April 26, 1927. **G. SEIBT** 1,625,914

METHOD OF MAKING THIN METAL SHAPES

Filed Sept. 26, 1924

*Fig: 1.*

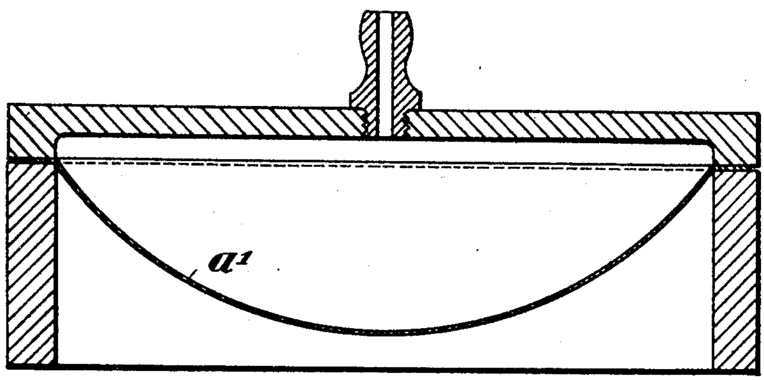
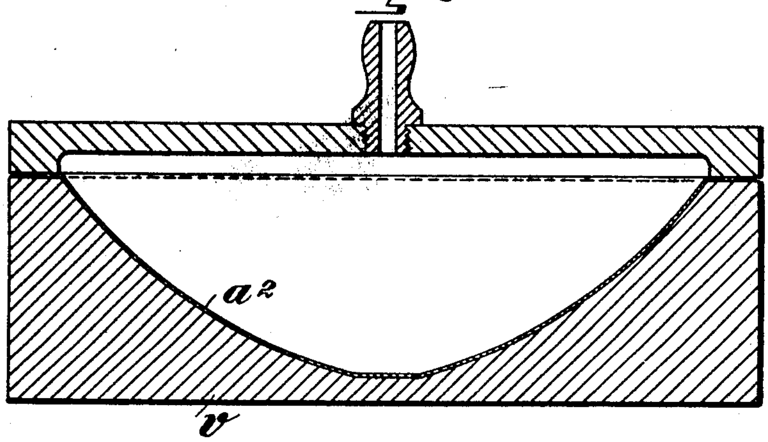



*Fig: 2.*

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# UNITED STATES PATENT OFFICE.

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## METHOD OF MAKING THIN-METAL SHAPES.

Original application filed July 23, 1923, Serial No. 653,396. Divided and this application filed September 26, 1924, Serial No. 740,108, and in Germany January 9, 1923.

My invention relates to the method of working thin metal sheet into extremely thin forms, so as to be of uniform thickness, and this application is a division of my application Serial No. 653,396, filed July 23, 1923.

The object of my invention is to draw or to extend a flat sheet of aluminum, copper, nickel or other metal into a suitable shape that is extremely thin or foil-like, the thickness being but a few hundredths of a millimeter, specifically less than five hundredths of a millimeter.

The articles that I have so produced are extremely delicate diaphragms for sound reproducing apparatus whose form is not flat, and generally of a curved cross-section, as of a sphere or similar regular curved body.

The finished product is so thin and foil-like that it cannot be pressed between metal dies, as the dies will tear the metal when the patrix is removed.

I am enabled to produce such thin diaphragms by supporting a thin sheet of metal at its edges and distending or drawing the metal by means of a plastic patrix, preferably air under high pressure.

My method will be explained in connection with the apparatus shown in the accompanying drawings, in which—

Figure 1 is a cross-section of one form of device for carrying out my method, and

Fig. 2 is a cross section of another form.

Thin diaphragms for talking apparatus which are made in the form of cups with straight walls (hollow cones) or cups with curved walls for the purpose of stiffening the diaphragms, are already known in the art. But these known diaphragms are of considerable thickness so that they do not meet certain requirements. Some of these diaphragms are also not designed so that all parts of the same vibrate in phase with each other, others do not have a sufficiently high natural rate of vibration, and a drawback of others is that the annular ring joining the periphery of the diaphragm with the peripheral clamping device does not consist of a single piece of non-perforated sheet metal.

If, as has already been proposed, the periphery of the cup-shaped diaphragm is only joined to its peripheral clamping device or support by narrow radial strips between sector-shaped or arcuate perforations, a diaphragm which is as thin as that made in accordance with this invention, would be deformed to an unpermissible extent by the operation of stamping out the perforations. And if, as has already been proposed, the stiff cup-shaped diaphragm be fixed to a separate, thin, elastic clamping ring of prepared paper, fabric, or the like, a diaphragm of the requisite thinness would also be deformed during manufacture when the apparatus is assembled.

Moreover, a diaphragm thus consisting of two parts (the diaphragm proper and the annular clamping ring) would be liable not to vibrate in unison at all parts of its surface, i. e., different elements of its surface would be liable to vibrate out of phase with each other.

