

Instruction Manual

Motion Picture Loudspeaker Systems

A. Introduction:

Although the company's roots extend back to the early days of motion picture sound, it has only been in the last few years that JBL has made a significant impact on the commercial theater market. Some of the reasons for this are the company's preeminence in high-quality sound reinforcement in general and the development of the notion of flat power response in particular.

In just the last year, JBL theater systems have been incorporated into some of the most prestigious dubbing theaters and screening rooms in the film industry. We now feel that the time is right to prepare a comprehensive applications manual for our theater dealers to aid them in system design and specification and to give them an edge over their competitors.

B. Systems for Smaller Houses:

1. A summary of house types:

By far, most of the theaters being built today are long rectangular rooms. They are usually built in groups called multiplex theaters for reasons of economy. Most of these theaters are mono, with a single loudspeaker behind the screen, and the seating capacity usually ranges from 200 to 500. In general, the larger houses, those seating 1000 or more, were built some years ago, and these are usually equipped with three or five loudspeakers behind the screen and will have a multi-speaker surround channel located on the rear and side walls. A very few houses, usually found only in larger cities, will have special effects low-frequency channels, such as Sensurround, for special screenings of important films.

2. General Acoustical Characteristics:

Historically, motion picture theaters, whatever their size, have been acoustically "dead" rooms; that is, they have considerable absorption on the boundaries, and reverberation times, even in the larger houses, rarely exceed 1.25 seconds. More likely, we will find the reverberation times in smaller houses to be in the 0.5 second range. The reason for this of course has to do with articulation and clarity of dialog.

The most common method of treating the interior of theaters is with velour draping. This is an interior treatment only; structurally, the architect relies on solid block walls to minimize sound leakage from adjacent theaters.

One of the most common problems encountered in theaters is a slap or reflection off the back wall, which often goes untreated. Should the back wall be curved, then the effect may be even worse, due to focussing of the reflection back to the front.

3. Sound Level Requirements:

Average peak levels of 85 dB-SPL are common in the theater. A minimum headroom figure above this would be 10 dB, but JBL recommends 15 dB for a greater measure of safety. The following factors are taken into consideration in determining the kind of system to specify and the amount of amplifier power which will be required:

- a. Room volume
- b. Room boundary area
- c. Reverberation time
- d. System sensitivity and power rating
- e. System directivity index

Table I presents JBL's system recommendations based on general assumptions regarding room ratios and reverberation times. All the theater dealer or contractor has to do is calculate the room volume and go to that entry in the table. The mid-house levels are those calculated by assuming that the reverberant sound in the theater and the direct sound from the loudspeakers are equal. Beyond that point, the sound level will drop off somewhat, while in front of that point the sound will be louder.

Details of the various JBL systems recommended for single channel use in multiplex theaters are given in Figure 1. The choice between several systems, all of which might meet the specification, must be based on a number of considerations. In general, the models 4672A and 4674A will result in less amplifier power requirement; however, these systems begin to roll off below 120 Hz, while the models 4671 and 4673 extend smoothly down to 45 Hz. Another consideration is enclosure depth. The space behind some screens can be as small as 0.6 meter (2 feet), and this often dictates system choice.

4. System Installation:

Whenever possible, the screen loudspeaker should be located one-third the way up the screen. Should the screen itself be higher than usual, requiring patrons seated toward the front of the house to look upward, then the loudspeaker may be placed somewhat lower. As a rule, the loudspeaker high-frequency element should be aimed toward the farthest seats. This is certainly the way to go if the back wall is draped. If it cannot be draped, then tilting the system down a bit may help. The system should be placed as close as 0.3 meter (1 foot) to the screen to minimize the effect of high-frequency sound reflecting between the screen and the wall behind the loudspeaker. If possible, the wall area behind the screen should be treated with sound absorptive material. See Figure 2 for details of this.

Most of the wire runs in a theater will be short enough so that a wire gauge no greater than AWG #12 will be required. All JBL theater systems should be considered as 8-ohm systems in making line loss calculations, and the general rule is that line losses should be held to no greater than 0.5 dB. Table II shows line losses for various runs and gauges.

The theater dealer should always try to specify a stereo amplifier which can be bridged for mono operation. Care must be taken that the amplifier's bridged mono rating into 8 ohms will not be exceeded.

C. Systems for Larger Houses:

1. Choosing the system:

Figure 3 shows the JBL systems normally specified for multi-channel use in theaters. Note that these systems all make use of Bi-Radial high-frequency horns. The models 4675 and 4676A-1 make use of the 2360 90-by-40 degree horn for normal coverage, while the 4676A-2 uses a pair of 2365 60-by-40 horns splayed for 90-degree coverage.

Of these three systems, the 4675 will be the most useful because it exhibits the smoothest power response of any system that JBL makes. This is, in fact, the one that has become well known in film production circles as "JBL's new theater system."

Table III will enable the theater dealer to specify and choose power for these systems in larger theaters. The powers given for each loudspeaker enable each channel to reach a level of 100 dB in the house. Depending on the exact nature of the multi-channel installation, the behind-the-screen resources may be five full-range channels, or three full-range channels and two low-frequency augmentation channels.

2. Powering the system:

With these larger systems, we have the option of biamplification. While this is more expensive than the normal single amplifier approach, it does result in far cleaner sound on peaks by making it impossible for low-frequency signals to modulate high-frequency signals. Figure 4 shows the two ways that these larger systems can be implemented electrically.

Biamplification allows considerably more power to be delivered to the LF portions of theater systems, since the passive dividing network is being bypassed. Biamplification should certainly be considered essential if the theater installation is intended for playback at levels in excess of 100 dB.

3. Installation of the system:

As we stated earlier, it is customary for screen loudspeakers to be located about one-third the way up the screen and as close as 0.3 meter (1 foot). The center loudspeaker should be normal to the screen, but the flanking loudspeakers may be toed in slightly, as shown in Figure 5, in order to ensure even coverage, and consequently better stereo, for those patrons seated off to one side.

D. Surround Channels:

1. General requirements:

While there is little consistent practice in specifying and implementing surround channels, we can lay down the following requirements:

- a. The total acoustical power delivered by the ensemble of surround loudspeakers should be equal to one of the screen channels. There are probably not many surround channels which meet this requirement, but it is essential if the full impact of surround information is to be appreciated. While a 15-dB headroom factor is a part of the power calculations for the screen channels, it may be unreasonable to demand that of the surround channel. Thus, a requirement that the surround channel be able to produce a level in the house of 95 dB-SPL will suffice. In the case of the distributed 200 mm (8") speaker system, a level of 92 dB is deemed sufficient.
- b. The quantity of surround loudspeakers should be sufficient so that listeners are not aware of only one of them. This usually means a minimum of eight: three each on the side walls and two on the back wall.
- c. The surround loudspeakers should exhibit wide dispersion so that the entire audience area can appreciate even coverage across the frequency range.
- d. Surround loudspeakers should be unobtrusive and not interfere with theater decor. This requirement may run counter to some of the acoustical requirements in that size is related to system efficiency.

The JBL 4401 monitor loudspeaker works extremely well since a small number of them, usually less than 12, will provide the desired level in many houses. The MC 4401 mounting cradle provides a convenient method of wall-mounting and angling the 4401 system. Table IV presents details of surround loudspeaker selection.

The use of multiple 200 mm (8") loudspeakers has been favored by Dolby Laboratories. While the hardware costs may be reasonable, the labor costs for this approach are accordingly higher. For this type of system, the JBL 8140 co-motional transducer will be a logical choice. The baffles used in such an installation should ideally be constructed according to the transducer manufacturer's plans or recommendations so that low-frequency response will be adequate. A lower cost approach calls for using one of the many standard

tilted front enclosures. As a rule, these are too small in volume for proper low-frequency response, and the client should understand this at the outset.

The 4671 theater system is recommended for high-power surround use. With an efficiency of 3.5%, relatively few of these units are required. They would normally be specified when the entire theater reproduction system was called upon to produce levels in the 105-to-110-dB range.

