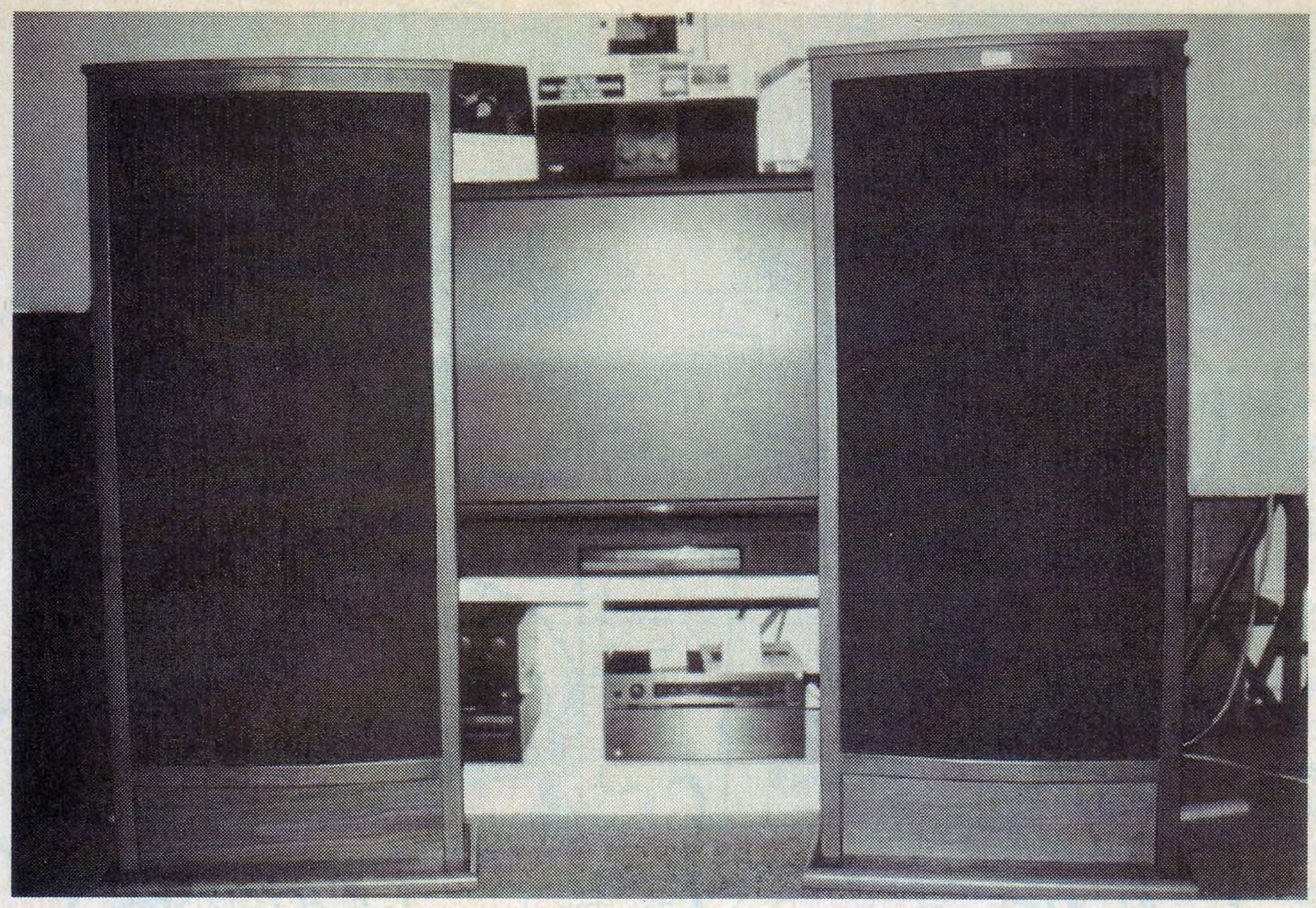
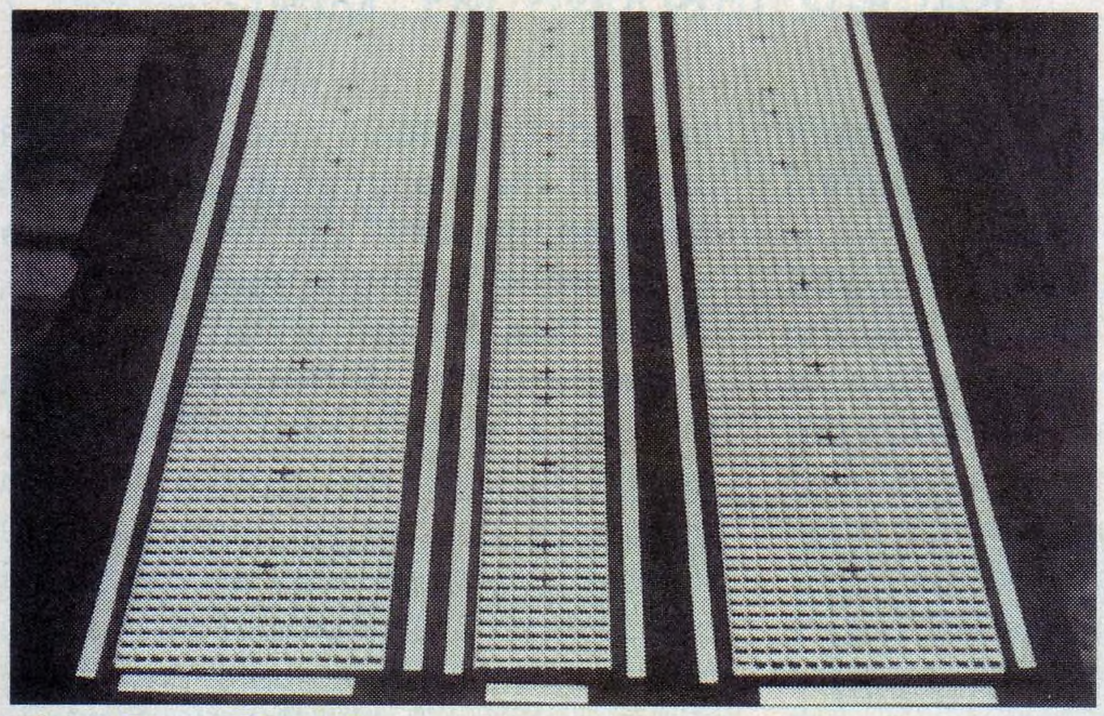


In this second article, we give the details on how to build this set of wide range electrostatic speakers which have been developed in Australia. They can be built using simple materials & readily available tools.

