Planning a Factory PA

Engineering the world's largest industrial PA system

By CONRAD EICHORN*

Newscaster Carl Weeks is heard by 15,000 K-F employees. Author is at the control console.


Some of the 50-watt amplifiers which furnish 5,400 watts to feed more than 600 loudspeakers.

IN building a factory public address system, the most important element is proper planning. Even an installation as large and complicated as the K-F Broadcasting System at the gigantic Kaiser-Frazer Willow Run plant presents few mechanical and maintenance problems if the preparatory planning is right.

Kaiser-Frazer and RCA engineers spent months planning every detail of the huge installation with the result that the actual work was a comparatively simple matter.

We determined in advance by exhaustive testing and experimenting, exactly what equipment was needed and the precise number and location of each unit in the system.

Services required were:

1. Paging, to originate from the control room or from the night telephone desk;
2. Announcing, to originate from the control room or from the main plant protection office, with provisions for future input facilities as needed;
3. Program pickups originating outside the plant area and received over telephone lines;
4. Recording facilities, both disc and wire;
5. Reproduction of recordings or transcriptions for broadcast.

To make all of this possible we installed an RCA type 76B4 consolette in the control room. The consolette includes four preamplifiers, one high-gain program amplifier, and one high-gain, 8-watt monitoring unit.

A six-position mixer is included, with the preamps connected to four of the mixer positions and banks of mechanically interlocked push keys connected to the remaining two.

The output of each mixer position is connected to lever keys which permit switching it to the program amplifier for "broadcasting" or to the monitor amplifier for auditioning. These key switches are interlocked to disconnect the studio loudspeakers and operate "on-air" light relays. A three-position switch in the input of the fourth preamp permits its operation from a microphone in the studio, the announcer's booth, or the control room.

Push keys in the fifth and sixth mixer positions allows any one of the six remote lines and two turntables to be connected instantly to either input. Ad-

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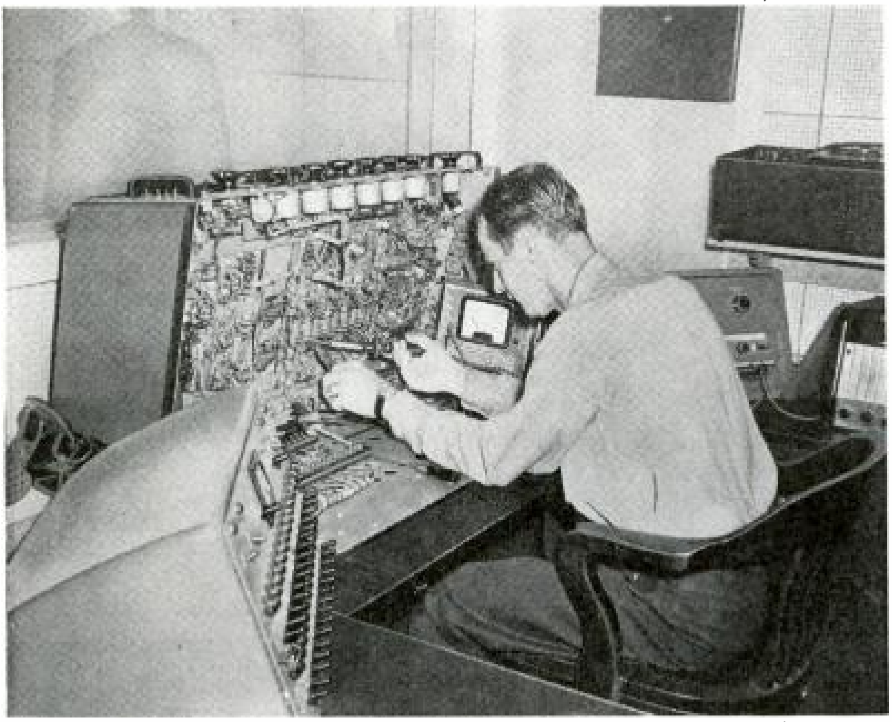
ditional push keys provide circuits for feeding cues to remote lines, and other lever keys permit use of monitoring amplifiers in emergencies.

We made provision for the operator at the console to control the output level from the speakers within 13 individual zones in the plant. Thus, we are able to adjust the output level without the necessity of making individual adjustments of the 100-odd power amplifiers.

