For the professional musician:

JBL SPEAKER SYSTEM HANDLES 300W PROGRAM

Fitted with corner protectors, flush side handles and castors, the prototype system is rigid, rugged and no more bulky than it needs to be for the job of making a really big noise from lead guitar or keyboard input. A semi-transparent black grille cloth provides the necessary finish, while still giving a hint of the hefty drivers behind.

This article gives full constructional details for a loudspeaker system especially designed for professional musicians. Husky and efficient, with a "continuous program" rating of 300W, it is particularly suitable for use with lead guitars or electric pianos. By way of interest, the article examines the difference between conventional hifi and specialised "music" loudspeakers.

by NEVILLE WILLIAMS

An earlier version of this system was presented in the Electronics Australia Year Book of 1976/77, with the cooperation of Harman Australia Pty Ltd, distributors of JBL products in this country.

In a recent discussion with Managing Director, Bill Martin, we asked whether any musicians still assembled their own stage loudspeakers; we were assured that they certainly did. Musicians and groups get closely involved in makes and models of drivers, the type of enclosures they can cope with, and the kind of sound they want to produce.

It transpired that the system we had described three years ago was still basically valid and typical, except that the K130 bass/middle driver specified on that occasion had been superseded by an up-dated model with even more ambitious specifications. The power rating of the new E130 is up from 250W to 300W (continuous program) and an extra 1dB of sensitivity has been added to the K130's already high figure of 104dB.

THE ENCLOSURE

In regard to the enclosure, we discussed this at some length with John Barclay, who is National Manager for the Professional Division of Harman Australia. He said that, for the role under discussion, the E130 could be regarded as a direct replacement for the K130. It could therefore be used in an enclosure built to the dimensions, as published earlier.

John did stress, however, that, with its extra sensitivity and power rating, an E130 can place enormous stresses on the enclosure when operating at full power. Everything needs to be solidly cleated, glued and screwed, with front-to-back braces for good measure.

Anything less firmly constructed may not withstand the stresses of being trucked and manhandled off-stage, and violently "pumped" on-stage. According to John Barclay, it is not unusual for cabinets literally to come apart at the seams, with the rear panel being particularly vulnerable.

The E130 is fitted with a metal cap over the voice coil, which sustains the response to a nominal 6kHz. JBL and Harman say that it can be (and commonly is) used on its own for lead guitar, vocals and keyboards.

Where there is a requirement for a more prominent upper register, one or more separate tweeter loudspeakers can be used – but they must be of a type with sensitivity and power handling to match that of the E130; otherwise, they would be completely useless.

More about this point later.

But why the distinction . . . vocal, lead guitars, keyboards? Surely a good system should be good for anything – hifi, guitars, electric pianos, organs, public address and what have you! It's a point that may puzzle hifi fans and one that warrants clarification.

The long and the short of it is that there are important distinctions between optimised "hifi" and optimised "music" loudspeakers involving such qualities as frequency response, distortion, sensitivity and overload characteristic.

A loudspeaker intended for a hifi system has to be capable of reproducing a wide variety of sound, from the deepest notes of a grand organ to the shimmering near-supersonics of a cymbal. It should have no obvious peaks or troughs in its frequency response, otherwise it will impart its own "colouration" to instrumental or vocal sound.

Distortion must also be as low as possible at all likely power levels, from a whisper to full volume in the particular listening situation – almost invariably a home environment.

HIFI LOUDSPEAKERS

To meet these needs, designers of hifi loudspeakers have tended to favour the use of voice coils much longer than the magnetic gap, such that a fixed number of turns remains in the gap, even during extensive cone excursions. The method provides good linear cone drive and accords with compact enclosure design, but it markedly reduces sensitivity, thereby necessitating considerable audio drive power.

For this reason, domestic hifi amplifiers are more likely these days to be in the 20-60W per channel class than 5-20W. In short, sensitivity is sacrificed in the knowledge that extra drive power (in this range, anyway) can be secured without too much hassle.

