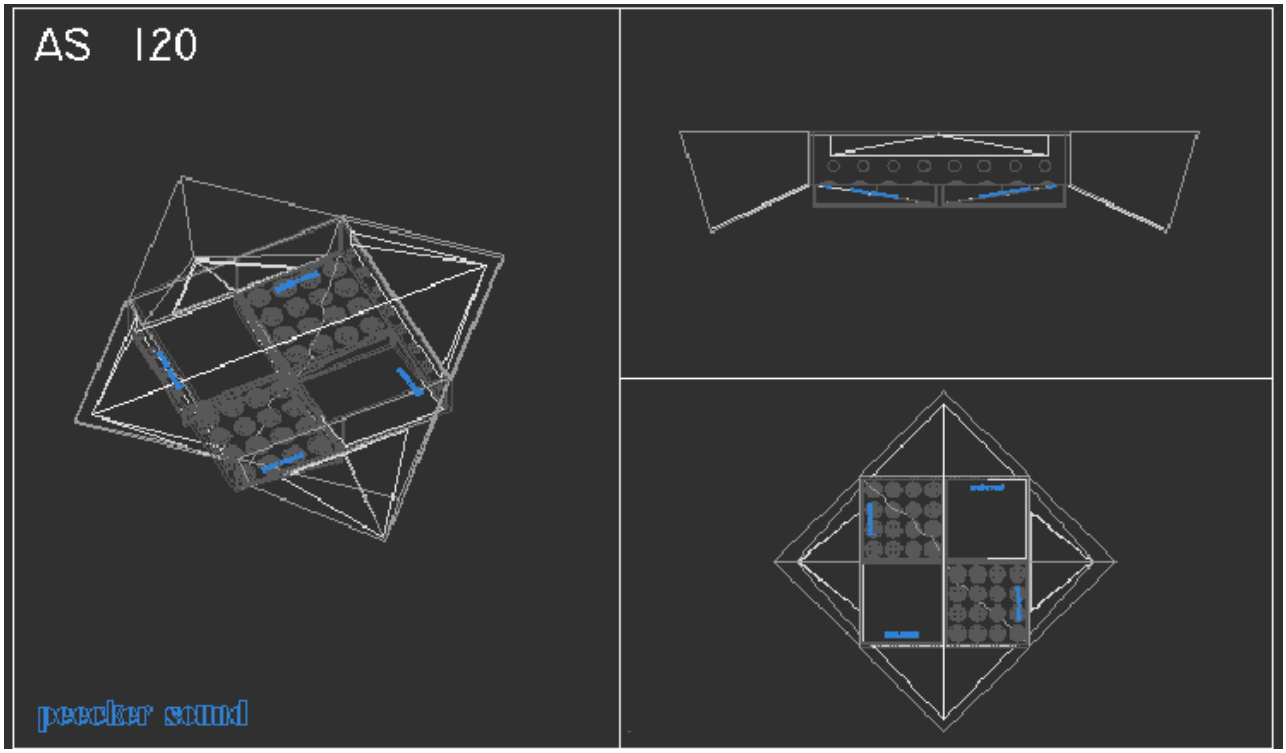


Figure 6. AS120 Crossfire acoustic loudspeaker system