By ROB McKINLAY

Wide range electrostatic loudspeakers; Pt.2

To build these loudspeakers, you will need the following equipment:
(1) a table or bench with a work surface of at least 700 x 1400mm, preferably coated with melamine, Laminex or a similar material. It must be flat and able to take heavy weights.
(2) One 1220 x 605mm sheet of 18mm chipboard or MDF (medium density fibreboard). This will need to be cut into three strips, two measuring 240 x 1220mm and one measuring 120 x 1220mm. These are used as the pressure pads when gluing down the air gap spacers. Subsequently, the MDF strips will need to be cut down again, to be used as grid pressure pads.
(3) 70mm disposable foam paint roller covers. One frame and two roller covers are supplied in the kit. More may be necessary depending on how you proceed.
(4) A soldering iron. This is needed to assemble the EHT supply boards and make the various connections from the supply to the panels.
(5) A heat gun such as the unit made by Black & Decker. This will be used to tension the film after it has been applied to the panels. Don't bother trying to use a hair drier. They are not hot enough and deliver too much air.
(6) Digital multimeter with a 200



This photo shows one treble and two bass panel matrix panels laid out with their respective air spacers ready to be glued. Note the crosses marked on the matrix panels.

After glue has been applied to the top of the matrix panels, the air gap spacers are placed around the periphery, as shown here.

megohm resistance range, to be used for checking out the individual panels.

(7) Tools such as wire cutters/strippers, pliers, screwdrivers, electric drill and bits.

As noted last month, the kits for these speakers include all the materials you will need, including adhesives. The enclosures are not included but are available fully finished. Having seen the excellent finish of the enclosures and having in mind their very reasonable cost ($499 for the pair), few people would wish to build their own enclosures from scratch.

Handy hints

The adhesives used in this project are very strong and durable. There are no solvents for them that are kind to your skin. Always wear the gloves supplied during the gluing operations and when applying the conductive coating to the diaphragms.

To ensure a good understanding of how this project goes together, it is a good idea to do a "dry run" with one panel half. Fig.1 shows an exploded view of the panels which are all the

