Oct. 4, 1932. H. VOGT 1,881,107

SOUNDING CONDENSER

Filed Sept. 15. 1928 2 Sheets-Sheet 1

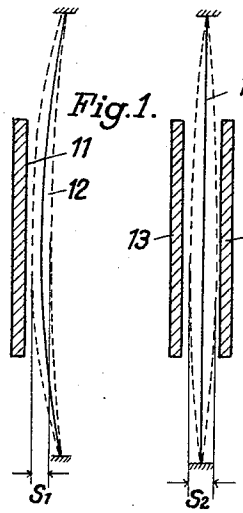


Fig.1.

Fig.3.

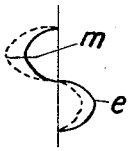


Fig.2.



Fig.4.

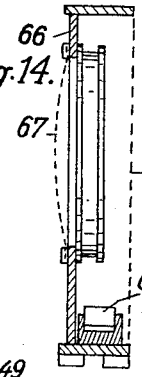


Fig.14.

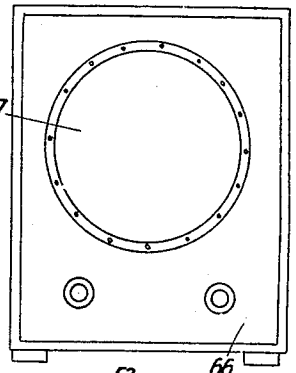


Fig.13.

Fig.12.

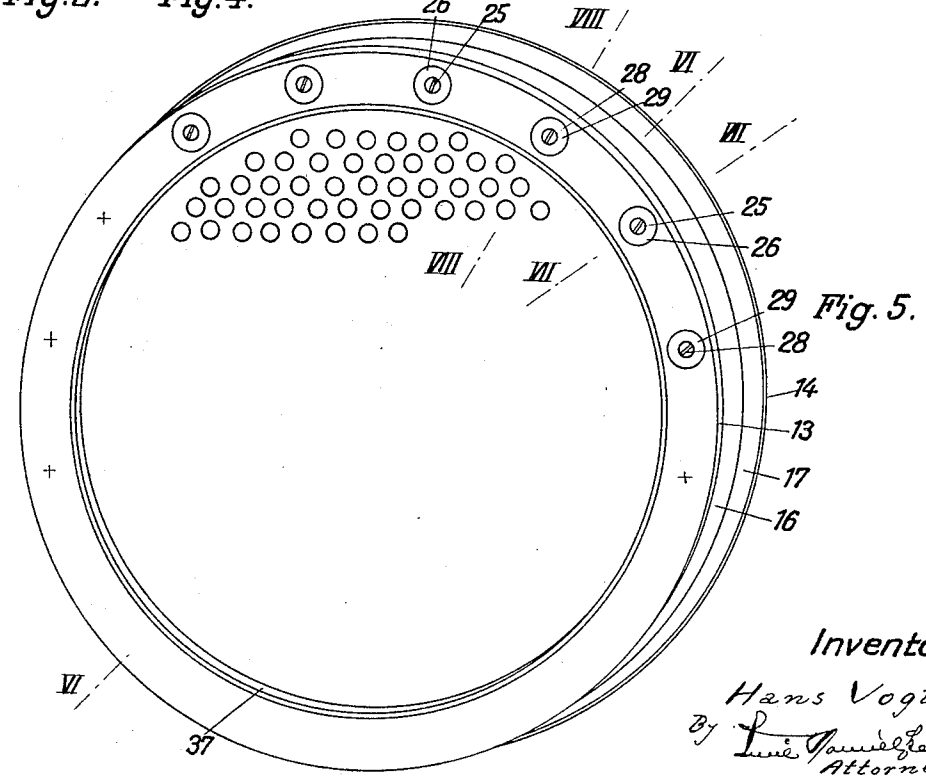


Fig. 5.

Inventor:
Hans Vogt
By Louis Samuels
Attorney.

