Build this monitor speaker

C. J. Rogers describes the construction of a transmission line enclosure

IN past issues of this magazine there have been many articles on the design and building of speaker enclosures. These fall into two main categories:– 1) Economy; in as much as building to a budget, and 2) The No-Compromise System, such as the built-in concrete horns.

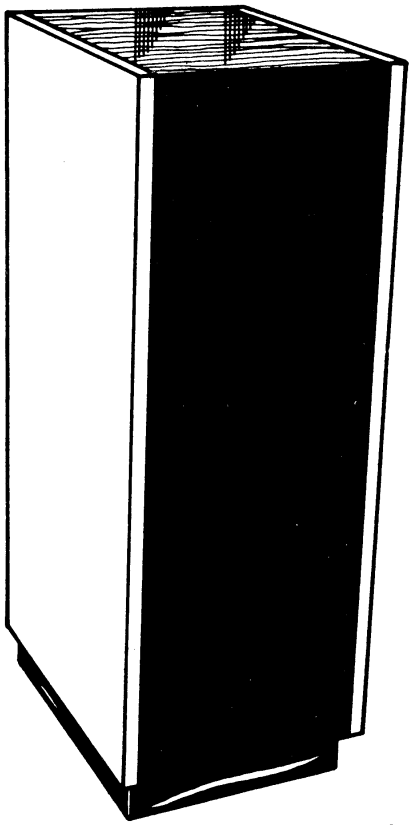
The design I have presented here is, in effect, also a no-compromise system; but with a few domestic considerations. It is one which I feel may be acceptable to the lady of the house, whereas a concrete horn may not be! Furthermore, it is a design, the cost of which I do not consider excessive.

We come to the design I have chosen. The transmission line labyrinth. A lengthy analysis of the workings of a labyrinth will not be gone into here, as it is more than well covered in an excellent article by Dr. A. R. Bailey. I think though that a brief description may be in order.

The labyrinth was once described as a lagged horn, and this, to some extent, may be true. The principle of the labyrinth is a long duct approximately of the same cross-sectional area as the cone of the drive unit, and a quarter wavelength of the fundamental resonance of the drive unit. These dimensions do not have to be rigidly adhered to, in that the quarter wavelength is not as critical as was first thought. The cross-sectional area of the duct may be reduced towards the end, as its powers of absorption do not need to be so great.

The workings are relatively straightforward. The line absorbs all rear radiation in the course of the duct, by damping. The Kinetic energy transmitted from the rear of the cone is absorbed in the duct, leaving insufficient energy for any phase reactions at the end of the duct. It is possible however, that a very slight rumble may be heard from the mouth of the duct at very low frequencies; but this is of such a small extent that it can be forgotten. I think it can be seen that the transmission line enclosure overcomes the disadvantages of the other systems outlined above. This being that there is no high loading as with the IB, and no critical tuning as with the horn and reflex designs.

Now I will move onto the design and construction of the enclosures. The design is relatively straightforward. First, an overall size was agreed upon (domestic co-existence etc.) Next, the choice of material. This was 18mm. high-density chip-board, which is universally adopted as enclosure material, being the highest density wooden material available. Then came the task of arranging the duct within. For optimum results, the first part of the duct should be as straight as possible, with acute bends as far from the cone as can be arranged. The rest of the duct being arranged in the most convenient way, allowing for the treble and mid-range units.



The duct starts with an area of 66 sq. in. at the drive unit end, and is reduced by 50% to finish at 30 sq. in. at the duct mouth. (66 sq. in. being the area of the cone of the B139.) The overall shape was decided upon, making the largest surfaces the sides, naturally braced by the duct divisions, thus reducing the individual unbraced surfaces to a minimum. This leaves the back as the largest unbraced surface. This was rectified by glueing and screwing to it two vertical and two horizontal equally spaced battens. All joints were reinforced with battens, and battens were also used for fixing the backs and fronts. The back was further braced by fitting a 1½ in. batten centrally between it and the back of the mid-range compartment.

Considerable efforts were made to reduce panel resonance and hence colouration. The measures mentioned above, of course, and also the finish. This was Formica outside, and a liberal coat of car underseal inside. With Formica outside and underseal inside, this forms a type of stress-lamination, reducing panel resonance considerably. The only parts of the enclosure which now have large unbraced surfaces are the confines of the enclosure where the bass unit resides. The sides of this have two diagonal 1 in. battens each side, and a 1 in. diameter dowel centrally fixed from side to side, as do the duct partitions at their top and bottom. The base of the enclosure is sufficiently braced by the plinth.

