[Second Edition.]

PATENT SPECIFICATION

Application Date : July 5, 1926. No. 16,794 / 26. 278,098

Complete Left : March 2, 1927.

Complete Accepted : Oct. 5, 1927.

PROVISIONAL SPECIFICATION.

Improvements in Horns for Acoustic Instruments.

I, PAUL GUSTAVUS ADOLPHUS HELMUTH VOIGT, of "Bowdon Mount", 121, Honor Oak Park, London, S.E. 23, British subject, do hereby declare the nature of this invention to be as follows :—

This invention relates to horns for loud speakers, gramophones and the like.

According to this invention, the inside shape of a straight circular horn is as nearly as possible such that the distance between any point on the surface and the axis measured along the tangent at that point is constant. This gives a curve known as the "Tractrix".

At the flare, this tangent becomes the radius. The flare diameter is therefore twice the tangent length.

If the horn is to be square, I prefer to make the square so that it will fit over the imaginary circular horn, touching it along the middle of each side.

If the horn is not required to project sound downwards, as for example in a table gramophone, only the upper half may be used, a flat surface forming the lower boundary, this flat surface should be continued in front of the flare if possible.

For convenience near the small end, the horn may be merged into a circular section of the same area as the previous section would have had at that point.

In practice it is nearly always necessary to bend the horn. At all bends, the inner radius should be large compared with the width. If a sharp bend has to be made where this is impossible, the sound travelling round the inner radius will be out of phase with that travelling round the outer radius. This tilts the wave front, and reduces the sound intensity near the inner radius.

These defects may be overcome by dividing the horn into several parts each of the same length which are joined together after the bend.

For example in a cabinet gramophone with a reasonably long mouth the 90° bend up to the tone arm may have to be so sharp that a considerable phase difference is produced. In such a case, I would divide the bend into, say, two paths ; one, the inner path being of one third the original width and the original inside radius, while in the outer path the inner radius is now greater than before and the width is two thirds. Thus the ratio of inside radius to width is increased in both cases.

Each path should be separately tapered (as if it was a "lamination" of a straight horn bent up). The inner path should be bent round further than 90° and then looped back so that the extra length due to the loop equals the reduction due to the shorter path in the bend. The length of both paths is thus made the same and the phase difference becomes negligible.

Dated the 3rd day of July, 1926.

P. G. A. H. VOIGT.

COMPLETE SPECIFICATION.

Improvements in Horns for Acoustic Instruments.

I, PAUL GUSTAVUS ADOLPHUS HELMUTH VOIGT, of "Bowdon Mount", 121, Honor Oak Park, London, S.E. 23, British subject, do hereby declare the nature of this invention and in what manner the same is to be performed, to

[Price

be particularly described and ascertained in and by the following statement:—

If the radiation of sound is considered, it will be found that at a distance from the source a velocity of 1 cm./sec. is accompanied by a pressure of approximately 43 dynes/sq. cm. As the source is approached, this relation continues to hold good until a point about a quarter wavelength from the source is reached.

When the source is closer than this, the velocity increases at a greater rate than the pressure.

In a horn constructed according to this invention, the taper at any point is as nearly as possible such that the sound is expanding as if the source was at a fixed distance which is at least a quarter wavelength, of the lowest frequency at which full efficiency is required, away.

Such a horn is illustrated in Fig. 1 of the accompanying drawings. A B C E are points on one side of the curve, while B B^1 and C C^1 are tangents to the curve and cut the centre line at B^1 and C^1 respectively. Arcs drawn with centres at B^1 and C^1 and radii B B^1 and C C^1 will represent the wavefront of a wave expanding as if the source was at B^1 and C^1 respectively. Since according to this invention, the rate of expansion shall be as if the source was a fixed distance away, it follows that the length of the tangent is equal to this distance. The property of this curve is therefore that the length of tangents such as B B^1 and C C^1 is constant. At the point where the tangent is at right angles to the centre line, it becomes the radius. I call this point the "mouth" and prefer either to terminate the curve at this point, or to continue the plane E F at right angles to the centre line.