Oct. 4, 1932. H. VOGT 1,881,107

SOUNDING CONDENSER

Filed Sept. 15. 1928 2 Sheets-Sheet 2

Fig. 7.

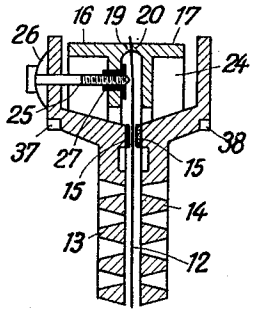


Fig. 6.

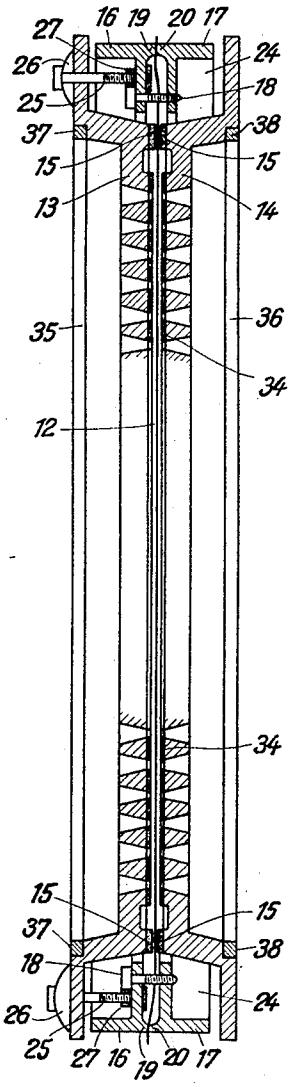


Fig. 8.

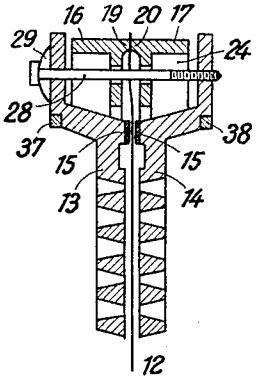


Fig. 9.

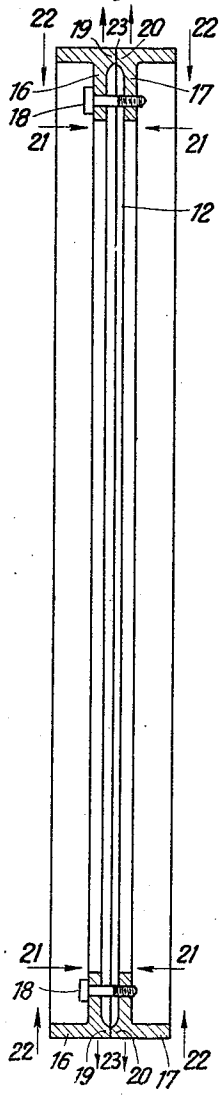


Fig. 10.

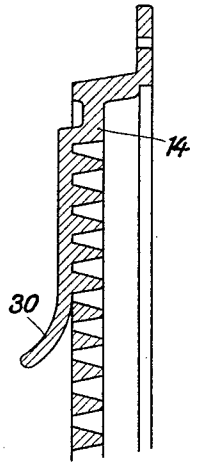
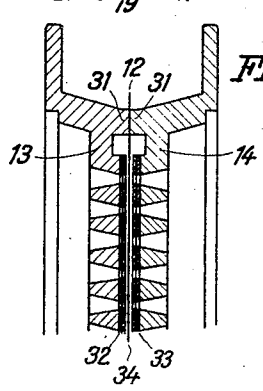


Fig. 11.



Inventor:
Hans Vogt
By [signature]
Attorney.

Patented Oct. 4, 1932

1,881,107

UNITED STATES PATENT OFFICE

HANS VOGT, OF BERLIN-WILMERSDORF, GERMANY

SOUNDING CONDENSER

Application filed September 15, 1928, Serial No. 306,158, and in Germany May 16, 1928.