Nor does a hifi loudspeaker manufacturer have to worry unduly about overload. With the onset of overload distortion, most hifi listeners will react automatically and "turn down the wick" before damage occurs.

A specialised "music" loudspeaker

system differs from the foregoing on almost every count. Consider, for example, the matter of frequency response:

A music speaker is not required to reproduce the sound of any instrument but only that of which it virtually forms a part. Needs vary with the type of instrument, as the following examples should indicate:

Church or classical electronic organ: Bass should be well sustained down to 32Hz, middles smooth, upper treble tapered off to minimise risk of the instrument sounding too "reedy".

Popular electronic organ: For theatre-style recitals, much the same as for a classical organ. For group work or a "zingy" solo sound, more sustained treble is desirable but a bass roll-off at 50Hz might be acceptable.

Bass guitar: Bass sustained to about 40Hz, treble response not important above 2500Hz.

Hawaiian steel guitar: Bass sustained to about 50Hz, treble about 5000Hz.

Lead and rhythm guitar: Bass sustained to about 50Hz, strong middle response to 6000Hz at least.

Electric piano: Broadly similar requirements to lead and rhythm guitar, above.

If a brighter than average sound is required, the response can be extended to 10,000Hz or more by the addition of one or more tweeters having an appropriate power rating.

Voice, vocals: Smooth response from 50 to about 7000Hz. Can be similar system as for lead guitar, electric piano, provided the middle and treble is not too peaky, rendering the voice harsh or sibilant.

Looking at these requirements, it is evident that the loudspeaker system for a recital organ or bass guitar must have a fundamental response down to the 30-40Hz region, combined with the ability to generate acoustic power appropriate to the environment. For large auditoriums it adds up to one or more powerful bass drivers, a bulky enclosure and power amplifier with an appropriate output rating.

To meet this specific need, JBL offer a number of specialist bass drivers, of which the E140 is typical. With a diameter of 15 inches, it has a nominal frequency response from 40-2500Hz and a power rating of 200W RMS continuous tone, or 400W continuous program. For a bass guitarist, it could probably be used alone but, for a recital organ it would have to be supplemented by adequately rated drivers covering the mid and upper range.

For all other applications, it is evident that the bottom octave can be compromised, if not sacrificed, and this

has important implications. The driver cone suspension can be stiffened, raising the natural system resonance to around 50-60Hz, and a more compact enclosure can be designed around these new parameters. While such a system will still produce plenty of output from low frequency drive, it will tend to be less "fundamental" in its quality. (It will also absorb a lot of punishment!)

A driver reflecting this philosophy is the one which forms the basis of the present system, the JBL E130. Also a 15-inch type with a 4-inch voice coil, it has a nominal frequency range of 50-6000Hz and a power rating of 150W continuous tone or 300W continuous program.

The fact that fundamental output is not required below about 50Hz has another important implication: cone travel will be less, the voice coil can be shorter (hence more of it in the magnetic gap) and efficiency can be improved.

In fact, JBL tend to major on high acoustic efficiency in all their musical instrument speakers by: (1) using large – and expensive – magnets; (2) by making voice coils no longer than necessary and (3) by winding many of the coils with square section wire, thereby putting 25% more conductor in the air gap. The resulting difference is nothing short of startling.

By way of comparison the JBL L-166 hifi system, a fairly sensitive unit by ordinary hifi standards, is credited with a sound pressure level of 89dB at a distance of one metre, on axis, with 1W drive.

But the E140 bass driver, mentioned earlier, is rated at 100dB at one metre on axis, also with 1W drive – a difference of 10dB! This is equivalent to a ratio of 10:1 in amplifier power, meaning that a musician could obtain the same sound pressure level from an amplifier one-tenth the size, or ten times the power level from an amplifier of given size! Subjectively, it will sound twice as loud.