We selected RCA 50-watt power amplifiers (MI 4288) having a combined hum and noise level at least 60 db below their rated output, with a frequency response of 75 to 10,000 cycles within 3 db.

The amplifiers are mounted in metal racks, six to a rack. They have plug-type terminals for input, output, and a.c., which provide easy means of replacing defective amplifiers. Each amplifier has two volume controls: one for high-level and one for low-level input.



The best system will have breakdowns. Engineer Henry Lyons shoots trouble in the console.

The relay power-supply units are selenium rectifiers capable of 24 hours of continuous operation under full load. They deliver 24 volts of direct current at 2 amperes.

Plate-circuit relays are mercury-contact units with 24-volt d.c. coils.

The transcription turntable is an RCA 70-D, equipped with a 72DX recording head.

For remote pickups from locations outside the studio, we use an RCA OP6-OP7 remote amplifier and mixer to feed the programs over telephone lines.

For the best all-purpose performance, we selected RCA MI-6311 paging horns, MI-6366 re-entrant horns, and MI-6308 industrial baffles, the latter using MI-12421 12¼-inch, 10-watt, cone speakers.

The paging horns and re-entrants are alternated throughout the plant, the spacing being determined by the noise to be overcome, to give the best overall reception of both voice and music.

The horns, equipped with MI-6306B driver units rated at 25 watts, are clustered five to an amplifier and therefore use but 10 watts each. This arrangement makes possible pin-point volume control in areas of varying noise levels. The industrial baffles and cones were installed only in the quiet areas, grouped 10 to the amplifier.

We guarded against line loss by selecting No. 12 copper stranded wire for speaker lines. Maintenance of the entire system thus far has been no problem at all, involving only such routine tasks as replacing damaged horns, drivers, matching transformers, and similar components.

Design Data for Speaker Enclosures

EXCELLENT loudspeaker baffling can be obtained in a relatively small space with a vented or bass-reflex enclosure. The vented enclosure is no more than a box of a specific volume constructed of heavy timber and provided with a loudspeaker opening and a vent. The graph shows how a correct enclosure will change the natural resonance peak (A) of the speaker to two smaller peaks (B), making response much smoother.

A simpler method than the standard engineering formulas has been suggested for arriving at the volume of the enclosure for speakers of various dimensions. It is based on the following figures: Use a box which has a volume in cubic feet equal to the nominal radius of the speaker in inches. Thus, with this method, a 12-inch speaker requires a cabinet volume of 6 cubic feet, and so on.

The port area is generally accepted as being equal to the actual radiating area of the cone, which is substantially less than that calculated from the nominal diameter of the speaker. For example, a typical 12-inch speaker requires an 11-inch hole for mounting, but the actual diameter of the useful section of the cone is only 10 inches. Resorting to a practical formula again, the port opening may be taken as 0.8 times the area of the speaker opening.

Cross-checking these figures with those obtained by using the more complex standard formulas, cabinet volume for a standard 12-inch loudspeaker is found to be substantially the same, 6 cubic feet. With a heavy-duty 12-inch speaker, which has a somewhat lower cone resonance, the volume should probably be increased.

In the smaller sizes the volumes suggested for a 10-inch and for an 8-inch speaker are substantially higher than standard formulas would indicate.

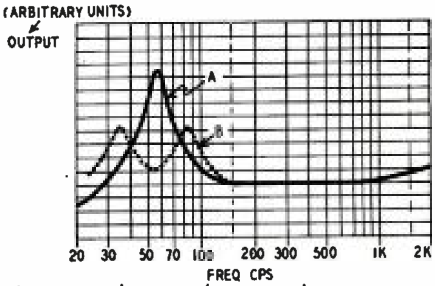
Summing up all these factors, the following recommendations can be made:

(1) For 12-inch loudspeakers, the enclosure volume should not be less than 6 cubic feet, and up to 8 cubic feet for heavy-duty speakers having a cone resonance around 55 cycles.

(2) For 15-inch loudspeakers, the enclosure volume should be at least 8 cubic feet, and up to a maximum of 16. With such large speakers, the very low cone resonance will extend the cut-off in any case to about 45 cycles.

(3) For 10-inch loudspeakers, the enclosure volume can be from 4 to 5 cubic feet.