My invention relates to sounding condensers for reproduction of speech and music in which a thin and light diaphragm is caused to oscillate or vibrate electrostatically, and more particularly to an improved condenser of the stated kind constructed and adapted to reproduce sounds in a most perfect manner not realizable in condensers as hitherto constructed.

A condenser made according to my invention is highly sensitive and adapted to cause the alternating current amplitudes introduced therein, to produce or provoke sound pressure fluctuations of great magnitude as compared with the sounding condensers as hitherto constructed, so that all minute modulations and delicate variations of sound and timbre will be reproduced so as to be clearly distinguishable and perceptible to the ear. Another advantage of my improved condensers resides in the fact that certain sound deformations or distortions which hitherto could not be overcome in condensers of this type and which greatly impaired the character of the reproduction, are minimized as will be explained more in detail hereinafter.

The quality of reproduced sounds is chiefly impaired in electrostatic devices as hitherto constructed, by the presence of disproportionality between the movement of the diaphragm and the supply of alternating current due to the enormous increase of the intensity of the field resulting from the reduction of the gap behind or adjacent to the diaphragm. Said disproportionality is perceptible in the reproduction as a so called non-linear or amplitude distortion and produces in the reproduction, especially in case of larger amplitudes, additional combination sounds and clattering or jingling noises.

Furthermore in all of the electrostatic devices for the reproduction of sounds as hitherto constructed and used the low frequencies are reproduced in a faint, poor manner only due to the minimal gap between the diaphragm and the rigid structure, resulting in the said devices from the intensive bending of the diaphragm, and the consequently reduced movability of the latter. It has been suggested to remedy this defect, for instance in the reproduction of speaking films, by providing particular, partly encumbering resonators tuned to various low frequencies. But this way of overcoming the stated disadvantage requires the provision of quite a multitude of loud-speaking devices in order to be able to reproduce the whole range of the low frequencies, and just this necessity involves considerable disadvantages particularly as regards the reproduction of the human voice.

The chief object of the present invention is to provide a sounding condenser for great performances or efficiency which constitutes a novel and advantageous combination of partly known features with a view to thereby solve and realize the problem of producing large sound volumes, without possessing the disadvantages hereinbefore intimated, respecting distortion of amplitude and dependence of frequency, and to thus form a condenser which is of best possible electrostatic efficiency and adapted to reproduce sounds in so accurate, clear and natural a manner as never has been attained heretofore.

With this object in view I employ, according to the present invention, a diaphragm of comparatively considerable size that is of more than 15 cm. in diameter, generally speaking, and mount the same midway between two perforated plates so as to be capable of oscillating free of load in the highly sensitive field between the two plates.

The electric field of great intensity is produced by a high continuous voltage pressure of more than 200 volts to be applied to the rigid structures. The employment of a diaphragm of a large size supported at its circumference only so as to not have any other supporting points and the application of a high electric field intensity is possible in my improved device owing to the fact that the diaphragm is located between two rigid structures so that the same will be unloaded as regards the high electrostatic forces resulting from the preliminary potential.

I am aware that diaphragms adapted to be electrostatically energized on both sides, are in themselves known in telephones. But

the hereinbefore stated disadvantages could not be overcome and better results without any inherent drawbacks could not be attained prior to my idea of employing a diaphragm of considerable size arranged so as to be unloaded, and using, in connection therewith, a comparatively high preliminary potential. I am also aware that electrostatically energized diaphragms of large size are in themselves known, but they do not oscillate while in unloaded condition and, therefore, require to be supported at certain intermediate points so that they cannot freely oscillate at the deeper sounds, while the higher sounds will preferably be reproduced and the amplitude will be distorted as hereinbefore described.