2. Powering the surround channel:

Figure 6 presents details of the implementation of the surround channel. At C through E, we show details of the electrical distribution. Depending on the number of surround loudspeakers, the hook-up will be series-parallel, and the resulting impedance can usually be held to no less than 4 ohms. An amplifier should be chosen whose 4-ohm power rating will not be exceeded. In some cases, the JBL model 9375 line matching autotransformer will be useful in maintaining the desired impedance. For the 200 mm (8") loudspeakers, a 70-volt distribution system should be used. See JBL Technical Note, Volume 1, Number 2, for details of this method.

E. Subwoofer Systems:

1. Background:

Universal's introduction of "Sensurround" during the seventies brought special effects very-low-frequency channels into the motion picture theater. Typically, these channels cover the range from 20-25 Hz up to 40-50 Hz. Quite high acoustical power output is required, since the ear is relatively insensitive to extremely low frequencies.

2. Implementation:

Most installations of subwoofers are dictated by the requirements of particular screenings, and instructions will generally come from the studios or through the film distributors. The Dolby model CP200 processor provides a low-frequency output that may be used to drive a subwoofer channel directly.

Table V presents data on selecting the number of subwoofer modules needed for particular sound levels in theaters of different volumes. The enclosure recommended here is the 4518. Its specifications with the 2245H LF driver are detailed in column 4 of JBL Technical Note, Volume 1, Number 1. It is important to provide adequate and stable power for proper subwoofer operation. Whenever possible, the amplifiers should be located at the loudspeakers themselves.

Note that as the number of modules is doubled, the sound pressure increases 6 dB. Three dB are due to the doubling of power

handling, and the remaining three come from mutual coupling, the tendency of two loudspeakers to behave as a single, more efficient loudspeaker.

F. Acoustical Response:

1. Concept of flat power response:

While most loudspeaker systems are fairly flat on axis, they tend to narrow considerably in their coverage angles at high frequencies. Their power response is said to roll off. If a loudspeaker maintains fairly constant horizontal and vertical coverage angles over most of its frequency range, then flat on-axis response will also imply flat power response. Since about half of the sound heard in the theater has been reflected at least once, it is important that loudspeakers exhibit fairly flat power response if the reproduced sound is to be natural.

Another consequence of using loudspeakers with flat power response is that little system equalization is required. Figure 7 illustrates this. At A, we see the boundary absorption in a typical well-designed theater. Note that it is quite flat over the frequency range. High-frequency losses due to air absorption are shown at B, and typical high-frequency screen losses are shown at C. When we add up all of these, we get the response shown at D, and this is exactly the acoustical response we would observe in the room if we were using a loudspeaker that had flat power response.

Figure 8 shows the standard "house curve" to which most theater systems are equalized. Note that it closely resembles the summed curve shown in Figure 7,D, indicating that flat power response systems will require little, if any added equalization in most houses.

JBL's theater systems using Bi-Radial horns exhibit essentially flat power response as well as flat on-axis response. The smaller systems exhibit flat on-axis response, but their power response rolls off slightly at high frequencies. JBL's passive dividing networks provide for a high-frequency boost which effectively makes any of the systems power-flat at high frequencies. In the smaller systems, this may be accompanied by a slight on-axis rise at high frequencies. Nevertheless, we recommend that the high-frequency boost be used in all theater applications.

H. System Assembly:

1. General comments:

JBL's theater systems are shipped to the dealer in component form. Every attempt is made

to ship the components complete so that the systems can be readily assembled. It is a wise dealer, however, who will keep a good stock of replacement components and mounting hardware.

The systems do not travel well in their assembled form, so they should always be assembled at their final site. All transducers should be checked prior to being sent out, however.

2. Details of assembly:

We present in Figure 9 detailed wiring diagrams of each of the theater systems, along with a complete listing of components in each system.

Figure 10 shows details of mounting LF transducers in the various 4500-series LF enclosures. The models 4507, 4508 and 4518 all require front-mounting of transducers. There are T-nuts mounted on the back side of the baffle, and the four mounting screws for each transducer engage these as shown at A.

Both the 4550BKA and 4560BKA have demountable back panels. These are removed and the LF transducers mounted in place with screws engaging T-nuts, as shown at B.

High-frequency horns are mounted as shown in Figure 11. The 2370 horn-2425 HF driver combination is placed directly on top of the 4507 LF enclosure, and its mouth is parallel with the front of the LF enclosure. It should be mounted flush with the front of the LF enclosure. Two angle irons may be used to secure the front of the horn to the enclosure, as shown at A. An alternate way to mount the smaller Bi-Radial horns (2370 and 2380) is to screw the bottom front flange into the upper front edge of the LF enclosure, as shown in Figure 11C. The user should note in general that Bi-Radial horns, because of their extended vertical coverage at high frequencies, do not normally have to be tilted with respect to the LF enclosure in order to provide proper coverage of the audience area.

When the 4560BKA enclosure is used, the 2370 horn is mounted in a space provided at the top of the LF enclosure. The upper panel is removed, and the horn is screwed into place, as shown at B.

The 2380 horn is mounted on top of the LF enclosure in the 4670A, 4673, and 4674A systems. With the 2445 HF driver in place, the horn-driver combination sits on top of the enclosure with its mouth parallel to the front of the enclosure. As in the case shown at A, the front of the horn should be secured to the enclosure top with angle irons, or by screwing into the front edge of the LF enclosure.

The Bi-Radial horns require the model 2506 mounting bracket for proper installation. Proper mounting is shown at bracket for proper installation. Proper mounting is shown at D. The bottom of the mouth of the Bi-Radial horn should be flush with the front of the LF enclosure, and the mounting bracket should be securely screwed to the top of the enclosure.

Figure 12 shows how networks are mounted. The smaller networks, models 3110A and 3115A, are mounted in cut-outs in the rear of the LF enclosures, as shown at A. The high-power 3152A is screwed onto the back of the enclosure, as shown at B.