The selection of the drive units is, of course, a prime consideration. They are as follows:-

KEF. B139 bass,
KEF. B110 mid-range,
KEF. T27 tweeter,
ITT-STC-4001G supertweeter.

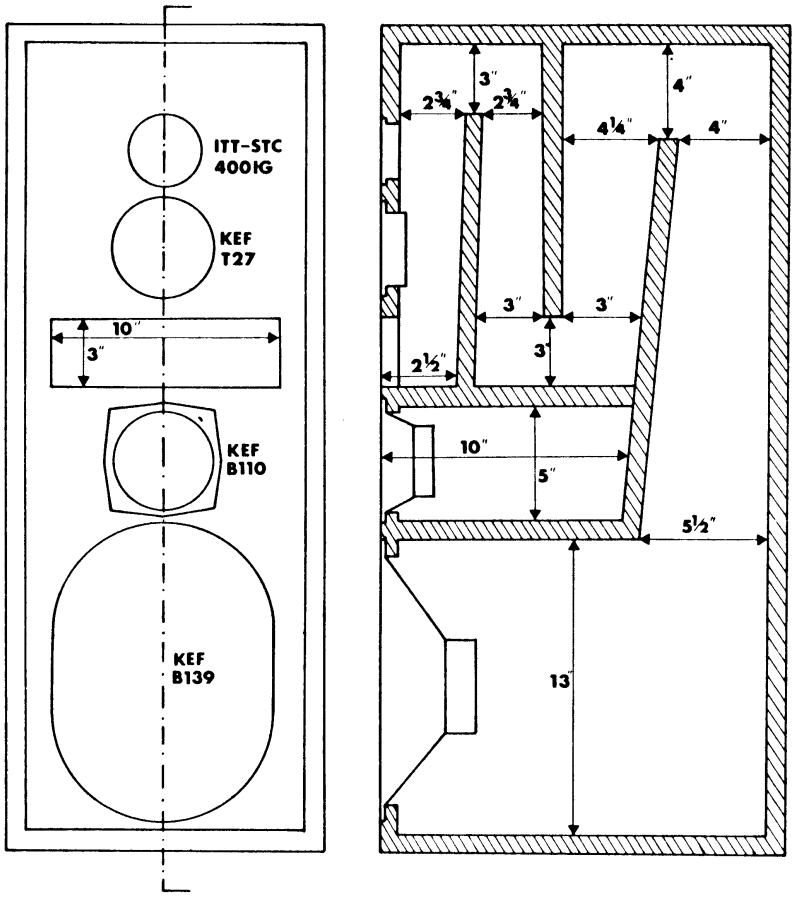
These units were chosen for the following reasons. The B139 must be one of the leading bass drive units made in the world at present, giving excellent low frequency response. The B110 for its excellent flat response, and lack of colouration in the mid-ranges, which after all must provide a lions share of the information. Both the tweeters were again chosen for their flat response in their working range, and for their superior polar response.

It is often asked if a supertweeter is necessary. Its inclusion, however, taking the range into inaudibility, gives a much smoother sound. Very high tones on their own may not be audible; but in a musical passage, if the frequency response cuts off within the limits of audibility, it will be heard as a harsh sound; far less natural than that of one which carries on to the upper and inaudible registers.

The cross-over frequencies are 375Hz, 3kHz, and 10kHz. The cross-over networks were supplied by Cambridge Audio Ltd., who also supplied the ITT-STC-4001G supertweeters. These networks are of the type used in their R50 enclosures, and have the flattest impedance curve of any commercially available unit I have seen so far.

The final design consideration is that of a choice of damping material. With reference to Dr. Bailey's article the choice is reduced to only one type of absorbant. This being long-haired natural pure wool fibres; these giving the highest acoustic absorption of any damping material yet encountered.