I shall now proceed to state in general the further improvements according to my invention. The diaphragms hitherto employed in connection with double-acting sounding condensers are not tensioned, since the unloaded arrangement, in contradistinction to diaphragms of unilateral energization, renders this possible. From an acoustic point of view this appears to be of advantage, as diaphragms of that said kind have no natural vibration. Experiments and tests made for the purpose, however, showed that diaphragms of that kind may be used for producing small sound volumes, but do not give satisfaction in case of producing large sound volumes mainly on account of generating, disturbing, fluttering and buzzing noises. This is due to amplitude distortion resulting from the electric field in the gaps between the diaphragm and the stationary structures rapidly increasing in accordance with the decrease of the space or distance, so that the movement of the oscillating diaphragm is not proportional to the course of the alternating current of sound frequency supplied to the device.

According to the present invention this drawback is overcome by mechanically stabilizing the unloaded diaphragm which consists of a very light and thin material of great tensile strength, in a manner that the diaphragm will be in a working condition in which the deflections or movements thereof are absolutely or approximately proportional to the variations or fluctuations of the alternating voltage supplied to the device.

A mechanical stabilization of the described kind can be produced in a simple and efficient manner by mechanically stretching the thin and light diaphragm in radial direction so that, when the same is bent out, the retroacting forces existing therein will considerably increase in accordance wih the width or degree of the said deflections or movements. Again, with regard to the resulting force causing the diaphragm to move, the increase of the electrostatic forces which is likewise non-linear and due to the approach of the diaphragm to the nearest adjacent stationary capacity surface, will be compensated thereby. By properly adjusting the degree of the mechanic stabilization so as to adapt the same to the other factors, it is possible to obtain a mutual compensation of the mechanical forces exceeding beyond the linear increase and increasing in accordance with the bending out of the diaphragm, with relation to the electrostatic forces increasing in accordance with the reduction of the gap or space and acting in opposite direction, so that a nearly perfect proportionality of the diaphragm movement and the alternating current supplied to the device.

A further improvement or feature of my invention resides in coating the stationary capacity surfaces of the condenser with an insulating varnish of a high dielectric constant. I am aware of the fact that capacity surfaces of sounding condensers have been coated heretofore for the purpose of avoiding sparking over and short-circuiting in case of contact between the two surfaces. But the coating substances heretofore employed for the stated purpose had a low dielectric constant only. The varnishes or lacquers employed according to the present invention, however, have a dielectric constant above 3. Suitable varnishes of the kind comprise preferably solutions of acetylcellulose or nitrocellulose, but the condensation products of the formaldehyde or of phenols are also suited for the same purpose. Insulating coatings made of the above stated substances involve a better field distribution respecting increase of field intensity in the air gap between the two capacity surface. As in a loud speaker constructed in accordance with the present invention the provision of very high intensities of field is feasible on account of the unloaded arrangement of the diaphragm, the employment of insulating substances such as varnishes or lacquers having a high dielectric constant is a suitable way of further increasing the field instensity independently of the preliminary tension.

With the above recited and other objects in view reference is had to the following specification and annexed drawings in which there are exhibited a few embodiments of the invention which are in no way intended as a limitation upon the scope of the subjoined claims as it is to be clearly understood that variations and modifications which fairly fall within the true scope of the said claims may be resorted to when found expedient.

In the accompanying drawings forming a part of this specification and showing in a somewhat diagrammatic manner and for purposes of exemplification a preferred form or embodiment of my improved loud speaker and the manner in which the invention may be practised, but without limiting the claimed

invention to such illustrative instance or instances.