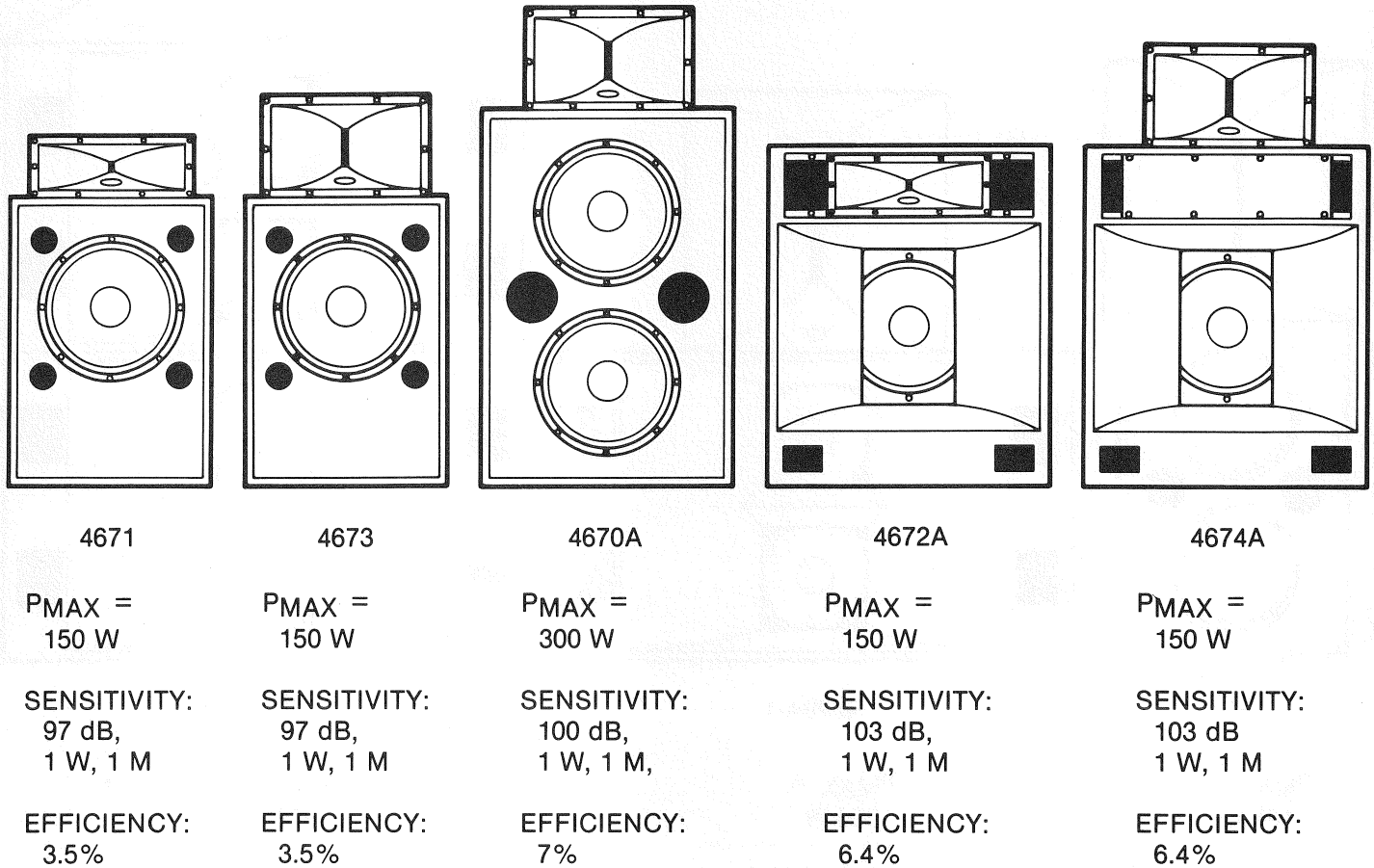


FIGURE 1. JBL SYSTEMS FOR SMALLER THEATERS

TABLE I. SYSTEMS AND POWER RECOMMENDATIONS FOR SMALLER HOUSES

SEATS	VOLUME (APPROX.)	SYSTEMS	POWER REQUIRED FOR 100 dB	RECOMMENDED AMPLIFIER POWER
200	1700 M ³ (60,000 FT ³)	4671	46 WATTS	100 WATTS
		4673	46 WATTS	100 WATTS
		4672A	23 WATTS	50 WATTS
		4674A	23 WATTS	50 WATTS
350	2832 M ³ (100,000 FT ³)	4670A	30 WATTS	50 WATTS
		4672A	30 WATTS	50 WATTS
		4674A	30 WATTS	50 WATTS
500	4530 M ³ (160,000 FT ³)	4670A	50 WATTS	100 WATTS
		4674A	50 WATTS	100 WATTS

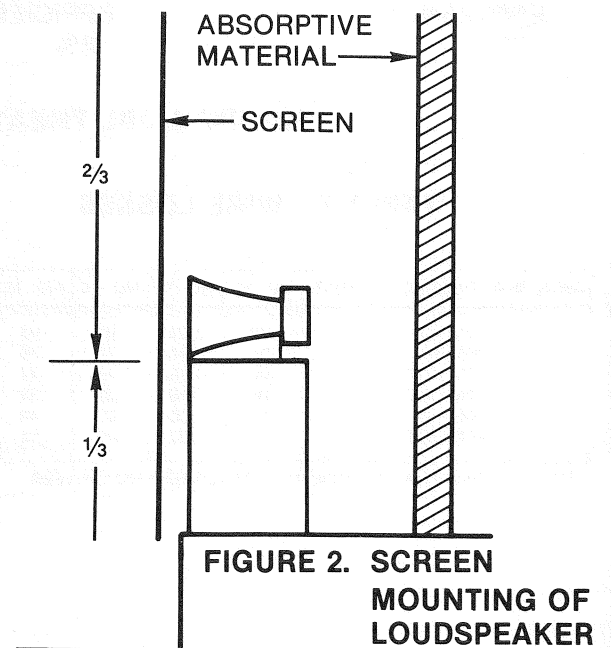
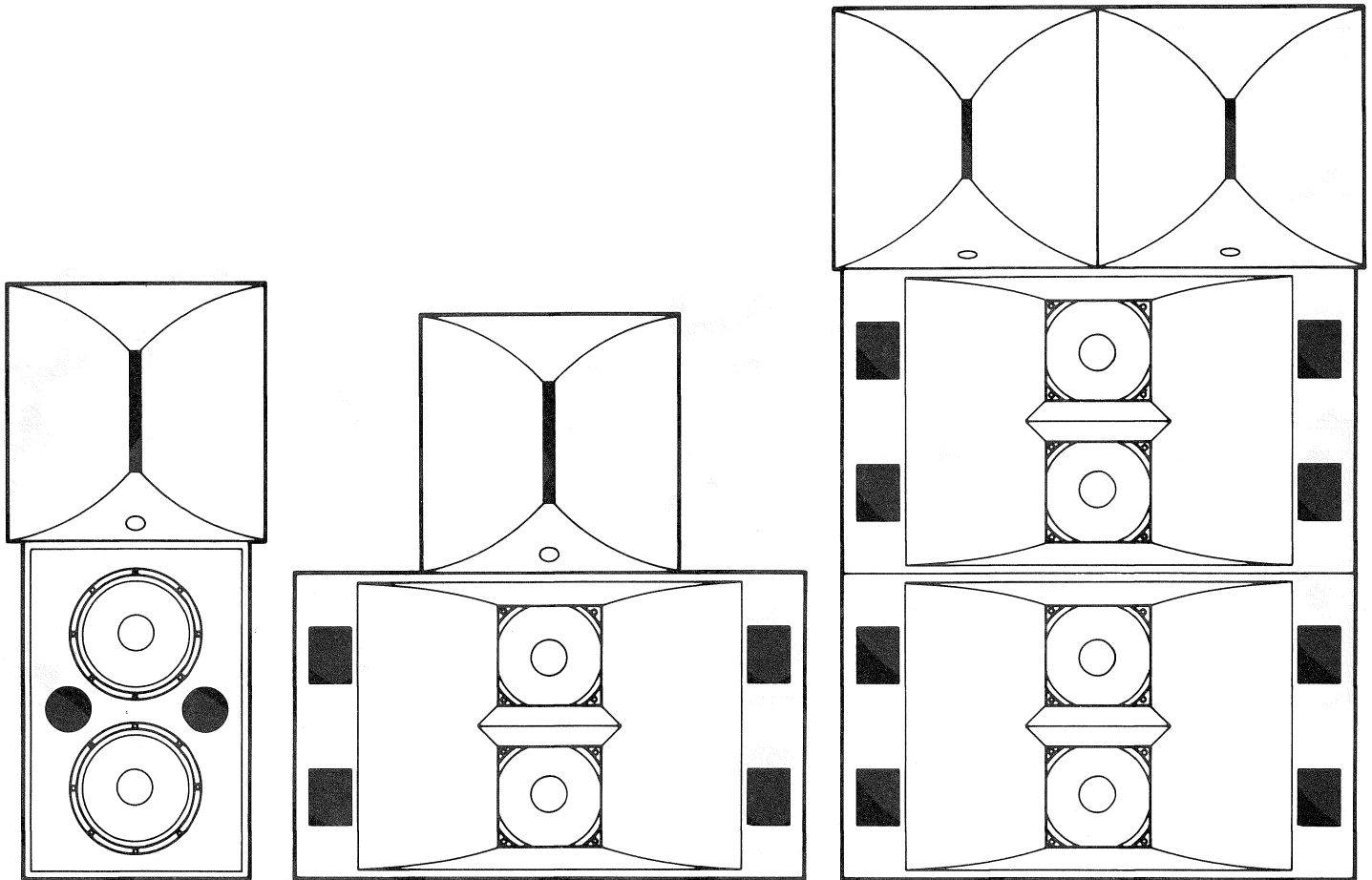