Now onto construction proper. The first requirement is a considerable amount of material. (Table 1). After considerable fiddling it has been found possible to get all the chip-board out of 1½ sheets. (Std. sheet size 8ft. x 4ft.) A cutting plan for this is shown in Fig. 1. It will be seen that the fronts and backs are cut across the 4ft. widths. Obviously you can't get four 1 ft. pieces from 4ft. but the thickness of the cut allows for a slight clearance around the fronts and backs which, when it comes to fitting, will be found to be a good thing! Without this the panel fits tight, and no one wants to have to bang into place



Internal arrangement of the enclosure

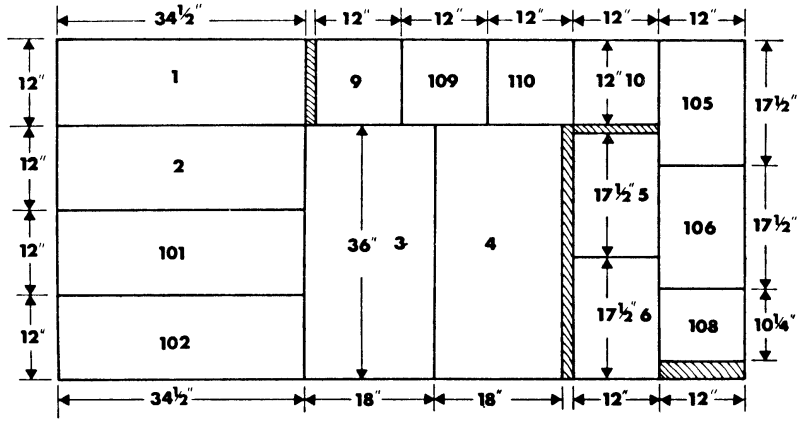
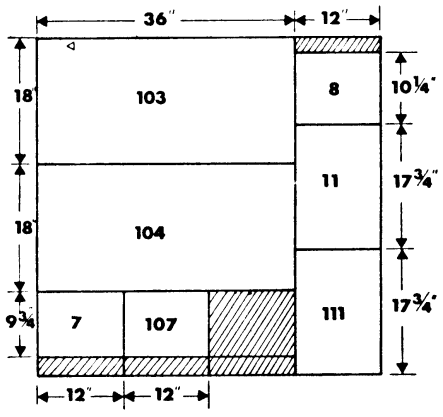


Fig 1—Cutting pattern for chipboard sheets



panels with expensive drive units mounted on them!

As most timber shops operate a cutting service, it should be possible armed with a cutting plan, to have the chip-board cut to size. I do not need to emphasize the importance of having the panels to size, and square. Although a small cutting charge may be made, it is well worth it.

Now, at last, to the workshop. Might I suggest, at fear of pricking many a conscience, that the workshop (including parts which have not seen the light of day for a decade or more!) should have a broom—that hairy thing with a long handle—put over it.

Cutting plan

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Next our attentions can be turned to the plinths. These are 2in. x 3in. planed timber. These I have jointed as Fig. 4 but would be perfectly okay butt jointed. These joints can now be glued and screwed with 2in. x 10csk. screws, or 3in. x 10csk. if butt jointed. All joints are glued with a good PVA adhesive, such as Evostic Woodglue. The plinths can now be glued and screwed to the bases 6. All screws are $1\frac{1}{2}$in. x 8csk. apart from those mentioned above, two in the back, and those used for the grill frame. I personally prefer Posidrive screws. They are considerably safer, as it is quite easy to slip with slotted screws; and the sight of a screwdriver through a speaker cone would break anyone's heart!

At this point I would like to draw your attention to another small, but invaluable piece of equipment—the Stanley Screwmate. For those of you who have never seen one, (and I must admit that until a short while ago neither had I) it is a drill that drills the pilot holes, counterbore for shank clearance, and countersinks all in one go. The use of this small tool must be an asset, as it saves much time, is neater and far more accurate. Also a pump action screwdriver, or screwdriver attachment for an electric drill is an advantage as there are nearly 500 screws to get through!

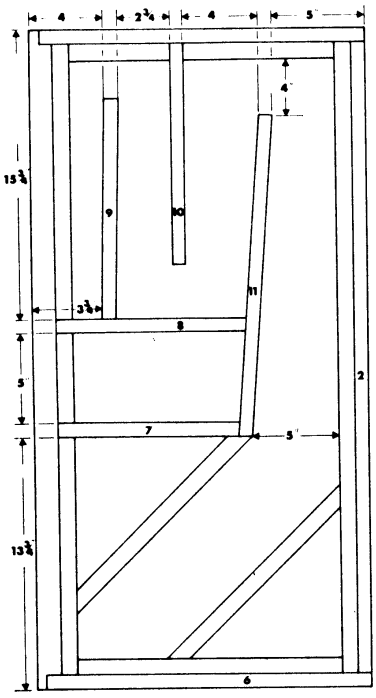
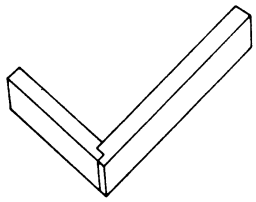