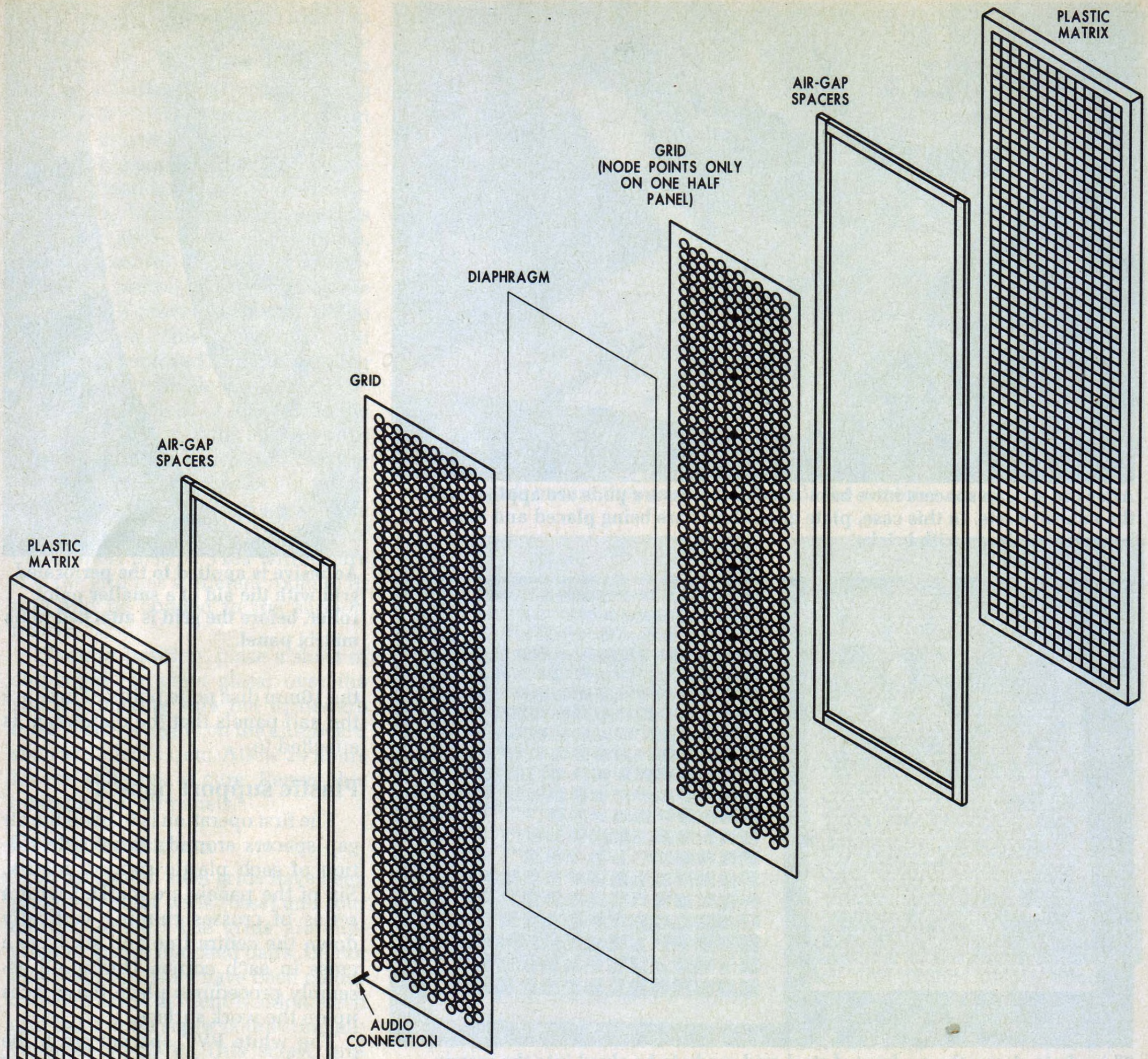
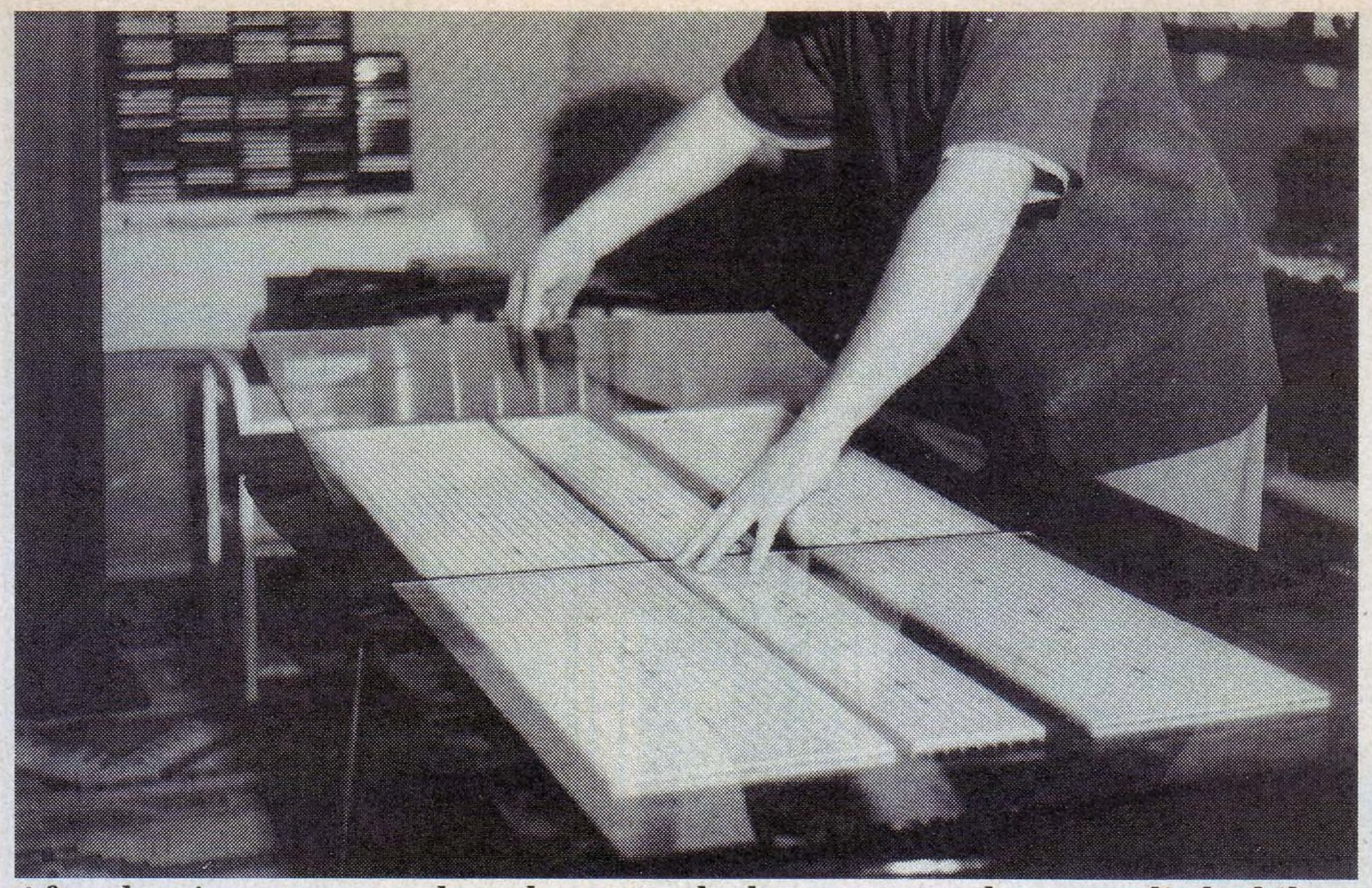
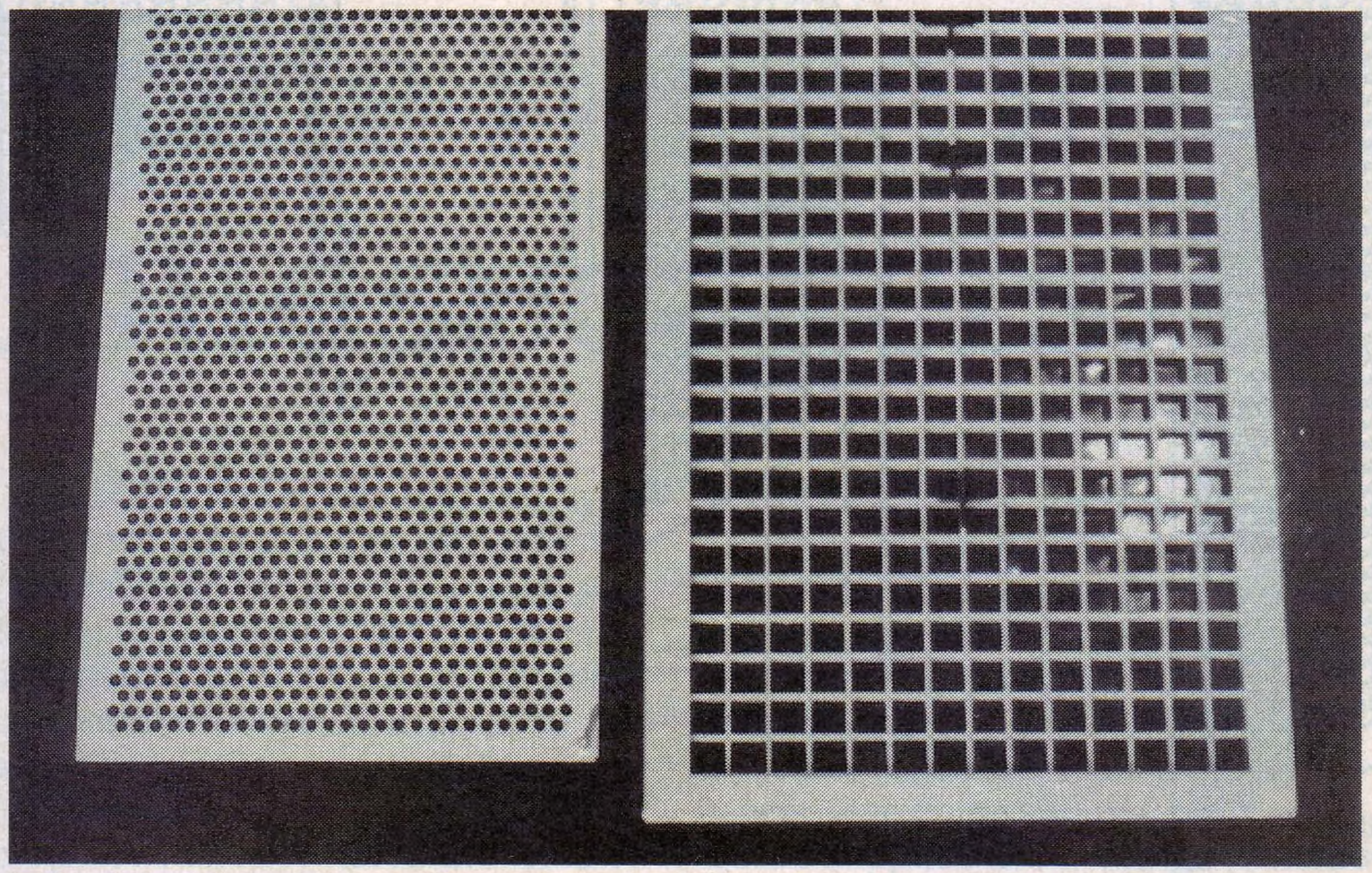


Fig.1: this diagram shows how the plastic matrix panels, air spacers, perforated steel grids and the central diaphragm are sandwiched together to make a complete panel. The central diaphragm is glued to the air spacers of one half panel and, after tensioning, is painted with a conductive coating.