The curve whose tangent to the centre line is of constant length is called the "Tractrix", and may be drawn by drawing a small portion of one tangent after the other. In the case of a square horn, the tangent to the corners is longer than that to the middle of the sides and a compromise is unavoidable. I prefer to make the section correspond to the tractrix. The shortest tangent is then correct, but the area is $\frac{4}{\pi} = 1.27$ times that of the corresponding tractrix. If the area is made equal to the corresponding tractrix, the tangent at the sides will be short, a defect which is partly compensated for by the excess length of the tangent to the corners.

Horns of any other cross section or of varying cross sectional shape are designed so that the change of area is based on the change in the corresponding tractrix.

When the horn has to be bent to make it more compact or for any other reason, the sound travelling round the inside of the curve will arrive out of phase with that travelling round the outside. To reduce this to a minimum, the ratio of radius of curvature to radius of horn should be as large as possible. If the bend has to be sharp, especially near the mouth, the radius of the horn will change considerably in the length of the bend. It is then better to make the bend not round a fixed centre, but round a variable centre. This will allow a better ratio of radius of curvature to horn radius.

The graphical construction is shown in Fig. 2. *ae* is the curve, and *xy* is the line representing, say the back of the cabinet. *gh* is the line (cutting the centre line at *k*) behind which the bend is to take place. Divide the horn up into sections $glkhf^1lf$, flf^1b^1pb and so on. Project *gh* to i_1, which must be found by trial and depends upon the space available between *gh* and *xy*. With centre i_1 draw an arc through *k* and mark off a length *km* equal to *kl*. Join and produce i_1m, mark off *mn* and mn^1 equal to *lf*. nn^1 are two points on the bent curve. For the next section flf^1b^1pb mark the new centre i_2 on mi_1 such that $mi_2 : ki_1 : : mn : kg$. With centre i_2 draw an arc through *m* and mark off *mq* equal to *lp*. Join and produce i_2q and mark off *qr* and qr^1 equal to *pb*. This gives two more points on the curve. Continue as far as is required and draw a smooth curve through the points obtained.

A better but more expensive method is shown in Fig. 3. The horn is divided into two or more properly tapered sections 1 2, 3 4 (not necessarily of the same area) which are bent individually about fixed or variable centres, continued until they are of equal length and then joined together again. In the figure, both sections are bent about a variable centre, small crosses indicating the positions of successive centres.

If the horn is assumed to have a horizontal partition along the centre which is preferably continued for some distance in front of the mouth, the sound will still expand prefectly in each half. When the sound is not required to expand downwards, as for example in a table gramophone, the lower half of the horn can be omitted and considerable space will be saved. The horn shown in Fig. 3 is such a "half horn" 5 6 being the extension of the theoretical partition.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is

to be performed, I declare that what I claim is :—

1. Horns for acoustic instruments designed so that the sound wave expands as if the source was at an approximately constant distance away from the point of expansion, such a design being obtained for straight circular horns by forming the walls to the shape of the curve known as the tractrix in which the length of the tangent from the centre line to the curve is constant.

2. Square horns designed as claimed in Claim 1 whose section gives a curve known as the tractrix.

3. Horns of any cross sectional shape, or whose cross sectional shape varies, designed as claimed in Claim 1, so that the area at any point approximately equals the area of the corresponding circular horn based on the tractrix.

4. Horns as claimed in Claim 1, 2 or 3 bent round a variable centre substantially as described and illustrated.

5. Horns as claimed in Claim 1, 2 or 3 split into two or more sections which are bent separately and joined together again in such a manner that the lengths of the air paths are approximately the same.

6. Horns as claimed in Claim 1, 2 or 3 in which a portion of the curve has been omitted, the dividing surface being preferably continued in front of the mouth of the horn.

7. Horns as claimed in Claim 1, which are basically a tractrix, bent, distorted or split to any shape substantially as described and illustrated.

Dated the 28th day of February, 1927.

P. G. A. H. VOIGT.

Abingdon : Printed for His Majesty's Stationery Office, by Burgess & Son.
[Wt. 8002A.—50/4/1934.]