In accordance with this invention the rim of the cup-shaped part of the diaphragm joins immediately onto a flat, annular, non-perforated ring which is adapted to be clamped or held in the peripheral clamping or supporting device.

Diaphragms which are thin, light and stiff enough, and are sufficiently free of internal stresses for the purposes of the present invention cannot be produced by processes of the kind proposed hitherto for similar purposes. Attempts have been made to produce cup-shaped, spherical, or curved metal diaphragms by depositing metal upon a surface of wax of the desired shape after making the said surface capable of conducting electricity.

Useful results might possibly be obtained, with difficulty, by this method when employing copper or nickel, but when aluminum is employed, which, as is well known, cannot be deposited electrolytically in thin layers, this method is useless. Moreover, the separation of the thin layer or metal skin from the wax surface is fraught with great difficulties, and is thus liable to destroy the skin.

Attempts have also been made to produce conical, thin aluminum diaphragms by spinning, i. e., by applying pressure by means of a burnisher or the like to the sheet metal while it is rotated in a lathe. This spinning process is applicable with metal of a thickness down to about 0.05 mm. and diameters of about 50 mm. A disc of the sheet aluminum is fixed at its periphery in a chuck rotated by the lathe. During rotation pressure is applied by a blunt tool until the desired shape is produced. This process becomes impracticable when greater diameters or thinner sheet metal are, or is, employed.

Besides, it will not answer for diaphragms of considerable cavitation. Its greatest drawback is that it gives rise to internal stresses in the diaphragm which result in rattling noises when the diaphragms are used for the reproduction of the voice. These noises are quite insupportable when the talking apparatus is energized with considerable power, as in the case of loud speaking telephones or the like.

In accordance with my invention all these disadvantages are avoided by shaping the diaphragm with the aid of a drawing process in which the patrix expands the thin sheet metal quite uniformly.

I have found it preferable to use a patrix which has no precisely defined shape, but which consists of a plastic material such as a fluid, as compressed air, thick grease, oil, or water under pressure. If a diaphragm is to be produced for a talking apparatus in which a hollow spherical shape is required, the drawing device shown in Fig. 1 will suffice. The diaphragm in the form of a flat disc is clamped at its periphery and compressed air is introduced into the device from above, so as to cause the diaphragm to bulge downwardly as indicated in Figure 1.

To produce a diaphragm of the shape required for another talking apparatus, and having a flat central bottom or other irregular shape, a matrix *v* as shown in Figure 2 is employed, which defines the shape of the diaphragm when the compressed air is introduced from above. An air pressure of up to about five atmospheres per sq. cm. is applied and this causes the diaphragm to be pressed firmly against the cavitated surface of the matrix.

To obtain a deep cavitation the drawing process is preferably carried out in several steps. In a single step an aluminum diaphragm of 100 mm. in diameter and a thickness of 0.03 mm. can only be bulged to a depth of about 14 mms. A cavity of a depth of 19 mms. can be obtained, however, if the drawing process is carried out in three steps and the metal is annealed by heating it at each step to about 300° to 350° C. It is important to use temperatures between these limits because a temperature of say only 220° is practically useless with aluminum, and temperatures above 400° are actually injurious because they result in tearing of the metal.

By following the aforesaid instructions aluminum diaphragms as thin as 0.02 mm., of a diameter of 70 mms. and a cavity 14 mms. deep may be produced.

It has already been proposed to shape diaphragms for talking apparatus by means of compressed air, but in these proposals it was not a question of making diaphragms of light metal and extreme thinness and great stiffness by drawing, but of producing celluloid diaphragms of unusual elasticity but not conical nor cup-shaped, and at the same time of a thickness of only a few tenths of a millimeter. Diaphragms of this kind are not within the scope of this invention because they do not enable the desired technical effect to be obtained but result in a contrary effect.

I claim—

1. A method of making extremely thin foil-like sound reproducing diaphragms which comprises clamping a thin sheet of aluminum around its edges and producing a drawing pressure on one surface of the metal by means of a plastic medium until the metal is reduced to a thickness less than .05 of a millimeter.

2. The method of making extremely thin foil-like hollow sound reproducing diaphragms which comprises clamping a thin sheet of aluminum around its edges and producing a drawing pressure by fluid on one surface of the metal sheet to partially extend the metal, annealing the partly formed sheet by heating the same to approximately 300° to 350° C. and then continuing the extension of the metal to obtain a thickness less than .05 of a millimeter.

3. The method of making extremely thin foil-like sound reproducing diaphragms which comprises clamping a thin sheet of circular metal of approximately 70 millimeters in diameter around its edges and producing a drawing pressure on one surface of the metal by means of a plastic medium until the metal is reduced to a thickness less than 0.5 of a millimeter and having a cavity of approximately 14 millimeters in depth.

In testimony that I claim the foregoing as my invention, I have signed my name hereto.

GEORG SEIBT.