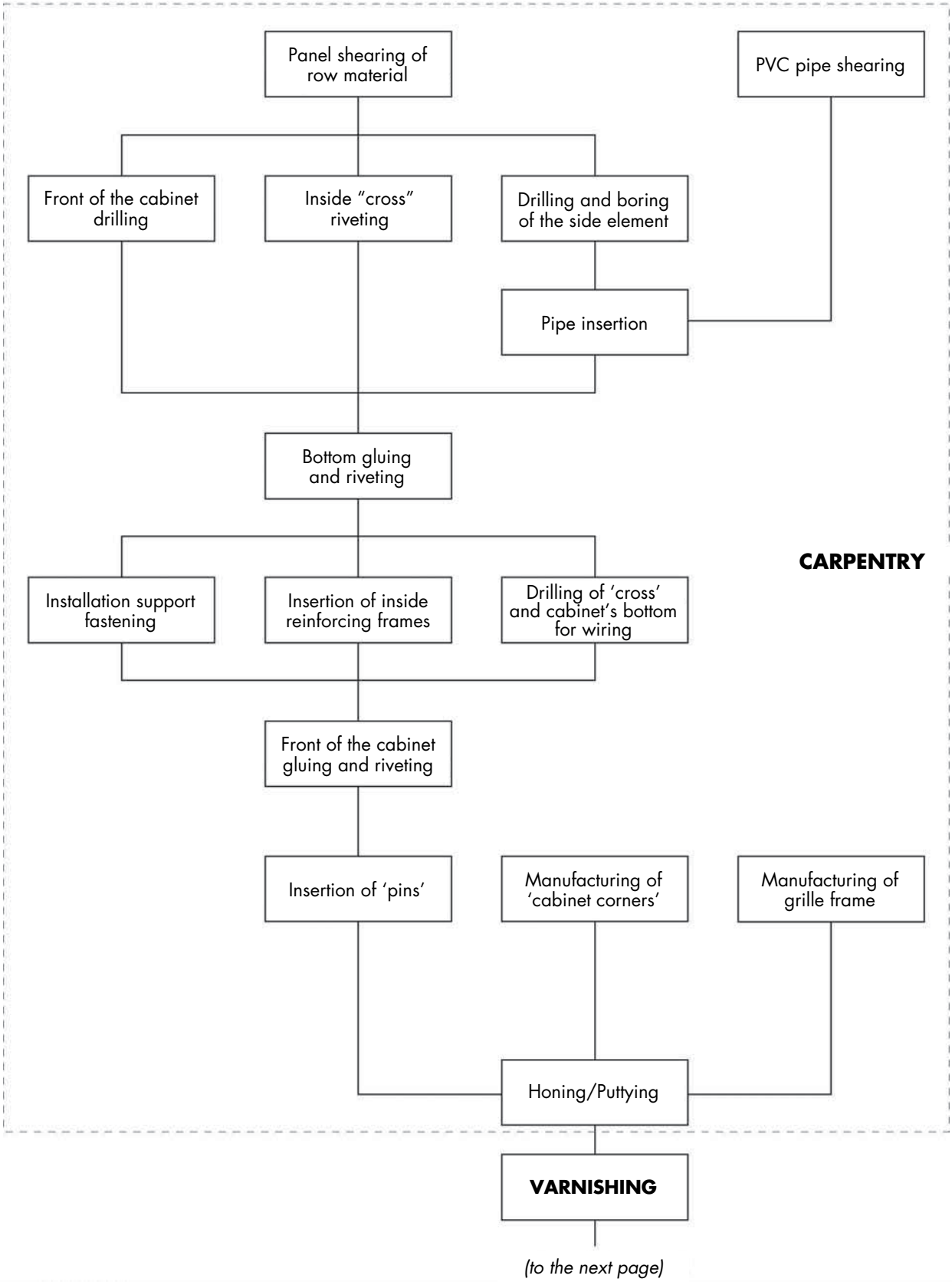
6.4 CAD 2D–drawing (exported in JPG)