2nd Edition

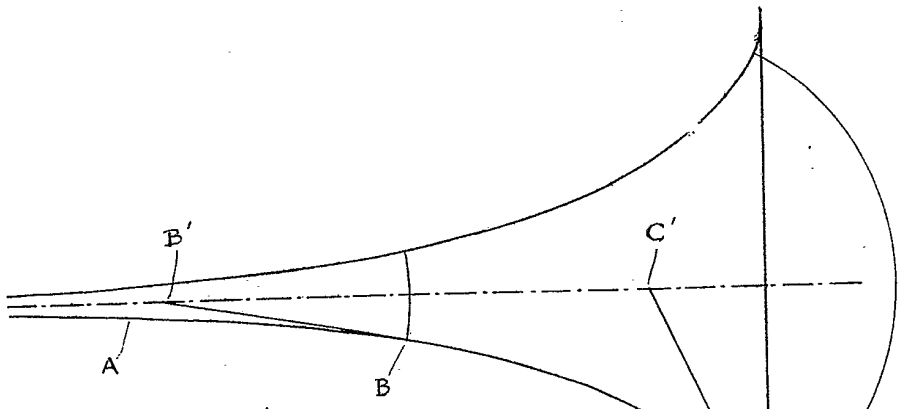

FIG 1.

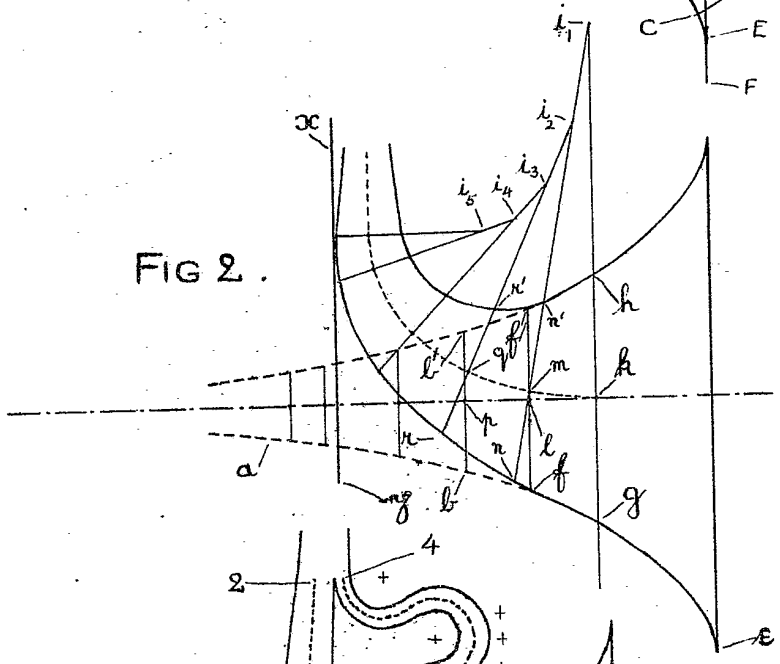

FIG 2.

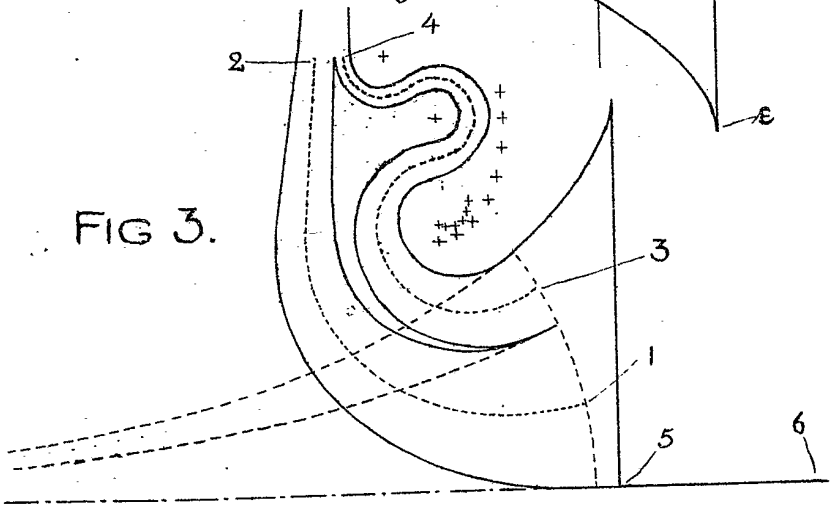

FIG 3.

Malby & Sons, Photo-Litho