FIGURE 2. SCREEN MOUNTING OF LOUDSPEAKER



4675

4676A-1

4676A-2

P_{MAX} =
300 W

SENSITIVITY:
100 dB,
1 W, 1 M

EFFICIENCY:
7%

P_{MAX} =
300 W

SENSITIVITY:
106 dB,
1 W, 1 M

EFFICIENCY:
8%

P_{MAX} =
300 W

SENSITIVITY:
109 dB,
1 W, 1 M

EFFICIENCY:
16%

FIGURE 3. JBL THEATER SYSTEMS FOR LARGER HOUSES

TABLE II. WIRE LOSSES

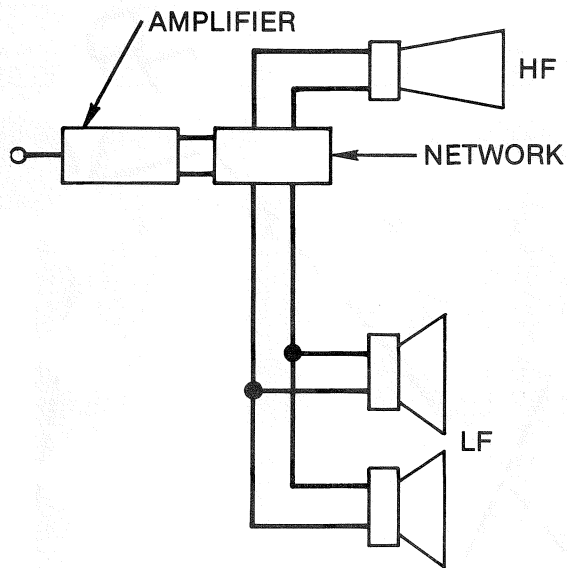
WIRE RUN (DOUBLE; COPPER)	NO. 10	NO. 12	NO. 14	NO. 16	NO. 18
10M (33')	.02	.032	.05	.08	.125
20M (66')	.04	.064	.10	.16	.250
30M (100')	.06	.096	.15	.24	.375
40M (132')	.08	.128	.20	.32	.500
50M (165')	.1	.160	.25	.40	.625
60M (200')	.12	.192	.30	.48	.750

FOR 8Ω LOAD, LINE RESISTANCE SHOULD BE 0.552 OR LESS.

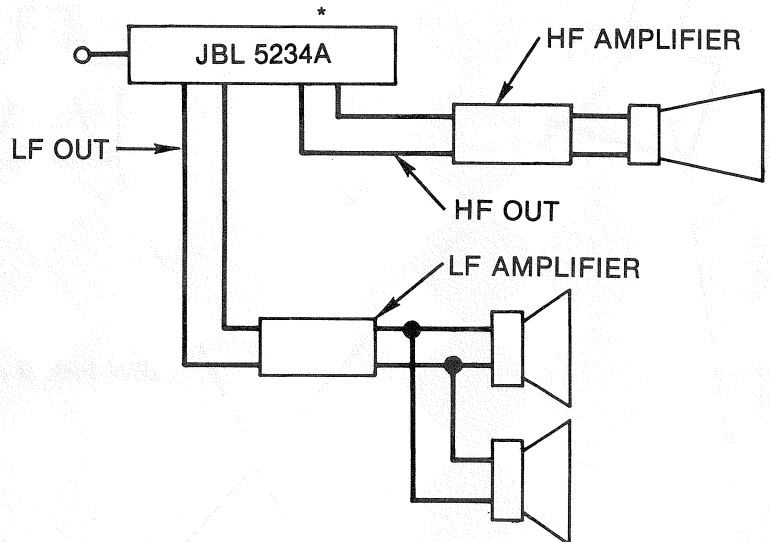
TABLE III. SYSTEMS AND POWER REQUIREMENTS FOR LARGER HOUSES

SEATS	VOLUME (APPROX.)	SYSTEMS	POWER REQUIRED FOR 100 dB	RECOMMENDED AMPLIFIER POWER PER LOUDSPEAKER
500-1000	8500 M ³ (300,000 FT ³)	4675	72 WATTS	150 WATTS
		4676A-1	63 WATTS	125 WATTS
		*4676A-2	42 WATTS	100 WATTS
1000-2000	14,160 M ³ (500,000 FT ³)	4675	90 WATTS	200 WATTS
		4676A-1	79 WATTS	200 WATTS
		*4676A-2	53 WATTS	125 WATTS

* BECAUSE OF THEIR EXTREMELY HIGH POWER RATINGS, THESE SYSTEMS WOULD BE SPECIFIED WITH MUCH LARGER POWER AMPLIFIERS THAN SUGGESTED HERE FOR USE IN SPECIAL, HIGH SOUND LEVEL APPLICATIONS.



FULL-RANGE AMPLIFICATION



BIAMPLIFICATION

*500 Hz, POWER RESPONSE CORRECTED CARD TO BE USED

FIGURE 4. FULL-RANGE AMPLIFICATION AND BIAMPLIFICATION

TABLE IV. SURROUND SYSTEM DATA

SEATS	4401 MONITOR	8140 DISTRIBUTED SYSTEM	4671
500-1000	8 UNITS @ 50 WATTS EACH	30 UNITS @ 5 WATTS EACH*	6 UNITS @ 100 WATTS EACH**
1000-2000	12 UNITS @ 50 WATTS EACH	38 UNITS @ 5 WATTS EACH*	10 UNITS @ 100 WATTS EACH**

*FOR A MAXIMUM LEVEL OF 92 dB
 **FOR A MAXIMUM LEVEL OF 107 dB
 BOTH 4401 AND 8140 SURROUND SYSTEMS SHOULD BE HIGH-PASSED AT 40 Hz OR HIGHER.

TABLE V. SUBWOOFER SELECTION DATA

NUMBER OF MODULES	EFFICIENCY	ELECTRICAL POWER INPUT	ACOUSTIC POWER	SOUND LEVELS	
				500-1000 SEATS	1000-2000 SEATS
1	2%	300 WATTS	6 WATTS	101 dB	100 dB
2	4%	600 WATTS	24 WATTS	107 dB	106 dB
4	8%	1200 WATTS	96 WATTS	113 dB	112 dB
8	16%	2400 WATTS	384 WATTS	119 dB	118 dB