Fig 2—see text



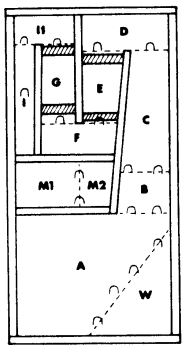


Fig 5—see text

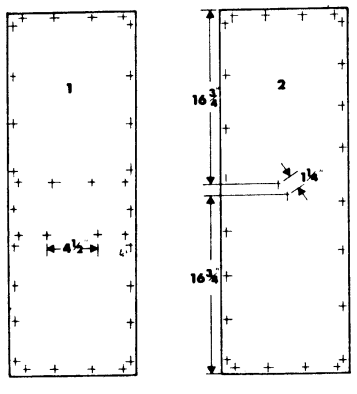


Fig 3—see text

So far we have a base with plinth. To this can be added the sides 3, 4, and top 5. The Formica covering may be fitted as I have done it, in which case the top must be fitted $\frac{1}{32}$in. lower than the sides. This is to allow for the fact that Formica is $\frac{1}{16}$in. thick, and edging strip is $\frac{1}{32}$in. thick. If the top is to be covered in one, the more conventional way, then the sides must be fitted flush to the top; but this is only a personal preference. Do not glue any parts yet, as it will be necessary to remove certain parts later.

Now fit the rearmost internal panel, 11 with great care, as it governs the mid-range top and base, 7 & 8 positions. You may need to chamfer a little off the edges of the mid-range top and base, 7 & 8 to get the required depth. The front edges of these should be fitted $1\frac{1}{4}$in. back from the front edges of the cabinet sides. The top of the mid-range unit 8 can now be fitted. This can be followed by the two other duct walls, 9 & 10. It is best to screw the top and bottom respectively of these parts first, and then the sides. Finally the base of the mid-range section 7 can be fitted, again screwing first the rear edge.

We now have a complete enclosure, less glue and battens. With the enclosure laid on one side, all the screws in the other side can be removed, and this side lifted clear. With one side now open, the bracing dowels can be cut, and their positions marked. These positions as in Fig. 5. All parts should now be removed from the other side. The centre vertical partition can now be drilled for the bracing dowels, which can be glued and screwed into position.

Final assembly can now commence. Starting with attaching one side to the base. Next the top, but this must still not be glued. All other internal parts can now be glued and screwed into position. Do not get glue on any parts fitting onto the top.

The battens can now be fitted. We require a framework around the front and back for these to be fitted to. The battens should be fitted with neat mitred corners, for preference, as corners are the natural places for air leaks. The battens fitted to the bottom front and back must be screwed from the inside. The ones at the top front and back should be glued in position, except at the corner joints. The two front to back battens at the base should be fitted next, the vertical screws for which must be fitted from the inside. Four short battens should be fitted next, to the top front to back corners, and these screwed only.

The only remaining thing to be done is to fit the four diagonal battens (two per side) in the bass chamber, and the cross bracing dowel in the centre of the bass chamber. Finally the brace in the centre of the back can be fitted. This must be cut at the same angle as the rear internal partition is fitted, and glued and screwed with two 2in. x 10 screws. These screws are used through the back. To make sure that it locates correctly at the back, when the back is fitted, it is necessary to fit a small location plate to the inside of the back. This was made of an odd piece of $\frac{1}{2}$in. ply, and fixed with 1in. x 6 screws; details as in Fig. 6 & 7.