EVEN MORE SENSITIVE

This is impressive enough but the E130 driver – rated to 50Hz – offers an SPL of 105dB or 5dB better again than the E140! Considering the sound pressure levels which professional on-stage musicians may want to create, it is not surprising that they are willing to pay large money for a sensitivity advantage over conventional hifi systems, of around 30:1, or 40:1.

(For a further discussion on loudspeaker efficiency, see page 32 of the November 1980 issue: "Loudspeakers, what happens to the watts?")

High-power, high sensitivity loudspeakers are expensive, but they are still a lot more economical and more manageable than a ten-fold (or more) increase in the power of already large stage amplifiers.

And, finally, there is the matter of power rating and overload. With the type of driver under discussion, the designer can arrange that the voice coil tends to move out of the gap as the cone approaches the limits of permissible travel. Instead of threatening the cone structure, excessive drive peaks tend to be rounded off, giving the system a "soft" overload characteristic – even if it happens at a very high volume!

In point of fact, the overload rating of the specialist JBL music speakers is not set by cone travel, but is a heat rating on the voice coil.

Thus the E130 is rated to operate quite safely, in terms of cone travel, with an amplifier delivering a nominal 150W RMS continuous tone – this at or around the frequency where the system impedance is lowest and the effective drive power is highest. But because the heating power of program material – even on stage – is lower than continuous tone, the continuous program rating is 300W.

Considering the sensitivity of the E130, that would represent a very substantial level of sound!

NATURE OF DRIVE

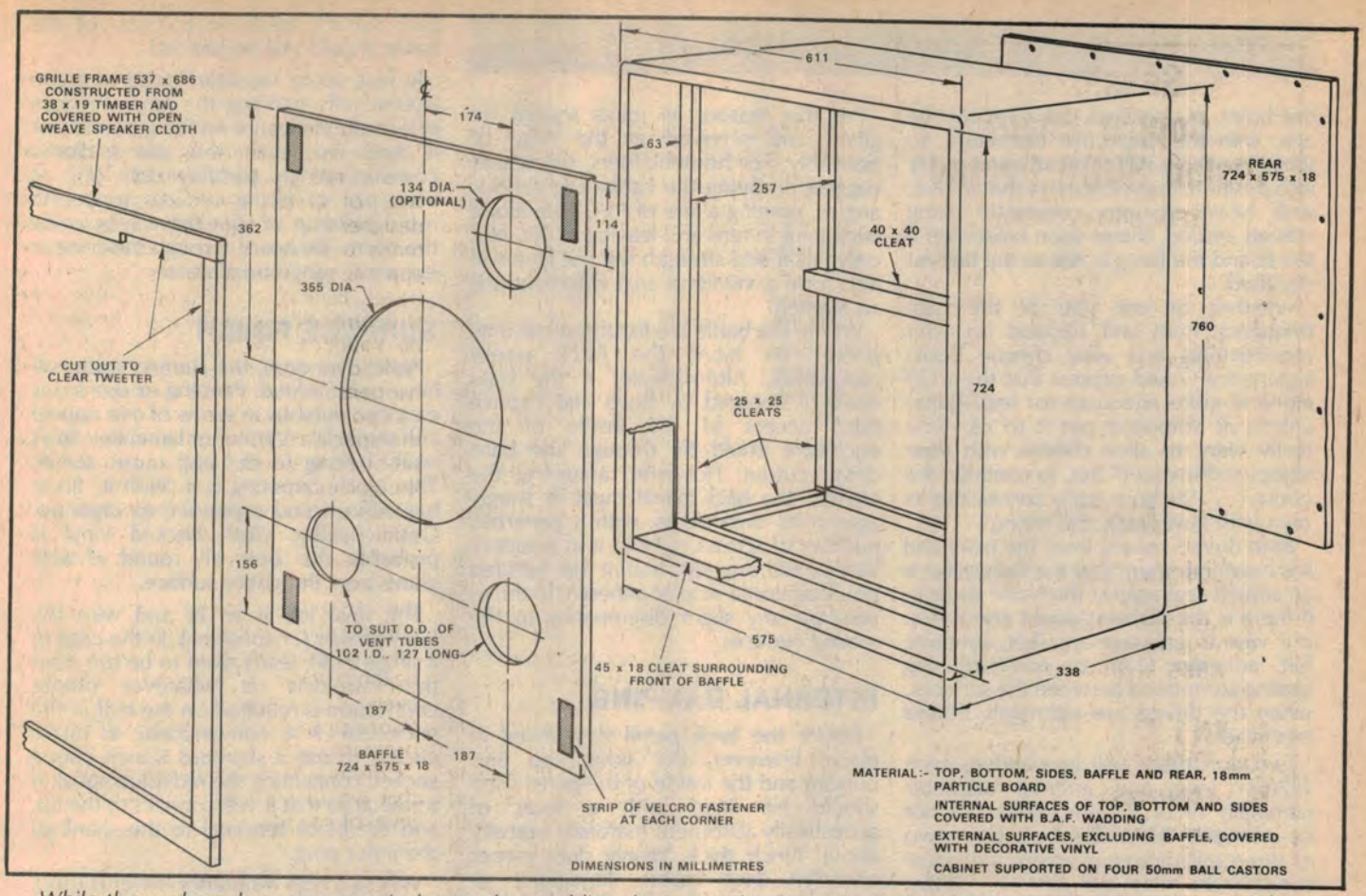
In passing, John Barclay stresses that the 300-watt program rating assumes clean drive. He states, as one of the hazards for stage loudspeakers, amplifiers which are inadequate for the job in hand and which are operated into overload by overenthusiastic musos. If the peaks are squashed into square waves and the "softer" passages exaggerated, the heat load on the voice coil can reach destructive limits.