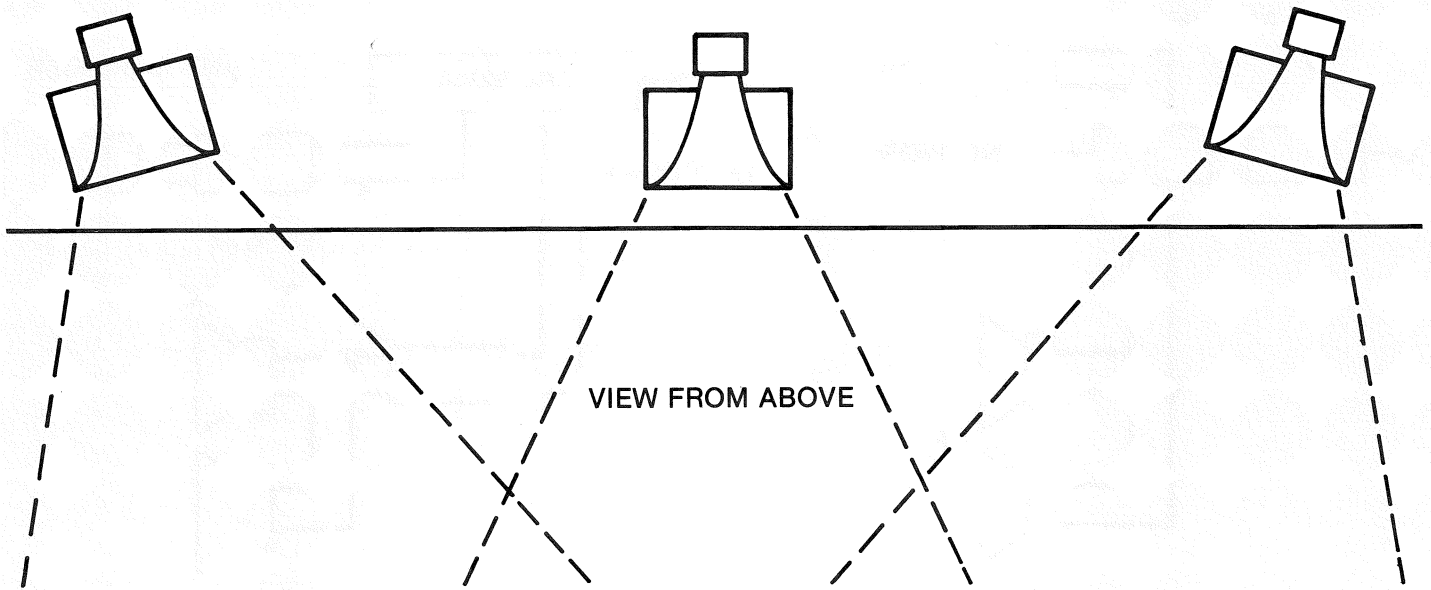
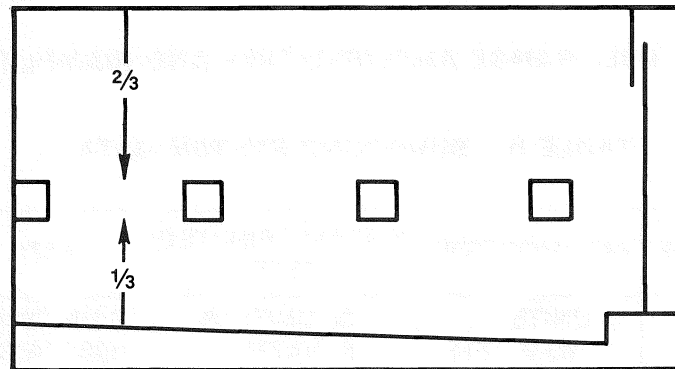
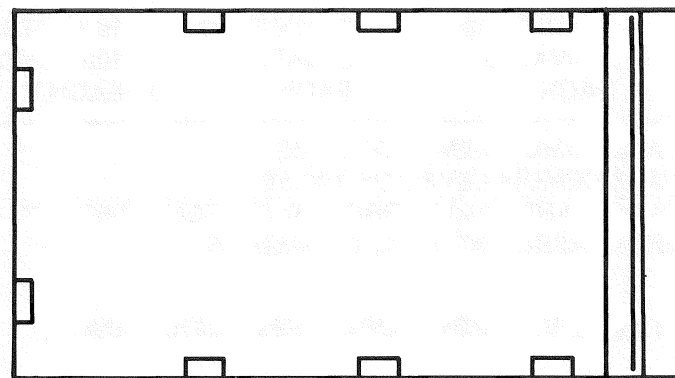