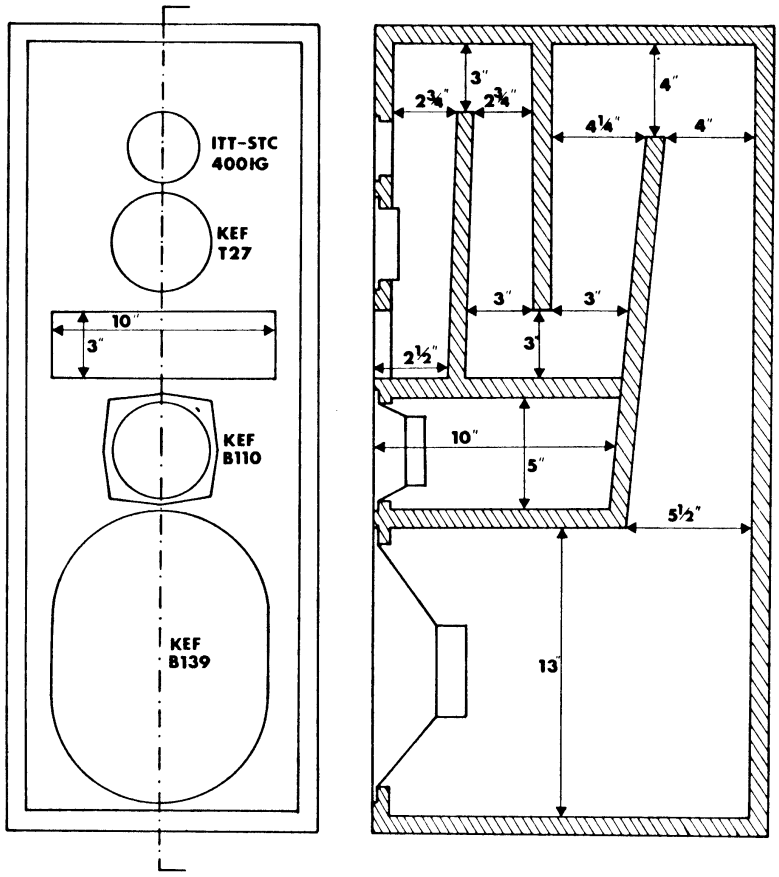
With the main cabinet set aside for the glue to dry, our attentions can be turned to the back and front. The four battens to be fitted to the back are outlined, and their screw positions marked, as in Fig. 7. The battens are fitted 2in. short on both planes, so that they clear the fixing rails. As we are looking for maximum bracing effect, the battens should have simple halved joints where they cross (Fig. 8) and not just butted.

We now come to cutting the holes in the front baffle. The duct outlet was cut with a jig-saw, and all the speaker holes were cut with a single point tank cutter. The blade of this was modified to give a flat cut and not chew up the blockboard. The literature supplied with the KEF units is quite comprehensive and no further details are needed; only that the supertweeter and B139 are fitted in a similar manner.

Fig. 9 gives the positions of the unit centres, with the exception of the B139, which has only the vertical extremes indicated.

The top of the enclosure is now removed to provide access to the inside of the duct. When the enclosure is filled with wool fibres, the wool will need some support to prevent it from compressing. It is therefore necessary to put in some staples, through which can be threaded a network of string for support. As the wool will need to be evenly distributed, it is as well to fit the string to form sections as Fig. 5 and refer to Table 2 for the amount of wool to be put in each section.

Undersealing the cabinet can now begin, starting with the cavity in the centre of the duct. Paint on the underseal to the first row of staples, and then tie the string in this part of the enclosure, to form triangles out from the dowel bracing strut. The string must not be tied tightly, as if it is, it



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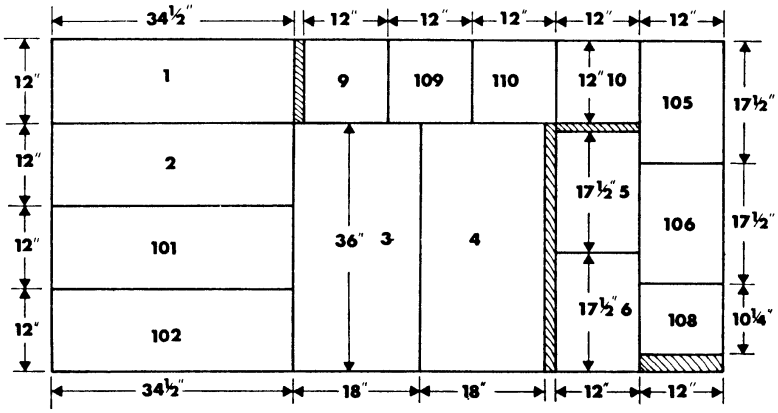

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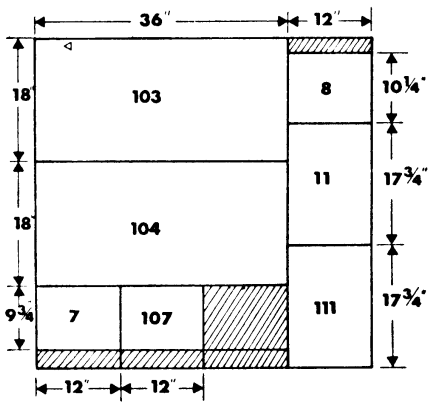

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will vibrate at certain frequencies—and any form of stringed instrument is NOT what we are trying to create.

