

ARMCHAIR PHONATICS X.— Designing and Making a Gramophone Horn By P. WILSON
(February 1926)

JUDGING from the number of enquiries I have received lately, there are quite a number of readers who desire to make a gramophone with a large external horn. Some practical hints on this subject were given by Mr. Balmain in the issue for December, 1923, and by "Isle of Streams" in the issue for October, 1925. Reference may also be made to a note (No. 318) by myself on page 100 and to a note (No. 285) by Mr. Balmain on page 152 of the current volume.

There are two fundamental properties of horns which should always be borne in mind. The first is that if two horns have the same size of open end but are of different lengths, the one with the greater length and smaller angle of taper will extract more energy from the sound-box than the other. There is, of course, a limit to the amount of energy that can be extracted from the sound-box without straining the diaphragm and the record groove, and for this reason, if for no other, there must be a limiting length of horn beyond which it is undesirable to go. The second property is that, *ceteris paribus*, the larger the open end of the horn the easier is the transference of the energy to the outer air. This is especially true as regards waves of low frequency—that is, the bass of the scale. These two properties can be demonstrated theoretically and they are amply borne out in current gramophone practice.

The main difficulty of horn design is to discover the most satisfactory curve. Theoretical principles are not sufficiently far advanced to give much assistance in this respect and the infinite number of possible variations makes experiment slow and uncertain. Recent practice, however, both in the gramophone and in the wireless world, seems to favour the curve known as the logarithmic or exponential curve. One of my friends who has made detailed measurements and calculations informs me that after due allowance has been made for the change of section from circular to rectangular, the horns of the new H.M.V. machines are based on the logarithmic curve. I do not propose to bewilder readers by describing what that curve is; I will rather give them simple rules by which they can draw the curve for themselves. First of all, I will give the rules for drawing the curve of a horn 4 feet long with an open end 2 feet across. Later on, I will show how the rules can be modified so as to apply to longer or shorter horns or to horns with a larger or smaller open end. It should be understood that for this purpose it is assumed that the horn starts at the sound-box. So that either there is to be no tone-arm at all, as in the machine described in Mr. Balmain's article of December, 1923, or else the tone-arm will take the place of a corresponding length of the horn at the narrow end.

Along the centre of a sheet of paper about 54" long and 30" wide draw a line 48" long. From one end of this line space off successive distances 3" apart. At the points so obtained, distant 0", 3", 6", 9", etc. from the end, draw lines perpendicular to the centre line and on both sides of it. Along these perpendiculars measure the distances from the centre line, and on both sides of it, given in the following table:

0"	3	6	9	12	15	18	21	24	27	30	33	36
.297	3/8"	.469	.594	3/4	.938	1.18	1 ½	1 7/8	2 3/8	3	3 ¾	4 ¾
39	42	45	48	<i>51</i>	<i>54</i>	<i>57</i>	<i>60</i>					
6	7 ½	9 ½	12	<i>15</i>	<i>19</i>	<i>24</i>	<i>30 (italics – these added from subsequent article)</i>					

For clearness, it is perhaps necessary to explain that this table means that at the end of the central line the length of the perpendicular should be ... on each side of the central line ; at a distance of 3" the length should be ... on each side ; at a distance of 6" the length should be ... on each side and so on. This process gives a series of points on each side of the central line. If smooth curves are now drawn, one on each side of the line, through those points, we get the plan of a horn four feet long, designed to a logarithmic curve, the diameter of the narrow end being and the diameter of the open end being two feet.

It will be noticed that at the sound-box end the taper of the horn is very small indeed; in a length of 3" the diameter only increases by ...". At the open end, however, the flare is very pronounced. The mathematically alert will also observe that the columns of the table given above can be divided into successive groups of three. The length of the perpendicular for the first column of each group is exactly double that for the first column of the preceding group. Similarly with regard to the middle and end columns of each group. This illustrates one of the properties of the logarithmic curve which probably has a good deal to do with its use in gramophone and wireless practice.