FIGURE 5. POSITIONING LOUDSPEAKERS BEHIND THE SCREEN



A. SIDE VIEW



B. TOP VIEW

FIGURE 6. SURROUND SYSTEM IMPLEMENTATION

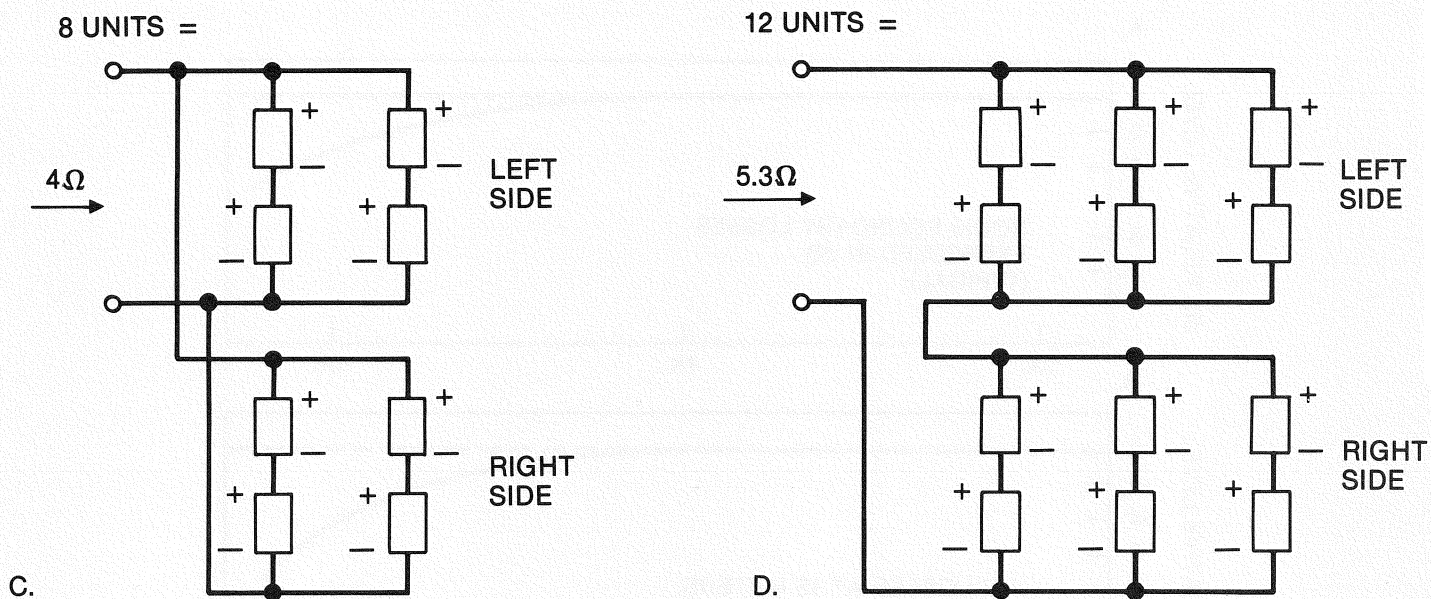


FIGURE 6, CONT'D. ELECTRICAL CONSIDERATIONS

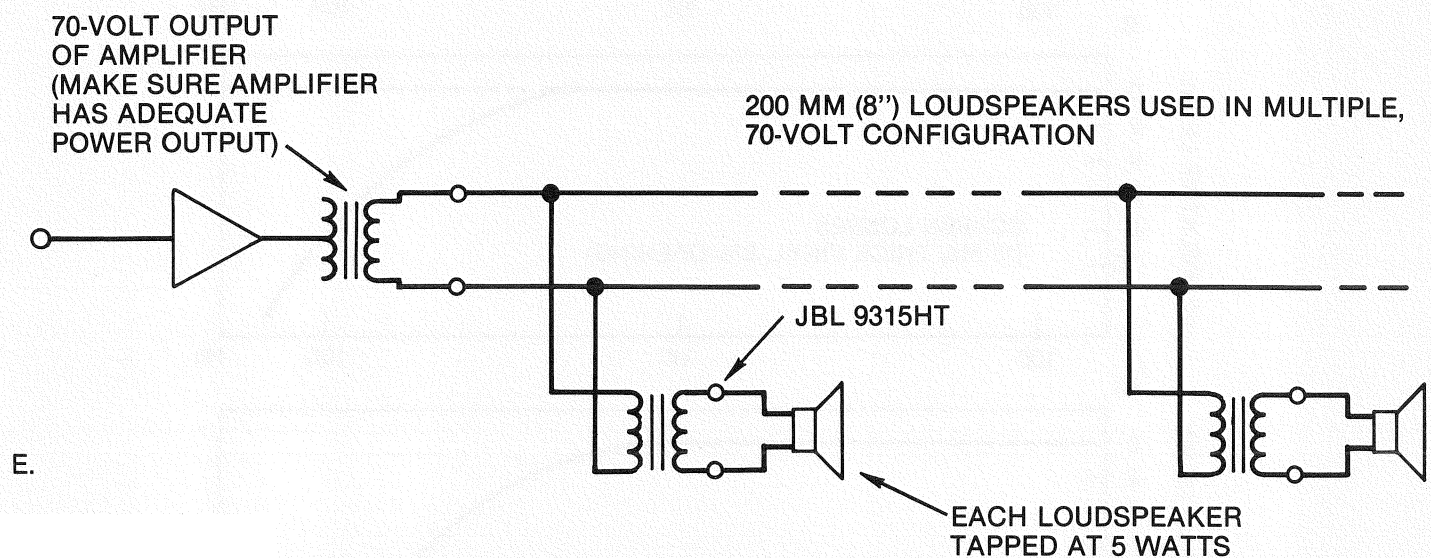


FIGURE 6, CONT'D. ELECTRICAL CONSIDERATIONS

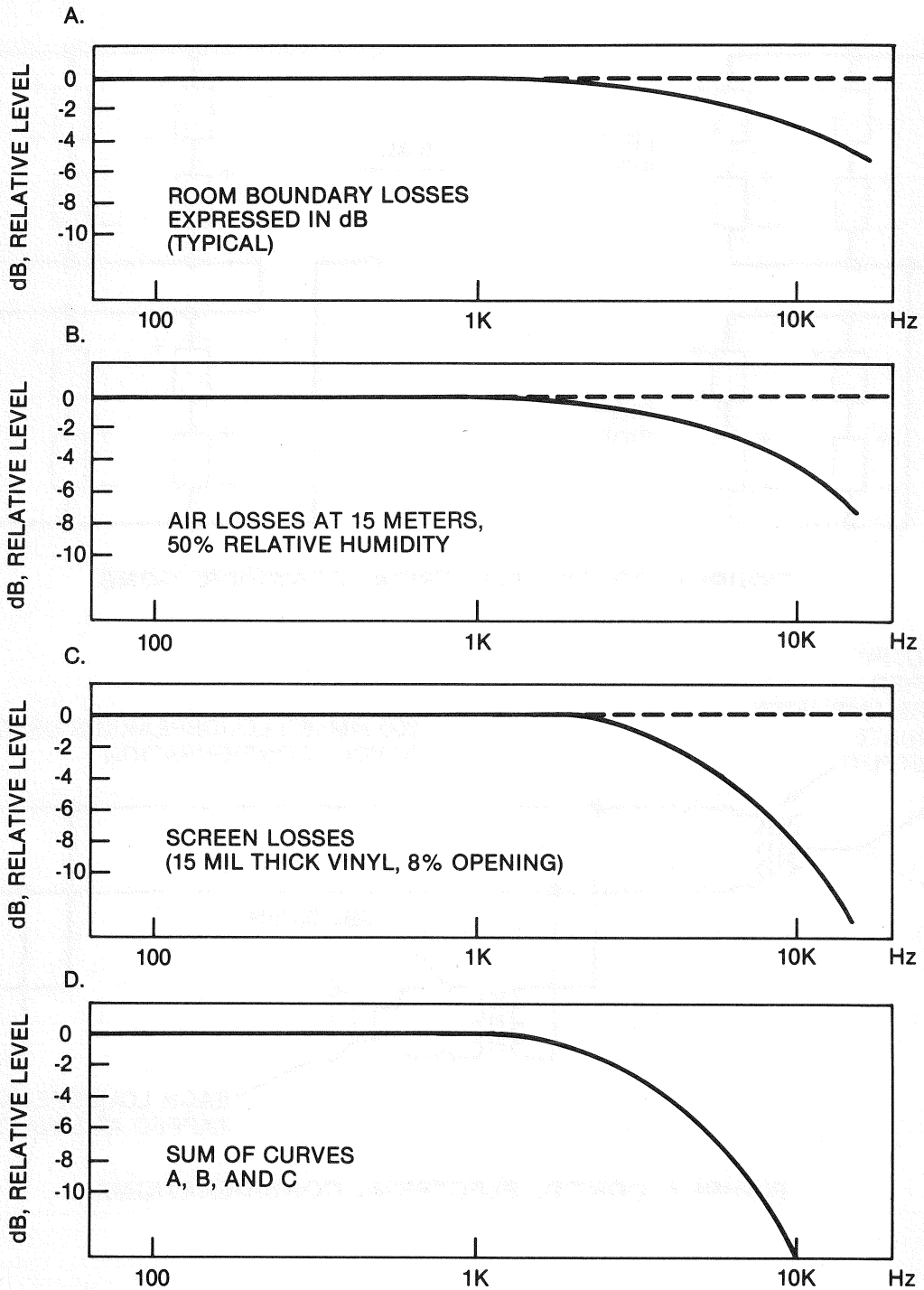


FIGURE 7. RESPONSE IN THE HOUSE

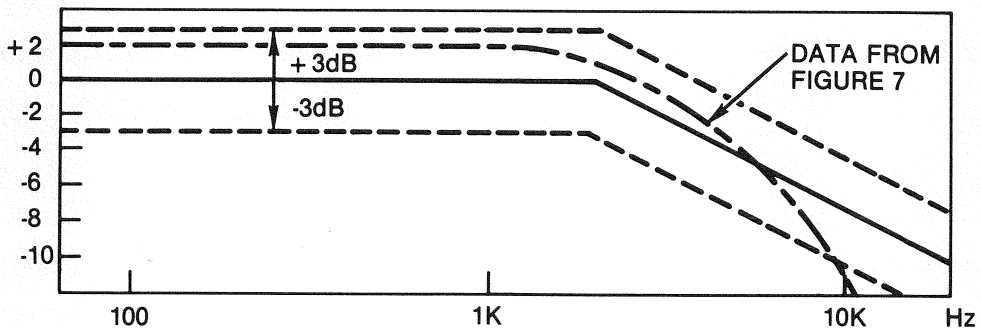


FIGURE 8. ISO STANDARD PLAYBACK RESPONSE

A. 4671: Components:

1-4507 Low Frequency Enclosure
1-2225H Low Frequency Transducer
1-2370 High Frequency Horn
1-2425J High Frequency Driver
1-3110A Network

B. 4673: Components:

1-4507 Low Frequency Enclosure
1-2225H Low Frequency Transducer
1-2380 High Frequency Horn
1-2445J High Frequency Driver
1-3115A Network

C. 4670A: Components:

1-4508 Low Frequency Enclosure
2-2225J Low Frequency Transducers
1-2380 High Frequency Horn
1-2445J High Frequency Driver
1-3152A Network

D. 4672A: Components:

1-4560BKA Low Frequency Enclosure
1-2225H Low Frequency Transducer
1-2370 High Frequency Horn
1-2425J High Frequency Driver
1-3110A Network

E. 4674A: Components:

1-4560BKA Low Frequency Enclosure
1-2225H Low Frequency Transducer
1-2380 High Frequency Horn
1-2445J High Frequency Driver
1-3115A Network

F. 4675: Components:

1-4508 Low Frequency Enclosure
2-2225J Low Frequency Transducers
1-2360 High Frequency Horn
1-2445J High Frequency Transducer
1-2506 Mounting Bracket
1-3152A Network

G. 4676A-1: Components:

1-4550BKA Low Frequency Enclosure
2-2225J Low Frequency Transducers
1-2360 High Frequency Horn
1-2445J High Frequency Transducer
1-2506 Mounting Bracket
1-3152A Network

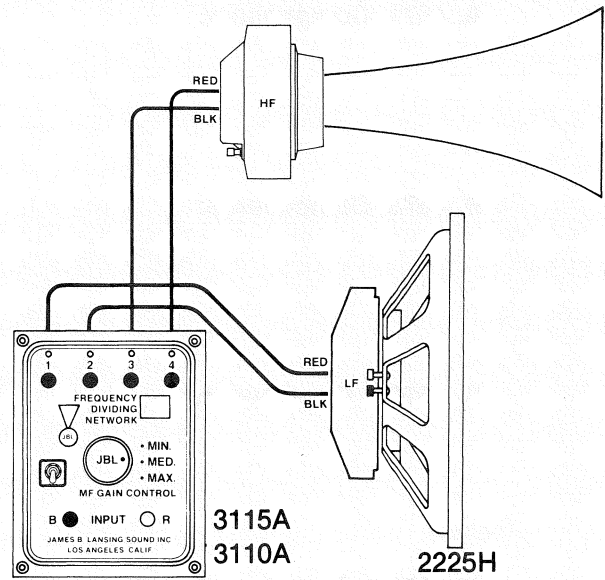
H. 4676A-2: Components:

2-4550BKA Low Frequency Enclosures
4-2225H Low Frequency Transducers
2-2365 High Frequency Horns
2-2445J High Frequency Drivers
2-2506 Mounting Brackets
1-3152A Network

FIGURE 9. JBL THEATER SYSTEMS COMPONENTS AND WIRING DIAGRAMS

J. Wiring Diagram for:

4671
4672A
4673
4674



K. Wiring Diagram for:

4670A
4675A
4676A-1

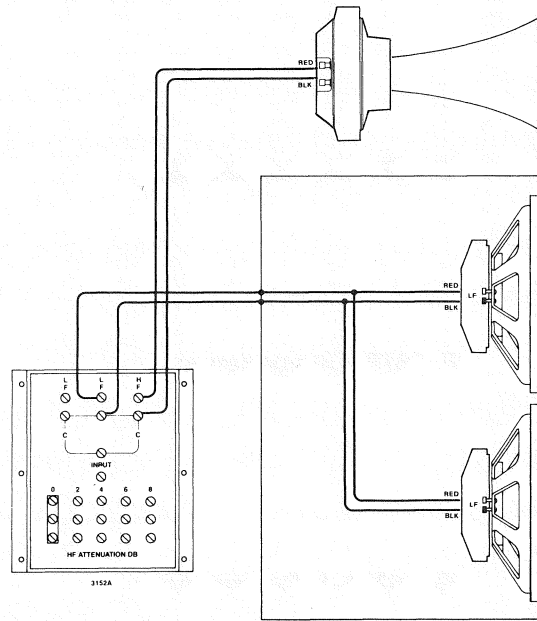


FIGURE 9, CONT'D.

L. Wiring Diagram for:

4676A-2

Note: Splay each HF Horn 22 1/2° off center
(Total Splay angle of 45°)

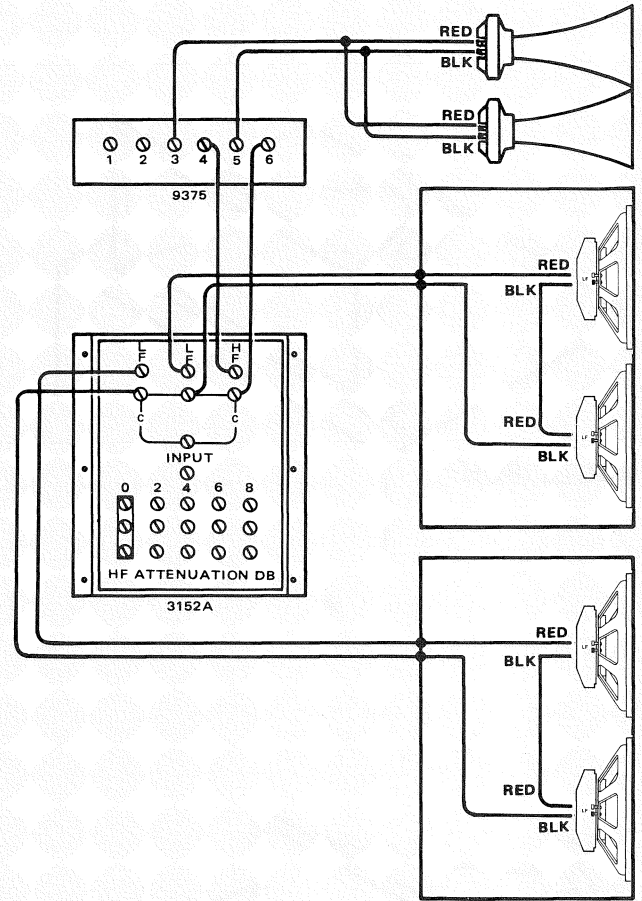
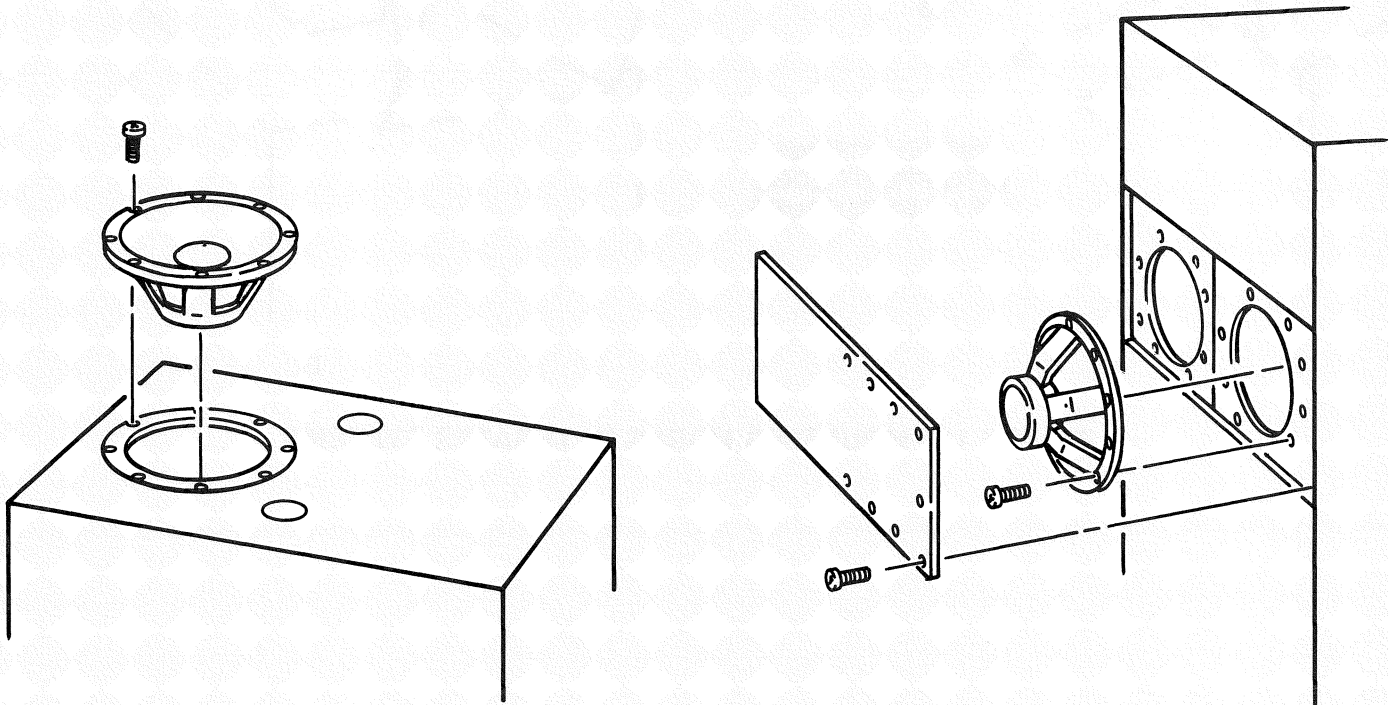


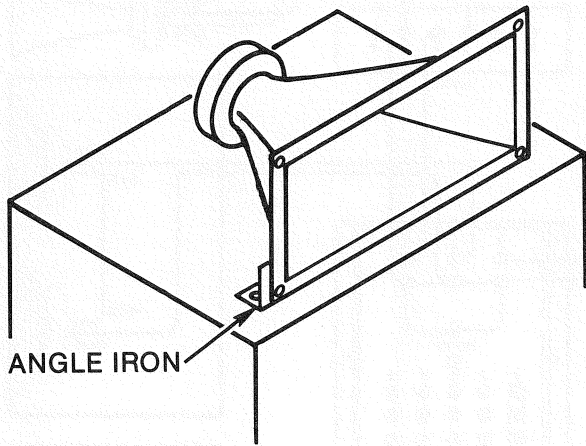
FIGURE 9, CONT'D.