After the air gap spacers have been attached, pressure pads are applied while the adhesive sets. In this case, plate glass sheets are being placed and these will be weighted down with bricks.



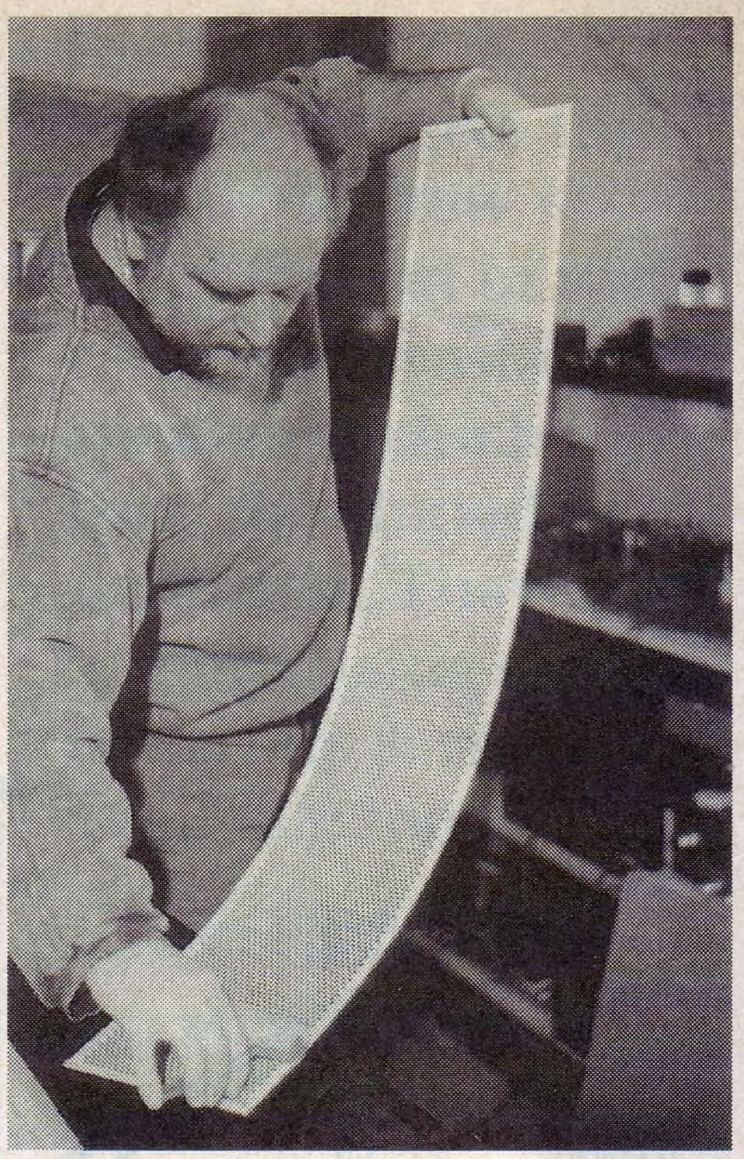
This photo shows the perforated steel grid ready to be glued into the matrix panel which has air gap spacers glued to it.

same in principle although the central treble panel is narrower than the two bass panels.

Essentially, each side of the panel is a plastic matrix to which air gap supports are glued. Then a perforated steel grid is fitted into the frame formed by the air gap supports. Then the plastic diaphragm is placed over one of the matrix/grid assembles and attached with adhesive. It is then tensioned with a hot air gun and sprayed with the conductive layer. Finally, the mating matrix/grid assembly is attached and the panel is complete.

The dry run should be as follows. Place a white plastic support matrix on the work surface with the black crosses facing up. Place two long air gap spacers on top of the matrix covering the edge square segments. Place a medium length air gap spacer at each end on top of the matrix, forming a rectangle with the two long spacers. Place a perforated steel grid centrally within the rectangle with the screw terminal protruding into the matrix; ie, facing the work surface. The black crosses should be visible through the holes in the grid. This is where the node points are attached.

This forms the basis on which the 12 half panels are assembled. Note that only six of these half panels carry



Adhesive is applied to the perforated grid with the aid of a smaller paint roller, before the grid is attached to its matrix panel.

the 10mm disc node points. These are the half panels that the diaphragm is attached to.

Plastic support panels

The first operation is to bond the air gap spacers around the outside section of each plastic support matrix. Six of the panels are marked with a series of crosses running vertically down the centre line and six have a cross in each corner. During all assembly procedures place these faces up on the work surface.

The white PVC spacers are to be bonded around the outside section of the plastic matrix. One side of the PVC strip will have a clear protective covering stuck to it; this face is to be kept up on the assembled half panel.

Before applying adhesive to any components, check that they fit in their intended positions. The long spacers may overhang the matrix slightly but this excess can be sanded off after gluing.

It is best to start work on a maximum of three half panels at first, until you have some experience with the process. Therefore, you can start with two bass half panels and one treble half panel. Place the three half panels on the work surface with the black crosses up. Select six long, four medium and two short air gap spacers.

Lay these on the work surface next to each other with the non-covered side facing up. This will allow you to roll a coat of adhesive, first over the long spacers, then the medium and short spacers, in one operation.

Note: it is essential to place a plastic sheet) under the plastic matrix before gluing, in case the adhesive runs down and sticks to the work surface, making removal of the matrix difficult. The clear plastic covering on the spacers will prevent adhesion to the pressure pad. This covering should be not be removed until all gluing operations are finished.

Apply a thin coat of adhesive to the non-covered side of the spacers with a roller. Place the spacers around the matrix outer segment as in Fig.1. It is important that the outer edge of the spacers line up with the outer edge of the support matrix. This will ensure that the grid has sufficient room to fit into and be bonded to the support matrix.

When in position, place a sheet of chipboard (or plate glass) over the spacers, making sure not to disturb them. Place weights on the chipboard such as 12 bricks, etc. Allow 24 hours for the adhesive to cure. Repeat this operation on all panels.

Grid preparation

12 perforated steel grids have been provided; eight wide (bass) and four narrow (treble). The grids are supplied in mirror matched pairs. Do not mix them up. They have been colour coded to assist in identification. Each grid has a 3mm screw connection silver-soldered to it. This screw protrudes through a segment of the plastic support matrix, enabling the signal connection to be made.