(4) For 8-inch loudspeakers, the en-



How an enclosure reduces speaker resonance.

closure volume should be from 3 to 4 cubic feet.

Two more points for our summary:

(1) The vent area will normally be made equal to 0.8 times the area of the actual loudspeaker opening.

(2) The installation of a "throat" around the vent, either inside or outside the cabinet, tends to lower the resonance of the system and, within limits, has the effect of increasing the enclosure volume.

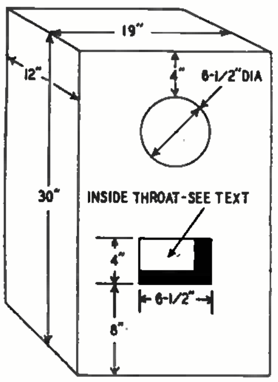
From a practical viewpoint we had no misgivings about the figures for 12-inch loudspeakers, vented enclosures for these units having been built and tested on previous occasions. Our main interest was to investigate the performance of a small speaker in a cabinet rather oversize by previous conceptions.

Another point in mind was that many readers have 8-inch loudspeakers on hand or may be obliged to use a 7- or 8-inch speaker for reasons of cost and availability.

Accordingly, we constructed an enclosure approximating 3 cubic feet with a vent of the specified size.

The particular loudspeaker had a natural cone resonance at a frequency just over 100 cycles, which was rather higher than expected. However, when mounted in the vented enclosure, the output was maintained to just under 60 cycles, below which it tapered off sharply. At the low frequencies, the bulk of the output comes from the vent.

By way of interest we installed a throat approximately 3 inches long, surrounding the vent on the inner side of the cabinet. This was found to produce a more gradual cutoff and, as far as could be judged by ear, to improve generally the performance of the enclosure below 100 cycles. In its final form the system delivered useful output



Typical dimensions for a vented speaker enclosure. The throat projection was 3 inches long on the model described, but it may be varied for best results by the experimenter.

down to 50 cycles, which was gratifying, considering the simplicity of the baffling arrangement, its moderate size, and the fact that the energy source was a relatively inexpensive 7-inch loudspeaker.

Although 50 cycles may seem well removed from the traditional 30-cycle lower limit, there are few loudspeakers in conventional cabinets which will produce fundamentals at this frequency.

It is useless to consider building a vented enclosure of light timber or even of sound-absorbent board supported on medium-weight battens. Such a cabinet would have very pronounced resonant effects and defeat the whole object of the scheme.

The handiest material is probably ¾-inch plywood, although, in practice, anything from ⅝- to 1-inch plywood or solid stock should be employed. The wood should be supported internally by a suitable framework, all joints being glued and screwed. Either the back or the bottom must be removable for access to the interior, and this must be securely screwed back in place.

The figures given for volume naturally apply to the inside of the cabinet, and some small allowance should be made for space occupied by the internal

SUGGESTED VOLUME FOR VENTED ENCLOSURE

Nominal Speaker Diameter	Volume of Box (Cu. ft.)	Area of vent (sq. in.)
8	4	30
10	5	45
12	6	76
15	7.5	115

framework and bracing. It is wise to line all inside faces with hair felt or other sound-absorbent material. If sound-absorbent board is employed, it will reduce the interior volume of the cabinet appreciably, and allowance should be made in the design for this loss.

The important factor is the interior volume, the actual shape and dimensions of the cabinet being less important.

For a balanced appearance in rectangular cabinets, height should be roughly 2.5 times the depth, and width about 1.7 times depth. Depth refers to the front-to-rear measurement.

Our own experimental cabinet for a 7- or 8-inch speaker is somewhat taller and narrower than these proportions. Accordingly, the dimensions in the drawing were modified to approach the above proportions and, happily enough, the outside dimensions are very simple ones to work to. By the time allowance is made for the thickness of the timber, the interior volume will be just over the minimum recommended figure of 3 cubic feet.

For larger speakers, the cabinet will need to be substantially wider, with a smaller increase in the depth and height to give the required volume.

The position of the vent in relation to the loudspeaker does not appear to be critical, and the vent can thus be shaped and located on the front face of the cabinet to give the most balanced appearance.

Our thanks are due to the Australian publication, *Radio and Hobbies*, an article by W. N. Williams being the source for most of the material in this article.