This is all the stringing to be done at present; and undersealing of the centre portion can be continued to near the top. If you now consider that the remainder can be undersealed with the top on, now is the time to fit it finally. If not, continue to underseal until the top can be fitted, and all parts needing undersealing can be reached with ease. After the enclosure, the back needs to be undersealed; leaving a 1in. border clear, and a 1in. square clear in one of the bottom corners. This clear area is left for the input socket. Each enclosure requires approx. 1 litre of underseal.

The next operation is the Formica covering, which is, of course, done to personal taste. My own are finished in black and white, and will not suit everyone. Whatever type is chosen there are a few points which must not be overlooked. My own are covered all over their external surfaces, but it is not necessary to cover the plinth. I think, however, that this is very worthwhile, as it goes a long way to enhance the appearance.

Whatever style is chosen, panels must be cut $\frac{1}{8}$in. larger all round. ($\frac{1}{4}$in. on all dimensions). Edges are best covered with Formica Edging Strip, as this gives a neater join line. After glueing on the panels (this is best done with Dunlop Thixofix, as it is easier to use, and equal to any for strength) the edges must be trimmed. If your local DIY shop, or someone you know has an electric routing machine, this task is made much simpler, and gives a superior finish. There is little else to say on the subject, except that each cabinet will require $2\frac{1}{2}$-3 pints of glue.

At this stage it is advisable to complete the remaining carpentry. The frames for the grill cloth are next on the agenda. These are made from $1\frac{1}{2}$in. x $\frac{1}{2}$in. Ramin, and cut $\frac{1}{8}$in. smaller on all dimensions. ($11\frac{7}{8}$in. x $35\frac{7}{8}$in.). The corners are made by halving joints, (Fig. 10) then glued and screwed with two $\frac{1}{2}$in. x 6 csk. screws per corner.

All that remains now is to drill a few holes. First we require a $\frac{5}{8}$in. diameter hole in the corner where the back was not undersealed. As we have to drill through the Formica as well, it is best to drill a pilot hole $\frac{1}{8}$in. diameter, and then drill half way through from both sides, starting from the Formica side. Now a $\frac{1}{4}$in. hole through the front and back division, for the wiring, as can be seen from the photographs of the inside. Also two 4BA clearance holes (No. 27) in the mid-range back for the B110 wiring. All the holes should be on the same side, as in the photograph. This completes all the carpentry. At this stage it is advisable to run a vacuum cleaner over the inside of the enclosures, this being the most effective way of removing all the dust, etc.

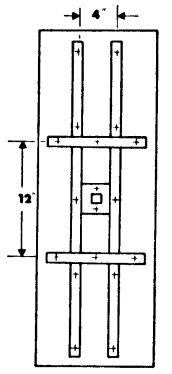


Fig 7

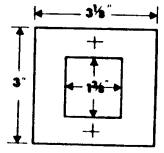


Fig 6

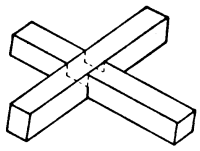


Fig 8

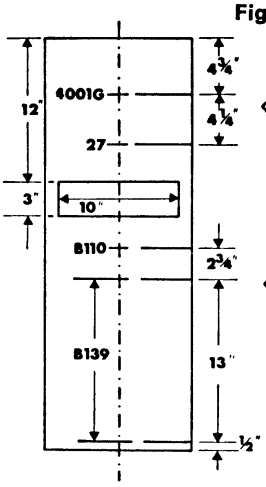


Fig 9

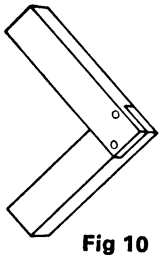


Fig 10

Next we come to the wiring. The two pairs of wires for the tweeters are passed through the $\frac{1}{4}$in. holes. The wiring for the mid-range unit is taken to the two 4BA clearance holes. The leads are then neatly looped, and then soldered and fitted over the two $1\frac{1}{4}$in. x 4BA screws, which are then passed through the holes. The same is then done on the other side, and from here to the B110. The wiring for the B139 is taken, of course, straight to the unit. All the leads are then marked to show which units they go to.

The connection used for the enclosure is a DIN type L.S. socket. This is glued into the back with Araldite, which was also used to seal the wires of the tweeters through the holes. It will be found that with a $\frac{5}{8}$in. hole in the back, the DIN plug will fit snugly into the hole, and only a small part of it is left protruding. This makes the assembly much neater, and less likely to accidental damage, and knocking—which can have catastrophic results in the amplifier department.