Before proceeding to the next step, check that the grid sits in the gap created by the air gap spacers, without the screw fouling the matrix. If necessary, carefully use side cutters to break out the offending piece of matrix.

Grid bonding

For this operation, you need a piece of MDF 5-6mm narrower and 5-6mm shorter than the grid, to enable pressure to be applied during bonding.

Cut some polyethylene sheet into strips that are wider than the grids to be glued. These will stop the pressure pad from sticking to the grid. Lay some polyethylene sheet on the work surface, then lay the plastic matrix on the sheet with the white PVC spacers facing up.

Hold the grid vertically in one hand and roll a light coat of adhesive onto the side of the grid that is to come into contact with the plastic matrix; ie, the side with the threaded portion of the terminal. Avoid getting adhesive on the diaphragm side of the grid or onto the threads of the audio connection terminal.

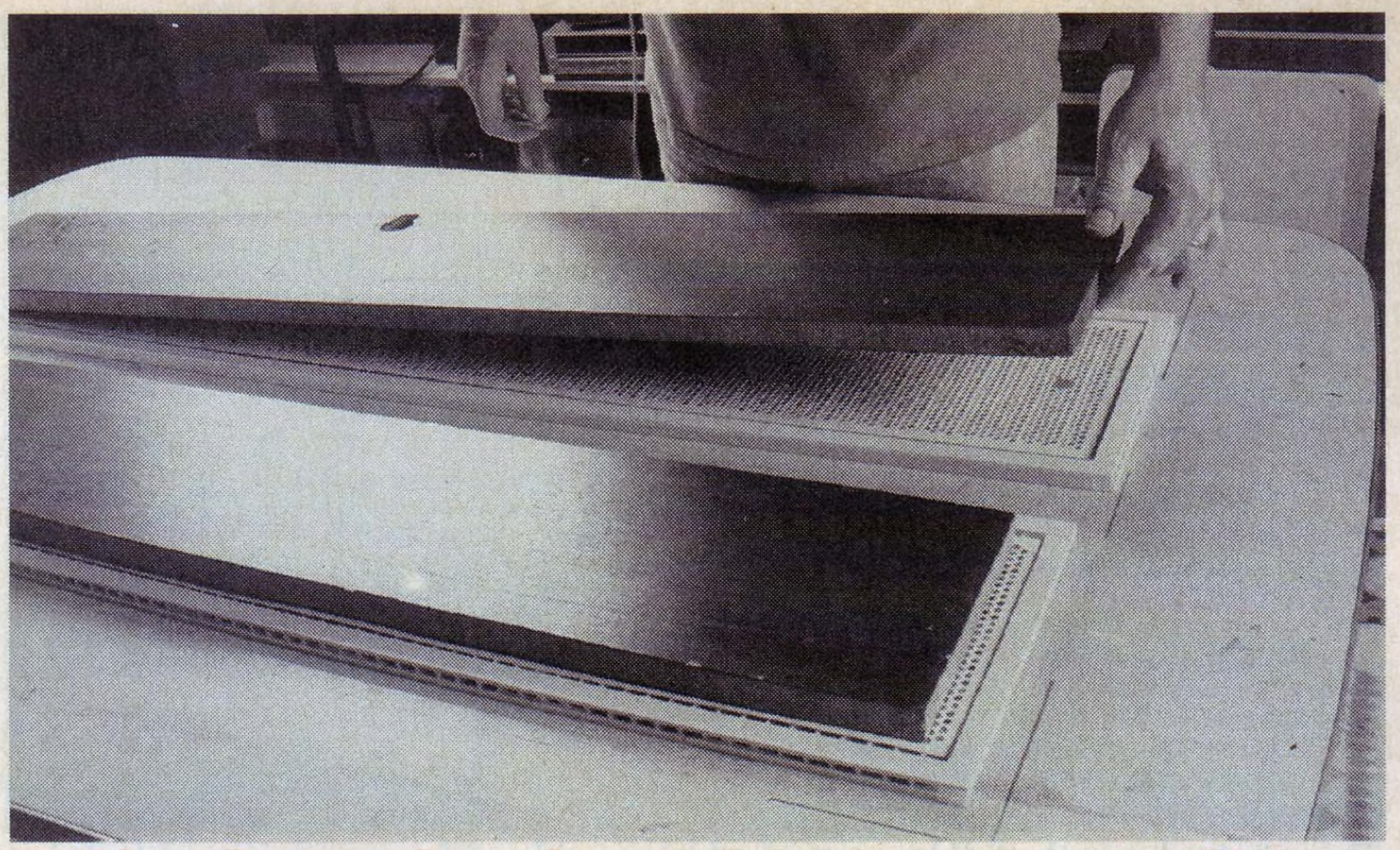
Place the grid centrally in the space created by the PVC spacers so that the glue contacts the plastic matrix. Ensure that the audio connection terminal does not foul the plastic matrix. Place a strip of polyethylene sheet over the grid and then the MDF pressure pad. Place weights on the MDF to ensure good adhesion to the matrix.

The polyurethane glue used for the construction relies on the moisture in the air to cure. Normal curing occurs in 24 hours. On very dry days the curing cycle will be longer. If there is any doubt as to whether the glue is cured, leave for additional time.

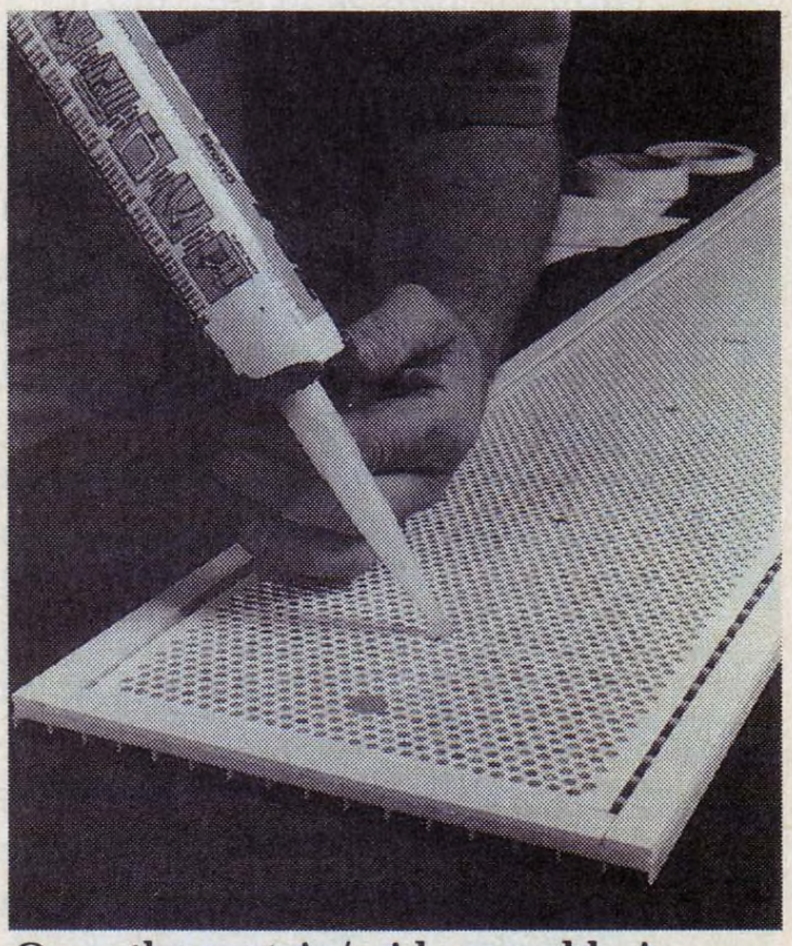
Repeat the above operation for all the grids, then remove the clear plastic covering from the air gap spacers.