(To be continued.)

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ARMCHAIR PHONATICS XI By P. WILSON—Gramophone Horns (continued)
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TO make a horn to the shape described in the last article it is necessary, first of all, to make a mould or template. The following method is suggested as being comparatively simple and accurate. Transfer the plan of the horn to a piece of three-ply board and cut out the board to that shape. Cut out a second piece of three-ply board to the same shape. Up the centre line of one board cut out a slot, as wide as the board is thick and extending from one end half way along the length of the board. Up the centre of the other board cut a similar slot but starting from the other end. With the faces of the boards at right angles to each other, slide one slot over the other so, that the boards fit together at right angles in the form of a cross.

The boards then form two perpendicular diameters of the mould. Place this with the large end on a piece of board or glass, rather more than 2 feet square, and fill in the spaces between the boards with clay or some other plastic material, moulding it and smoothing it so that each horizontal section of the mould is circular. When quite dry, face the mould with tin-foil, stuck on with water only, so that the horn will not adhere to the mould.

For the material of the horn itself, the amateur is limited to such things as paper or to some plastic material. A material known as "plastic wood" has recently been placed on the market by the Celestor Manufacturing Company, of 55, Dartmouth Road, Forest Hill, S.E. 23, and this should serve the purpose very well indeed. Strawboard is hardly suitable since it cannot easily be bent so as to follow the double curvature of the mould. Strips of tough brown paper, stuck on with strong flour paste to which some size has been added, serves quite well. The thickness of the horn should be about $\frac{3}{16}$ of an inch at the narrow end, but may be thinned down to $\frac{1}{16}$ of an inch at the open end. When the pasting or moulding is finished, the horn should be left on the mould for a fortnight or so to dry, and then varnished or lacquered with three or four coats, both inside and out.

To return now to the question of design. The table given in the last article stopped at a length of 48 inches where the length of the perpendicular was 12 inches. The next few lengths beyond that point are :—

Distance from end	51"	54"	57"	60"
Length of perp.	15"	19"	24"	30"

So that if the curve were continued to 51 inches the C diameter of the open end would be 30 inches, whilst if the horn were continued to 5 feet, the width of the open end would be 5 feet also. As things are at present such a horn would be unwieldy, to say the least. If a longer horn is desired with a reasonable size of open end, all that is necessary is to alter the scale along the centre line. Thus, instead of stepping off distances of 3 inches as previously described, distances of 4 inches or 5 inches or 6 inches, etc., could be stepped off, the lengths of the perpendiculars at successive points remaining the same as before. If we took distances of 4 inches along the central line, the perpendiculars would be a ... of an inch at the end, of an inch at 4 inches from the end, ... of an inch at 8 inches from the end, and so on. This would give a horn 64 inches long with an open end of 2 feet, or a horn 6 feet long with an open end of 3 feet 2 inches. It would also have the effect of decreasing the taper all along the length. Similarly, we might shorten the horn whilst still preserving a large open end by stepping off distances of, say, 2 inches along the central line. This would increase the taper and give a 2 feet open end for a length of only 32 inches. But if such a small length of horn is required it would probably be better to retain the smaller angle of taper and be content with a smaller open end.

It will be seen from the above that, using a logarithmic form of curve and keeping a constant diameter at the sound-box end, we can still alter two factors to suit requirements, viz., the length of the horn and the diameter of the open end. For any length of horn a logarithmic curve can be drawn to give any width of open end and vice versa. There is enough scope for variation here to provide us with gramophone "revolutions " for the rest of our lives ! As I have remarked before, there is probably some functional relationship between the length of the horn and the width of the open end which will give the most satisfactory results. We await some bright genius who will show us what that is. In the meantime we can only go on trying and trying and trying.

Note: Next month I hope to conclude my notes upon flexibility and record wear. But I should like to warn readers in advance against playing Parlophone records with fibre needles. The fibre friction soon rips up the surface. Parlophones are the only records I know where this is the case.

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