6.5 CAD 3D-drawing (exported in JPG)



7. THE OPERATION SCHEDULE



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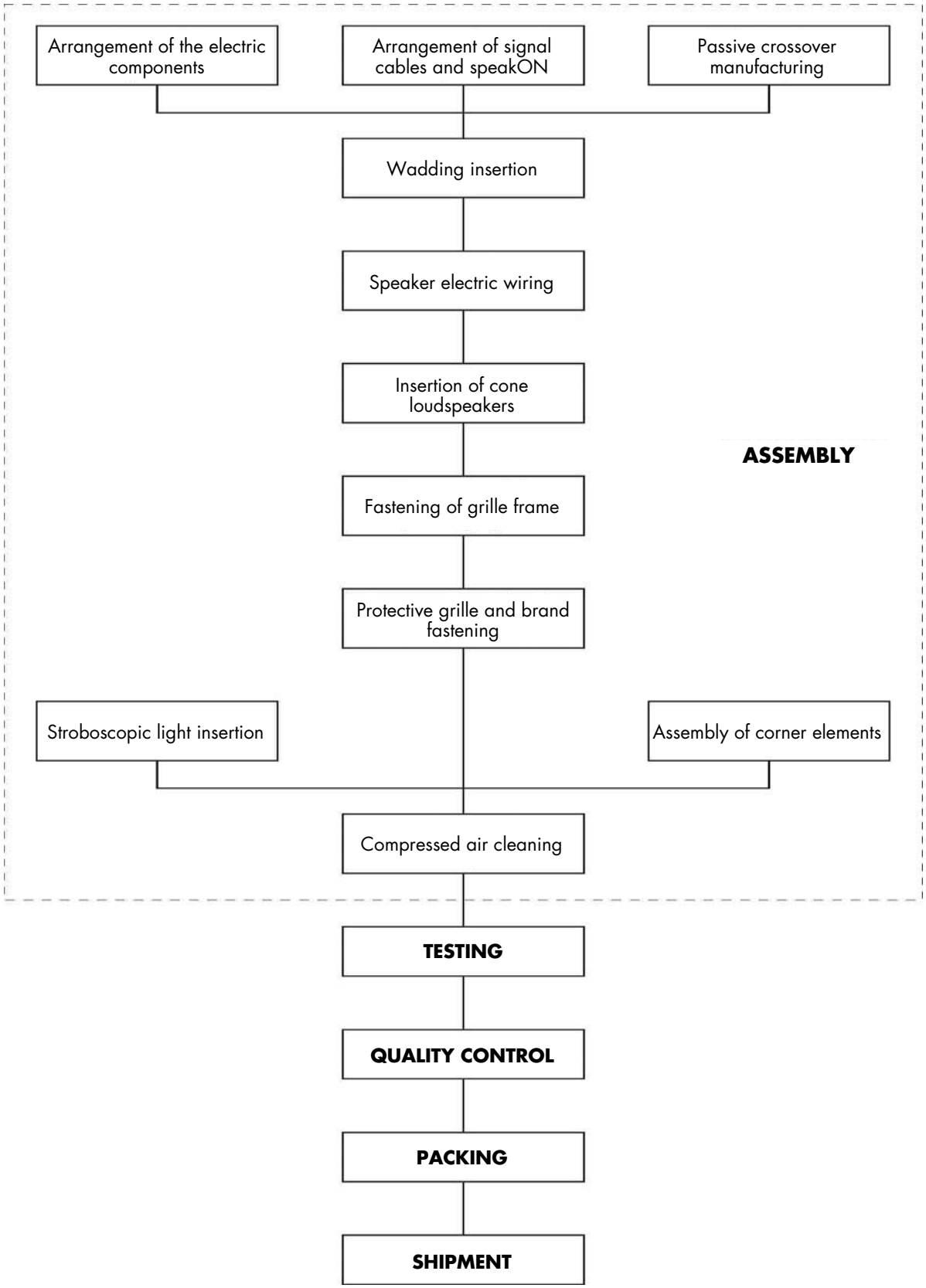
Arrangement of the electric components
Arrangement of signal cables and speakON
Passive crossover manufacturing
Wadding insertion
Speaker electric wiring
Insertion of cone loudspeakers
ASSEMBLY
Fastening of grille frame
Protective grille and brand fastening
Stroboscopic light insertion
Assembly of corner elements
Compressed air cleaning
TESTING
QUALITY CONTROL
PACKING
SHIPMENT