What John Barcaly is saying, in effect, that the use of a 300W amplifier does not give automatic protection for a 300W loudspeaker. If the amplifier is abused and overloaded, so also will be the loudspeaker.

While the natural response of the E130 is quite reasonable for a high powered driver – nominally to 6000Hz – it needs reinforcement at the top end for a deliberately bright sound. The problem is that no ordinary tweeters would be adequate, because both sensitivity and power rating would be far below that of the E130. JBLs answer to this need is what JBL refers to as the "2901 High Frequency Power Pack".

The term "power pack" is explained by the fact that it is a three-element package comprising a high frequency driver, and a high-pass network and treble control intended to be mounted in a position which will provide access as necessary.

The actual tweeter is a high efficiency compression driver, with integral horn loading and a frontal high frequency lens



While these plans show one practical way of assembling the 250W music system enclosure, other constructional methods are possible, depending on the facilities available. It is even permissible to vary the proportions slightly to suit timber sizes or the dimensions of a vehicle, but the actual internal volume must remain the same. The drivers mount from the front and, provided the E130 is retained by bolts and captive nuts, the back panel could be made a fixture. See text regarding sealing.

to ensure wide dispersion of the sound. With aluminium voice coil and an impregnated phenolic diaghragm, it has a nominal impedance of 16 ohms but is suitable for use with either 8-ohm or 4-ohm main drivers, and with power ratings up to 300W RMS. The unit measures 134mm across the front face and is 292mm deep.

TREBLE RESPONSE

The network is designed to take over above 3kHz and the manufacturer's curve suggests that the 2901 treble driver is about 2.5dB down at 10kHz, and about 7dB down at 15kHz. While the treble driver can be mounted separately from the bass driver, JBL suggest that it should most logically be mounted high up on the baffle of the main enclosure. Since the 2901 driver is sealed off at the rear, it will not suffer any pumping by pressure in the main enclosure.