The cross-over is now fitted, and this is fixed with two $\frac{3}{4}$in. x 6 round head screws onto the base of the enclosure; at the point where all the leads have been brought to, and the leads soldered in place.

The rest of the string lattice-work can now be tied in place. Before the wool is weighed out, it should be spread out and sprayed with a suitable moth-proofing, which can be bought in aerosol cans. One can is sufficient for all the wool required for the pair of enclosures. After spraying, the wool should be spread out to expand to its fullest amount, and left to dry for 24 hours.

The bass chamber is strung in a random manner, but there should be a considerable network between the rear diagonal battens, as a tightly packed wedge of wool is put there to give a smoother acoustic path into the duct, and to help damp any standing waves in this part of the enclosure.

At this stage some staining is required; this being Black Oak. It is applied to the front of the front baffle, the grill cloth frame, and to all exposed edges that have not been covered, (front, sides, etc.).

There must be an effective seal provided for the fronts and backs. This is achieved with the use of adhesive-backed foam-rubber draught-excluder strip. The type used was approx. $\frac{3}{8}$in. wide by $\frac{1}{4}$in. thick. When fitted it compresses to $\frac{1}{32}$in. thick. This was fitted with two strips around the front and back. Approx. two packs were used per enclosure.

—Driver mounting—

The back can now be fitted, and our attentions turned to mounting the drive units. They are fitted with, for preference, hexagon recess screws. The 4001G, with 4BA csk., the T27 with $\frac{1}{4}$in. BSF csk.; the countersinking for which you have to do yourself. If you are not so sure about countersinking the holes (an operation which requires a great deal of care and precision) they can be fitted with $\frac{1}{4}$in. BSF cap screws. The foam-rubber gasket supplied with the B110, and the T27 are used; a piece of draught excluder strip for the B139, and a felt gasket for the 4001G. The use of these screws means that an allen key and spanner are used for tightening the screws, and not an easy-to-slip-with screwdriver. (Perish the thought!)

When all the drive units are fitted, it is necessary to prevent the wool coming into contact with the drive units, and coming out of the duct mouth. For this I used an old piece of net curtain, glued with Bostik 1 across the mouth of the duct, and the back of the units. This also must not be fitted tightly. The bright metalwork on the fronts of the units should be given a coat of matt black paint (chassis, bolts, etc.) with the exception of the 4001G diaphragm. The application of paint to these parts, and the black stain applied is to give a uniform appearance to the front, and to make sure nothing is visible through the front grill.

More on the Monitor—

Mr. C.J. Rogers gives further information on the very popular Practical Project featured in the August issue.

THE padded appearance of the Monitor speaker which I find I and many other people prefer, was achieved with the use of draught excluder strip of 'super grade'. This is a little thicker than the standard grade used before.

It is fitted in three strips around the grille frame. It is necessary to stain the foam-rubber. Here black oak stain was used, but diluted with water in a ratio of one part stain to three parts water. It will be appreciated that quite a large amount of stain will be required and sould be applied lavishly. This is somewhat messy, and requires about three days to dry.

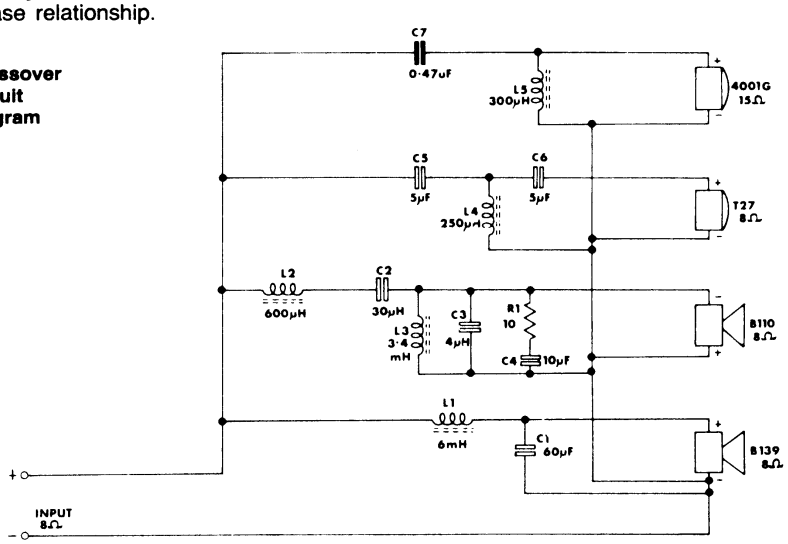
When dry, the grille cloth can be fixed. Personally, I prefer Tygan, which I have used; but of course any good quality grille cloth may be used. The cloth is folded over the frame to overlap the width of the frame back, and stuck down with Bostik 1. If Tygan is used, it may be made tight by a little careful application of heat, from an electric fire. The frame is held approx. 8in away from the fire, and the heat is evenly applied. The time necessary is normally about 10 seconds. If other types than Tygan are used, they must be made as taut as possible during fitting. Each grille frame was fixed in place with six pieces of black Velcro dress fastening, 3in long, and glued in place.