Diaphragm nodes

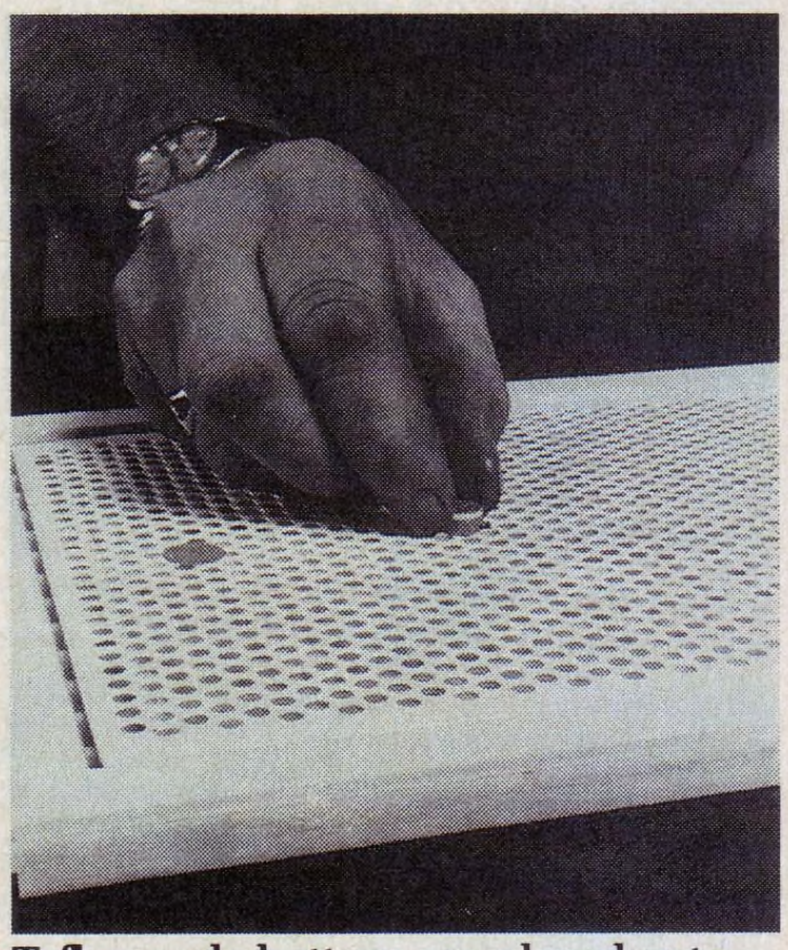
Six of the plastic matrix panel halves are supplied with a series of black crosses running vertically through the



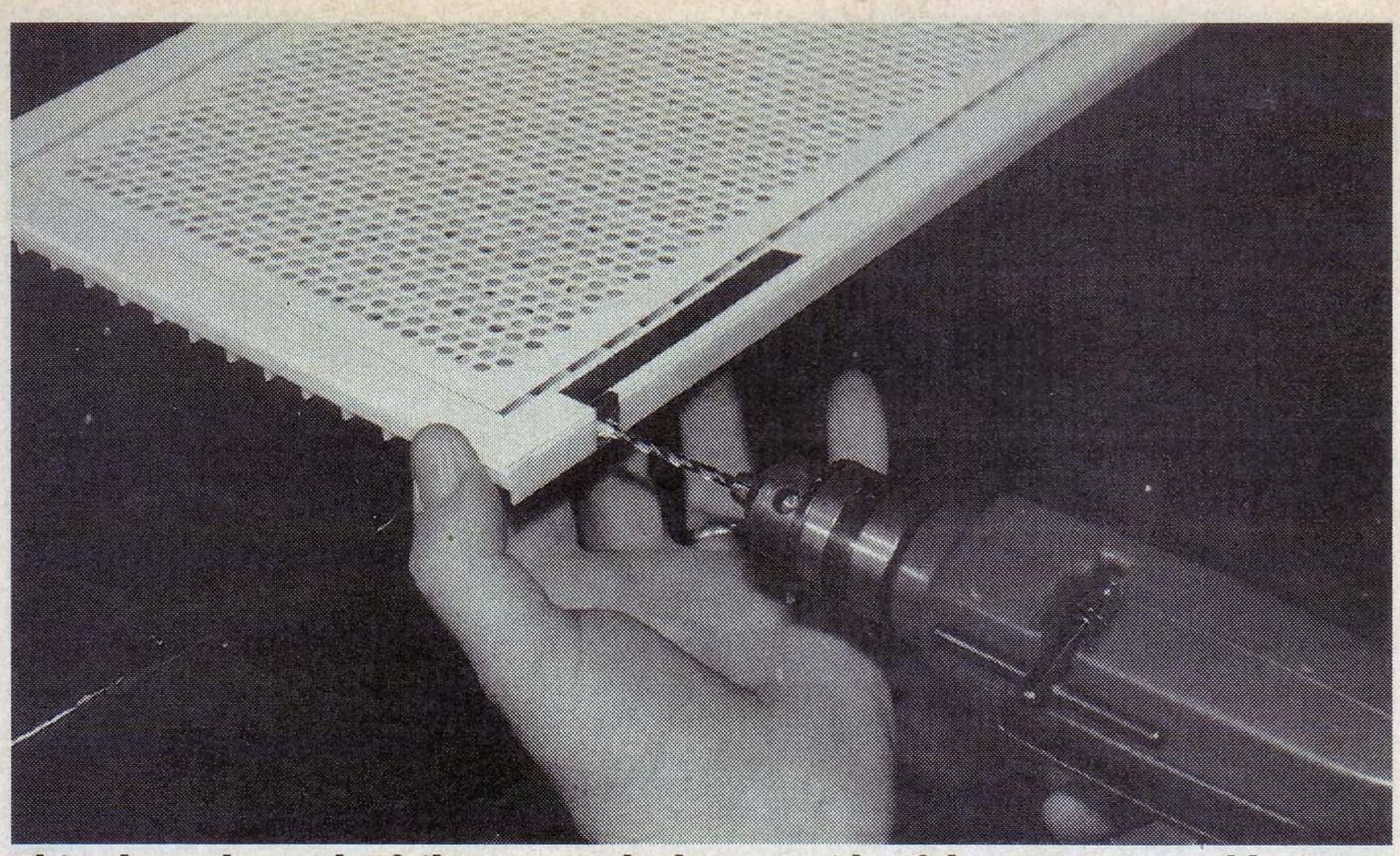
Once the perforated grids have been attached to the matrix panels, MDF pressure pads ensure they are kept flat while the adhesive cures.