Unfortunately, the 2901 is an expensive unit and anyone keen to augment the treble response of the E130 may be wise to discuss other possible options with Harman Australia Pty Ltd, at Unit 13A-2, 6-8 Byfield St, North Ryde, NSW 2113. Phone (02) 887 3233.

So much for the design philosophy behind musical instrument loudspeakers and the particular pair of drivers chosen for the system described here.

Turning now to construction of the enclosure, dimensional drawings for this and other JBL systems have been available for some time from Harman Australia in the form of an informational kit. It is available for $10.00 from the address given earlier.

Overall dimensions of the relevant enclosure there represented were 30in (762mm) high, 24in (610mm) wide and 12½in (318mm) deep. The material specified was ¾in (19mm) void-free plywood or high density particle board. Internal volume neglecting cleats, padding and speaker displacement, came out at about 3.8cu ft or 108 litres.

For those who have the original JBL informational kit, it would be possible to work entirely from it, following the dimensions, assembly method and finishing details, as set out.

What we describe in this article is essentially a variation from that original data, evolved for the local market, largely as a result of collaboration between Harman Australia and Wasp Industries Limited. This company has accumulated a lot of experience in manufacturing music cabinets and systems for the Australian market.

The enclosure as illustrated is somewhat deeper overall than the JBL design, but it allows the fret and baffle to be set back to gain vital protection during transport and use. In fact, the proportions of the enclosure could be varied somewhat to suit timber cutting sizes but the actual internal volume must not be altered.

Another point is that the JBL specifications suggest the use of 19mm material for the enclosure walls, whereas locally available particle board is normally 18mm thick. The difference should not be significant, provided everything is solidly assembled and braced.

EXTRA CLEAT

Incidentally, the extra cleat around the inside lip of the cabinet is optional, its purpose being partly functional, partly cosmetic. It does lock and seal the baffle firmly in position and it does increase the thickness of the exposed front edge as a precaution against abuse. It also makes the enclosure look a lot more massive than it really is!

While it would be possible – and even convenient – to cut the holes with the baffle already fixed in position, it may be wiser to prepare the baffle fully beforehand to guard against the possibility of an inadvertent error. Cut

the holes as specified, taking particular care with the respective diameters, so that everything will fit neatly and firmly into position. Experience has shown that, with heavy systems constantly being moved around, things soon loosen up if the fit and the fixing is not to the highest standard.

Whether or not you fit the high frequency horn will depend on your requirements and your cheque book. Experience would suggest that the K130 alone is quite adequate for lead guitar unless, as someone put it to us, "you really want to slice cheese with your strings at thirty feet!" But, to continue the quote, ". . . the horn really comes into its own with keyboards and Moog".

Both drivers mount from the front and it is most important that the flanges form an airtight seal against the baffle surface. If there is the slightest doubt about this, it is wise to envisage a gasket, adhesive felt, adhesive foam or non-hardening sealing compound between the surfaces, when the drivers are ultimately bolted into place.

Two port tubes will be needed, each 127mm long and internal diameter nominally 4in or 102mm. Results will not be adversely affected if the tube is two or three millimetres oversize, Individual constructors may be able to obtain suitable scraps of large diameter cardboard tubing, or plastic drainage tubing, or even make up their own by glueing and rolling sufficient layers of stout paper or light card.

Alternatively, rectangular port tubes could be fabricated from scraps of plywood or masonite, securely pinned and glued at the corners and then glued into matching cutouts in the baffle. The length would have to be the same as for the round tubes but the internal cross-sectional area would have to be manipulated to about 8170 sq mm or 12.6 sq ins.

BAFFLE: FLAT BLACK

After pinning, glueing and sealing the port tubes into position, the whole front of the baffle and the inside of the tubes should be painted flat black. The baffle should now be ready to build into the cabinet.