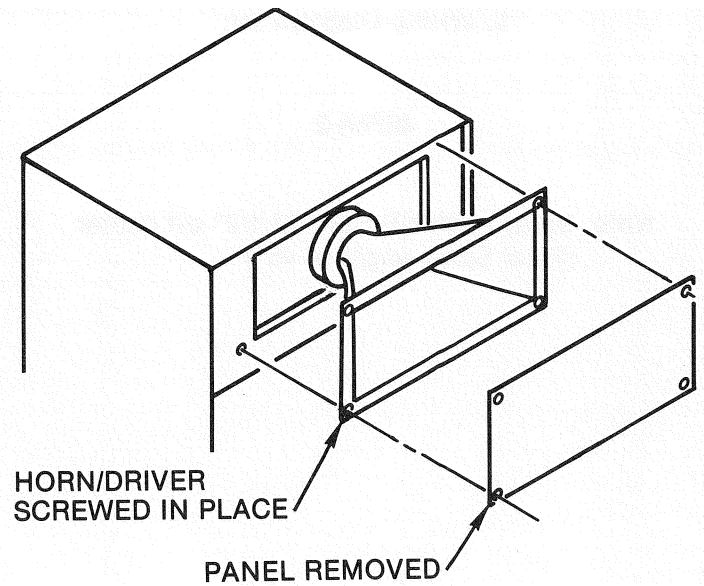
A. MOUNTING LF TRANSDUCERS IN 4507, 4508,
AND 4518

B. MOUNTING LF TRANSDUCERS IN 4550BKA
AND 4560BKA

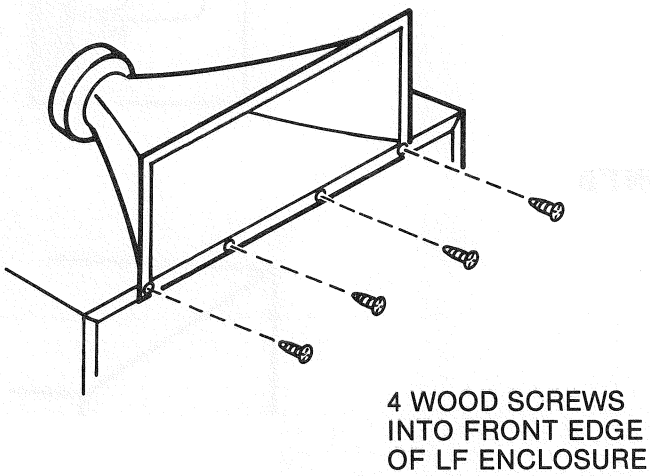
FIGURE 10. LF ENCLOSURE ASSEMBLY INSTRUCTIONS



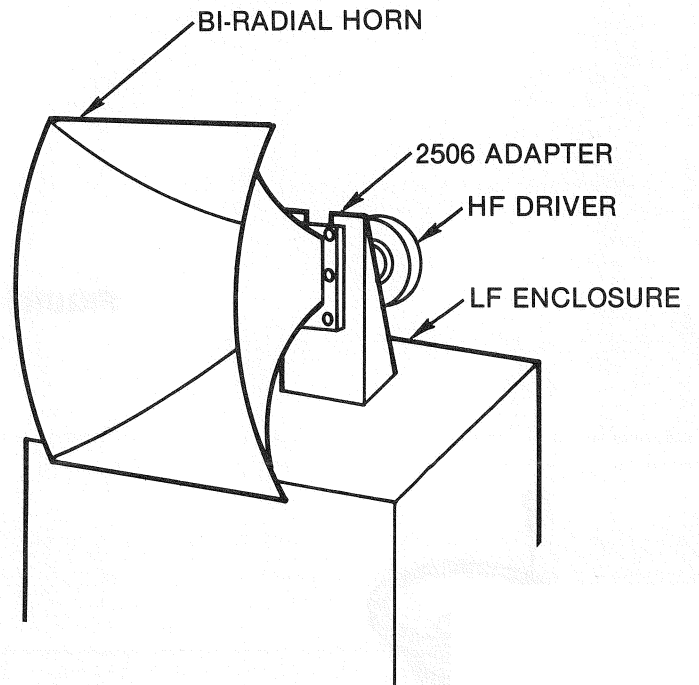
A.



B.



C.



D.

FIGURE 11. MOUNTING HORNS IN THEATER SYSTEMS

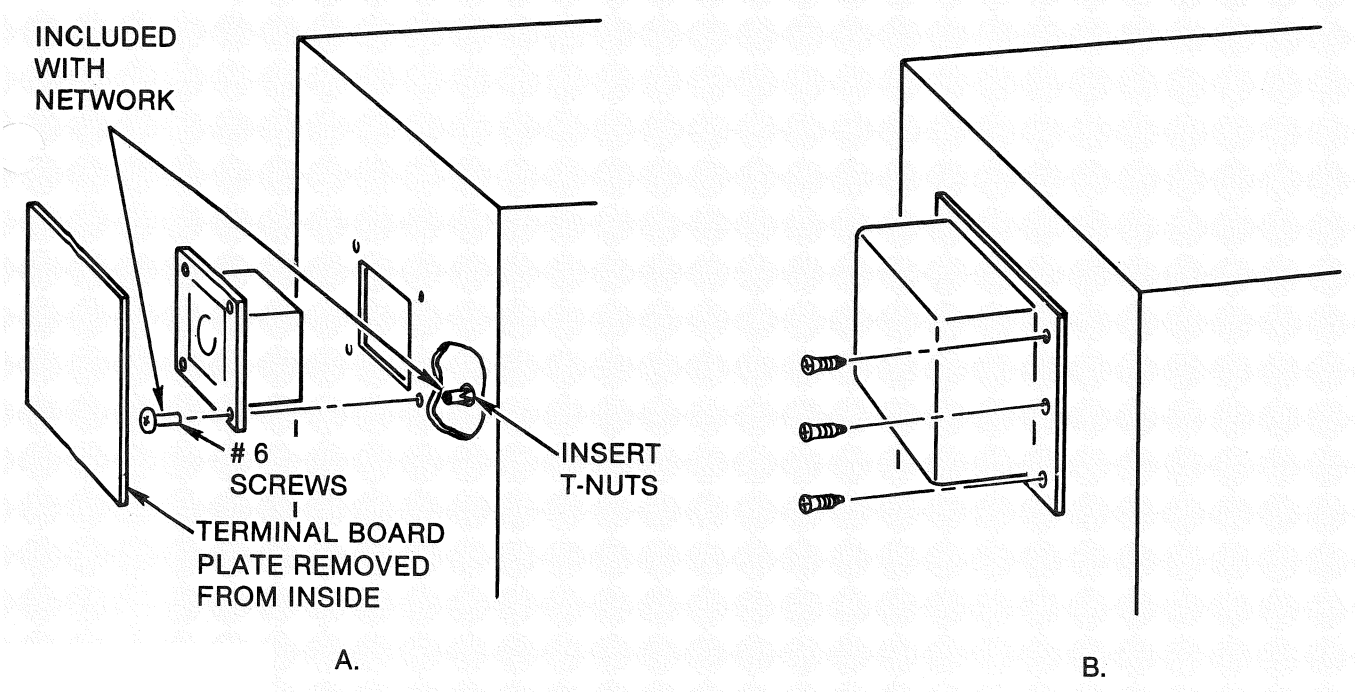


FIGURE 12. MOUNTING NETWORKS



JBL Incorporated
P.O. Box 2200
8500 Balboa Boulevard
Northridge, California 91329 U.S.A.