The 1½in sq bracing batten for the back has been queried. It is fitted to the centre of the mid-range chamber. It is best screwed to the back first, and then screwed to the mid-range chamber, while located by the back.

The bracing dowels are the shaded portions in Fig. 5 and the cross-bracing dowel for the bass chamber is fitted centrally across the chamber, but its position is far from critical. The dimensions of the plinths were covered in Fig. 1.

There seems to be some confusion as to the wiring of the drive units. This is quite straightforward, as the P.C.B. of the crossover is clearly marked; as is the polarity of the drive units. The only thing to watch is that the mid-range unit is wired reverse polarity. This is done to ensure correct phase relationship.

Crossover circuit diagram



Readers have asked if it is possible to use the ITT-STC-4001K supertweeter, which is an 8ohm unit. this would be OK if the whole crossover network were redesigned. Therefore, it is possible, but far from practical when a proprietary crossover is being used.

Component suppliers are detailed below.

One final point is that the enclosures should be constructed one at a time. This saves considerable confusion and any shortcomings found need not be incorporated in both and any mistakes only cost half as much!

Specification

Overall size: -39" high × 13½" wide × 18" deep. (3" high plinth)
Weight: -106lbs.
Crossover Frequencies: -375Hz; 3kHz; 10kHz.
Duct length: -89in measured along the centre line.
89in = ¼ of 37.5Hz wavelength.
Duct area: -66sq.ins. max. -30sq. ins. min.
Port area: -30sq.ins.
Bass volume: -3.1628cu. ft.
Mid-range volume: -0.3462cu.ft.
Damping material: -Long hair wool fibres. ½lb. in the mid-range. 2lb. in the bass.
Cabinet material: -18mm. high density chip-board throughout.
Stress laminated with Formica outside, and Auto underseal inside. All joints glued an screwed with glue blocks. Max of 5" between screws. Braced with 1" dowels and 1" × 1" batons.
Finish: —Black and White Formica, with Black Tygan grille.

These tables were unfortunately omitted from the August issue:

Table One: Materials

1½ sheets — 18mm. High Density Chip-board.
70ft. — 1" × 1" soft wood batten.
1ft. — 1½" × 1½" soft wood batten.
16ft. — 1½" × ½" Ramin.
8ft. — 3" × 2" Planed Deal.
4½ft. — 1" diam. Dowel.
420. — 1½" × 8csk. screws.
16. — 2" × 10csk. screws.
16. — ½" × 6csk. screws.
1 bottle — Evostick Wood Glue.
1 tin. — Black Oak Wood Stain.
1 tube. — Clear Bostik.
3 pints. — Dunlop Thixofix Adhesive.
2 litres. — Auto Underseal.
17sq. ft. — Formica.
6 packs. — Formica Edging Strip.
2½ roll ft. — Tygan.
3ft. — Black Velcro.
2 packs. — Super Draught-excluder-strip.
4 packs. — Standard Draught-excluder-strip.
5lbs. — Long hair Wool Fibres.
1 can. — Aerosol Moth Proofer.
1 ball. — Thin String.
1 pack. — Staples.
2 DIN. L.S. Panel sockets.
2 — KEF. B139 Bass Speakers.
2 — KEF. B110 Mid-Range Speakers.
2 — KEF. T27 Tweeters.
2 — ITT-STC-4001G Supertweeters.
2 — Cambridge Audio R50 type Cross-over Networks.

Table Two: Wool packing

A =	8½ ozs.	G =	1¼ ozs.
B =	2 ozs.	H =	1 ozs.
C =	3 ozs.	I =	1¼ ozs.
D =	2 ozs.	W =	11 ozs.
E =	1 oz.	M1 =	4 ozs.
F =	1 oz.	M2 =	4 ozs.

Total of 2½lbs. per enclosure.