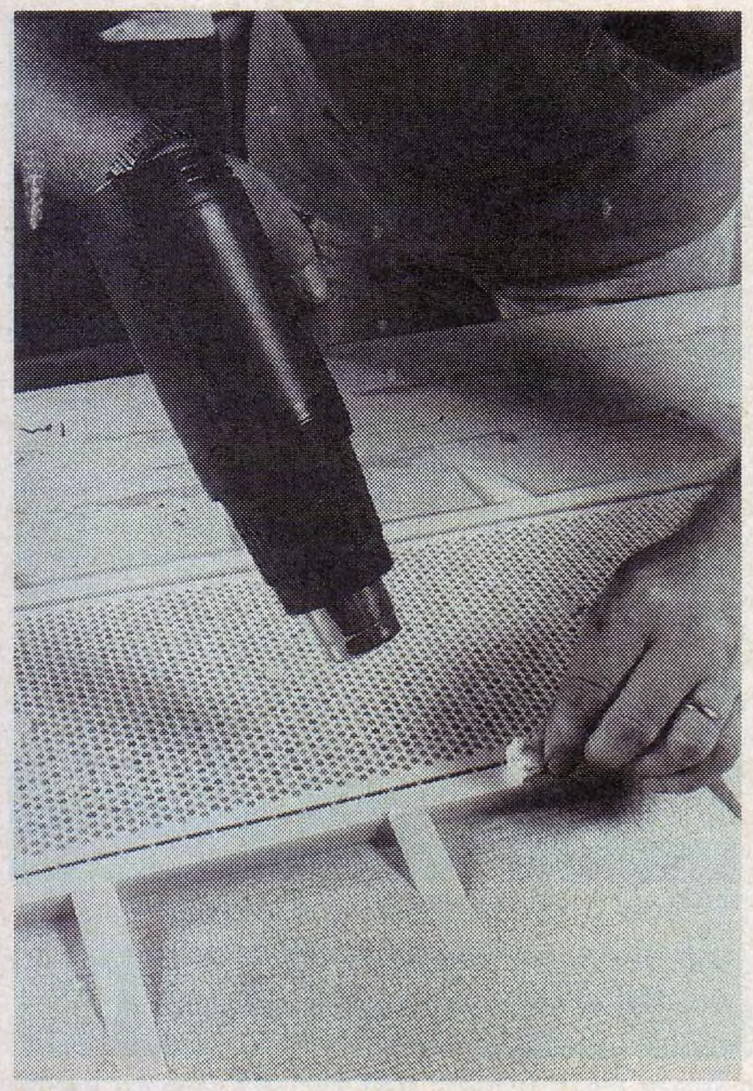
Once the matrix/grid assembly is complete, blobs of silicone are applied to the grid to form nodes for the diaphragm.



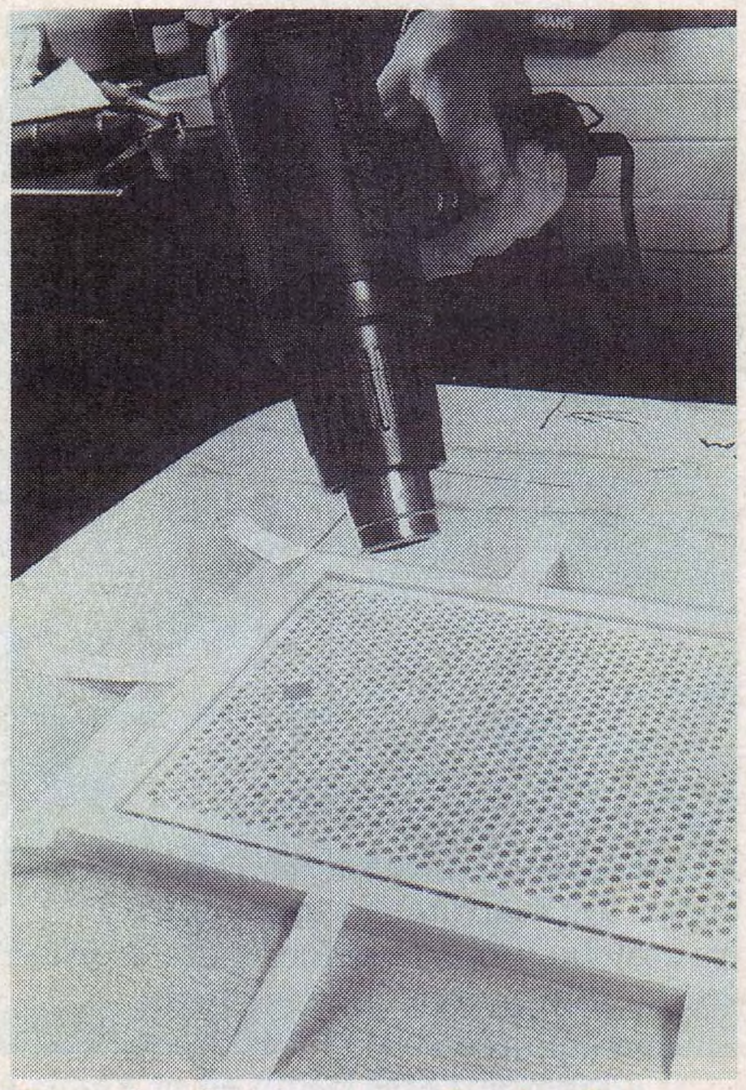
Teflon node buttons are placed onto the blobs of silicone (see previous photo) & pressed down using a steel ruler (see text).



This photo shows the foil tape attached to one side of the matrix assembly. It is then drilled to take a screw connection.



The clear plastic diaphragm is stretched over the panel and taped down as shown and the adhesive is activated by the heat gun.



Once the diaphragm adhesive has cured, the film is tensioned on the panel by shrinking it with the heat gun.

centre axis. These crosses are where the nodes are to be fixed and should be visible through the grid. If the centre is not visible, project where it should be and mark the grid with a felt pen at this point.