While we have assumed the use of cleats, the main enclosure can be assembled in any way which will ensure that it is completely rigid and airtight, except for the deliberate air path through the twin ports. This is important acoustically since, with the internal pressures generated by a speaker of this power rating, panel rattles or the whistling of air through cracks can be very obvious. Furthermore, a relatively bulky enclosure, manhandled frequently into vehicles and on to platforms, will soon loosen up if not put together rigidly.

For this reason, all joints should be glued and screwed at the time of assembly. For homebuilders, we would suggest propping the cabinet at various angles, running a line of PVC glue along each joint in turn and leaving to set. Not only will it add strength but the glue will also form a meniscus seal wherever it is so applied.

Where the baffle is a fixture, some may prefer to have the back panel removable. Alternatively, if the bass driver is secured by bolts and captive nuts, access to the inside of the enclosure could be through the base driver cutout. However, assuming the former, the back panal must fit snugly against its own cleats, with a generous number of screws to hold it in position. We would suggest that it be bedded down against a strip of adhesive foam, to take up any slight discrepancy in the mating surfaces.

INTERNAL DAMPING

Before the back panel is screwed in place, however, the sides, top and bottom and the inside of the panel itself should be lined with a layer of acoustically absorbent material, typically about 1-inch thick. Heavy duty carpet underfelt (not foam), fibreglass, or bonded acetate are all suitable for the purpose, glued and/or stapled firmly into position, so that they will not droop against the inner ends of the port tubes.

While not obvious from this picture, the E130 is a large and heavy loudspeaker requiring a 355mm cutout and weighing 10.1kg. The metal dome cap is not just decorative; it holds up the response to about 6kHz. It is available in 4, 8 and 16 ohms versions. The 2901A treble power pack is compatible with all three.

Bare surface areas on the rear of the baffle should not be padded.

In fact, some musicians tend to argue against fully padding the inner surfaces of a music enclosure on the grounds that it tends to "dull" the sound. Some compromise by padding only one of each pair of facing surfaces to permit more build-up of standing waves inside the box to be heard through the cone as extra mid range brightness!

SURFACE FINISH

About this time, the surface finish will have to be added. Painting or staining is easy but dubious in terms of eye appeal and durability. Veneer or laminates don't really belong to the pop music scene. Thin black carpeting is a "with it" finish but difficult and expensive to organise. Good quality, cloth backed vinyl is probably the best all round choice, glued over the entire surface.

The final job is to fit and wire the loudspeaker (or speakers). In the case of a single E130, leads need to be run from the terminals to whatever output connection is required on the rear of the enclosure. It is conventional, in music circles, to use a standard ¼-inch phone socket, connecting the red (plus) speaker terminal so that it will connect to the tip, and the black terminal to the shank of the input plug.

Where a high frequency driver is used, as well, this will have to be interconnected, along with its splitter network. In the prototype unit, as pictured, black wires run to the respective speaker negative terminals, a white wire to the high frequency driver plus, and a red wire to the E130 plus.

For those planning to build their own enclosures, the lumber, oddments and finishing materials would have to come from the usual handyman supply sources. At this point in time, we do not know of any pre-cut panel kits for the particular JBL system described here.

JBL loudspeakers are distributed in Australia by Harman Australia Pty Ltd, Unit 13A-2, 6-8 Byfield St, North Ryde 2113. Phone (02) 887 3233. They can be obtained from, or ordered through, Harman/JBL dealers in all states. Harman advise that the recommended user price for the E130 driver is $259.00. Recommended user price for the 2901 High Frequency Power Pack is $459.

A finished enclosure, similar to that pictured, is obtainable from Wasp Industries Ltd, 39 Chalder St, Marrickville, NSW 2204. Phone (02) 560 3488. They can advise about interstate outlets. Price of the cabinet is $185.00 with rubber feet or $195.00 fitted with castors, as pictured.

The same company can supply the driver(s) separate, or the complete system ready to operate for the cost of the individual units: enclosure $185 or $195; E130 $259; 2901 (optional) $459.