The nodes are made up of small discs of 2mm thick Teflon attached to the grids with silicone adhesive. Place a blob of silicone adhesive about 5mm in diameter and 4mm high at the centre of each cross. Place a white Teflon disc with the backing paper (brown side) up, gently on top of the blob. Place an ordinary piece of A4 paper on top of the long PVC spacer on either side of the Teflon disc.

Using the edge of a steel rule, press the disc into the blob of silicone until the rule is resting on top of both pieces of paper. The surface of the disc should be parallel to the surface of the air gap spacer. Now move up to the next node position. Repeat this process on all panel halves which are marked with the black crosses running down the centreline (six of them).

The Teflon discs have an adhesive layer which is covered by backing paper. As the disc has been set at a position level to the top of the air gap spacers, plus a thickness of paper, they will be level with the air gap spacer when the backing paper is removed. The diaphragm will adhere strongly to the adhesive on the disc, eliminating diaphragm rattles and the need for a matching disc on the other half panel.

This method of construction greatly reduces the risk of EHT leakage from the conductive side of the diaphragm to the grid. Leakage caused by dust collecting on the node points is also eliminated. Allow the silicone adhesive to cure before attaching diaphragms to these panels.

Installing the foil tape

Each panel has a wire attached to its diaphragm for the EHT. Some matrix panels do not have a fully filled-in section on one side. The side that is filled in has the foil tape attached to it. The 150mm long foil tape is placed on the air gap spacer, running towards the top of the panel.

From the small roll, tear off about 150-175mm of foil tape. Peel about 50mm of the backing from the foil and apply the tape at the connection point first and run it onto the top of the PVC spacer. The tape needs to be turned through 90° toward the top of the half panel.

The easiest way to do this is to fold the tape over at 90° in the opposite direction to that which is desired; ie, fold the tape towards the bottom of the panel. Peel off some more backing and fold the tape back on itself towards the top of the panel. This will make a neat turn in the tape. Peel off the backing about 50mm at a time and stick the remainder of the tape down onto the air gap spacer.

Drill a 3mm hole through the foil and matrix at the connection point. Don't use too much pressure as the matrix is fragile. Crimp or solder an eye connector to 400mm of EHT wire and fix to the panel connection point with a screw and nut. It is best if the terminal is on the inside section of the matrix. This will allow the channel section to sit as close as possible to the matrix. When tightening the screw, be careful not to tear the foil tape.

Diaphragm installation

It is suggested that the diaphragms for the narrow treble panel should be fitted first. This will give some expe-

rience for the more difficult bass panel. Place the half panel with the Teflon node points spacer side up onto the work surface. Make sure that the clear protective covering on the air gap spacers has been removed, as mentioned earlier.

Remove the backing paper from the Teflon node points. Remove the clear backing from the supplied diaphragm. "TOP" has been marked on the diaphragm surface to identify it. Tear off four pieces of masking tape about 80mm long and attach them to each corner of the diaphragm.

With the help of an assistant, hold the diaphragm taut over the half panel and lower it onto it. It is important that the diaphragm overlaps the air gap spacers on all sides before coming into contact with the Teflon node points, as the adhesive bond will be difficult to break if an error is made.

If an assistant is unavailable, tape down one end of the diaphragm to the work surface, keeping the other end off the panel. Lower the diaphragm down onto the panel, ensuring there is some overlap around all edges.

Tape the diaphragm down to the work surface using more masking tape. Use tape in the four corners and at about seven or eight equally spaced positions along the longest edge. Tension the diaphragm as much as possible by pulling on the tape prior to sticking to the work surface. This initial tensioning will not affect the ultimate tension achieved after the heat shrinking process. It is simply to make this process easier.

The diaphragm should now be taut and wrinkle free. The node points should be visibly contacting the diaphragm all down the centre axis of the half panel.

Using a heat gun on low setting, aim the hot air from about 150mm at an angle of about 45° at the PVC spacer. Keeping the heat gun moving at all times along the air gap spacer, use a small pad of folded tissue to gently push the heated diaphragm into contact with the PVC. The heat will melt the adhesive backing and allow a strong bond to the PVC spacer.

Follow this procedure all the way around the perimeter of the panel. Small wrinkles will occur in the diaphragm during this procedure. Don't worry about them. They will disappear when the diaphragm is fully tensioned.

Conductive fluid is applied to the diaphragm film with the aid of a small sponge.

After the diaphragm is stuck to the panel it will need to be tensioned. Keeping the heat gun moving at all times, direct the hot air around the edges slowly working towards the centre of the panel. Take care not to blow the diaphragm down onto the grid. If this does happen it may be released by gently heating and pushing through from underneath with a paint brush.

The alternative method is to release the diaphragm from the PVC spacer nearest to the stuck down portion using gentle heat, and lifting the diaphragm clear of the grid. It can then be re-stuck to the PVC spacer.

The correct tension has been reached when the diaphragm will not shrink any more. This point can be determined by passing the gun over the diaphragm and watching if any wrinkles appear as heat is applied. If none do, the diaphragm has reached its maximum tension. If wrinkles appear or the diaphragm "sags" when heat is applied, continue with the shrinking process.

Applying conductive coating

Note: it is essential that the conductive coating is applied in temperatures above 20°C. Failure to do so will lead to a poor surface cure.

After the diaphragms have been tensioned they need to be made conductive. Gently wash down the surface of the diaphragm with methylated spirit and a clean tissue. Do this three times (on the same diaphragm). Ensure that the diaphragm is dry. The heat gun can be used for this.

Pour a small amount of the acrylic conducting solution into a small bowl. Using a small piece of sponge, lightly swab the solution over the surface of the diaphragm. Keep the conductive coating about 5mm from the internal edge of the air gap spacers except in the area that will be contacted by the foil tape on the other half panel. The conductive coating should overlap this air gap spacer by about 10mm for the length of the foil tape. This is the only portion of air gap spacer that should have the conductive coating overlapping it.

The covering should be light with no evidence of puddles. Avoid air bubbles on the surface. If any foreign matter such as hair sticks to the coating, it may cause a discharge path for the bias voltage. Avoid this like the plague. Do not allow the conductive solution to spill over the side of the panel as this may also allow a leakage path for the EHT. Make sure that the solution is applied to the diaphragm area that the foil tape will contact when the panel halves are assembled. Now put this panel aside and coat the next. The solution takes about two to three hours to cure.

Check the resistivity and continuity with your multimeter. Place the two probes gently on the diaphragm surface about 100mm apart. The resistance reading should be 20 to 100 megohms. Place the probes at either end of the diaphragm on the conductive coating. A reading of over 20 megohms should be obtained. The actual value is not critical. This test just confirms that the diaphragm is conductive all over.

When using probes on the diaphragm ensure that it is not punctured. Next month will give the final assembly instructions. **SC**