Figure 1 illustrates the oscillating positions of a diaphragm of a large diameter at unilateral electrostatic energization; Figure 2 shows two curves which illustrate the course or manner of the oscillations of the diaphragm depicted in Figure 1; Figure 3 is a sectional view similar to Figure 1 at bilateral electrostatic energization; Figure 4 shows two curves similar to Figure 2, to illustrate the course or manner of oscillation of the diaphragm depicted in Figure 3; Figure 5 is a perspective view of a sounding condenser constructed in accordance with the present invention; Figure 6 is a vertical section of the condenser shown in Figure 5, taken on the line VI—VI of Figure 5; Figure 7 is a vertical section taken on the line VII—VII of Figure 5; Figure 8 is a vertical section on the line VIII—VIII of Figure 5; Figure 9 is a sectional view of a spanning and stretching frame comprising two annular rings; Figure 10 illustrates, in a sectional view, the manufacture of the perforated capacity body of the condenser inclusive of an auxiliary layer cast integrally therewith; Figure 11 is a fragmentary sectional view of a modified construction and form of the two capacity bodies when made of a suitable insulating material; Figure 12 is a diagram showing the connections required for operating the sounding condenser; Figure 13 is a front view or elevation of the condenser accommodated in a casing serving as a sounding screen; and Figure 14 is a sectional view of the casing shown in Figure 13.

The Figures 1 to 4 serve the purpose of showing the difference between the oscillations of two diaphragms of a large diameter whereof one is arranged so as to be unloaded while the other one is of loaded arrangement, and which are both subjected to the action of a strong electric field with an alternating field superposed thereon, in order to illustrate the occurence of amplitude distortion in the loaded diaphragm.

In Figure 1 the symbol 11 denotes the stationary plate and 12 designates the movable diaphragm of a condenser telephone. The dotted lines show the different positions of the diaphragm 12 depending upon the tension. Figure 2 illustrates the conditions by way of two curves, the curve e indicating the tension and the curve m illustrating the oscillation of the diaphragm, and the effect of disproportionality hereinbefore mentioned, will be apparent from Figure 2. The movement of the diaphragm in dependence upon the alternating voltage e is greater at decreasing distance or gap than at increase of gap.

The Figures 3 and 4 illustrate the bilateral energization of the diaphragms and further show how or that unilateral loading of the diaphragm is avoided by the two plates 13 and 14 provided on both sides of the latter so that the diaphragm is caused to symmetrically move in both directions, the maximum amplitude s_2 in this case being substantially greater than s_1, that is that of the diaphragm shown in Figure 1.

In Figures 5 and 6 showing a perspective view and a cross-sectional view of the sounding condenser, the diaphragm 12 sandwiched between perforated plates 13 and 14. The diameter of the efficient portion of the diaphragm may be between 15 and 60 cm., insulating rings 15 being provided for adjusting the space or gap between the two plates. The peripheral edge of the diaphragm is fixed and clamped between two metallic rings 16 and 17 by means of a series of screws 18 symmetrically disposed in the two rings. The outer edges or faces of the two rings 16 and 17 separately shown in Figure 9 are enlarged to form inner annular flanges 19 and 20 adapted to co-operate to grip and hold the peripheral edge of the diaphragm. Thus it will be seen that when the screws 18 in the radially projecting ridges are tightened the inner ends of the latter will approach each other as indicated by the arrows 21 in Figure 9 and the two rings will be deformed thereby so that the outer flanges or edges of the rings are displaced in inward direction, indicated by the arrows 22, and the inner flanges 19 and 20 are displaced in outward direction as indicated by the arrows 23 in Figure 9. Consequently the diaphragm 12 peripherally clamped between the two rings 16 and 17 will be spanned and stretched in radial direction when the screws 18 are tightened.

The rings 16 and 17 with the diaphragm 12 under tension constitute a body, as shown in Figure 9, which is to be placed between the two capacity bodies 13 and 14. The latter are shaped to form, when composed as shown in Figure 6, a peripheral annular channel 24 for the reception of the rings 16 and 17, a series of symmetrically arranged spanning screws 25 being provided in the one or the other of the two channel-halves, so that upon tightening of the screws 25 the interconnected rings 16 and 17 will be displaced laterally and, therefore, the diaphragm will be subjected to a pulling action in radial direction and further stretched thereby to the desired degree. The diaphragm 12 is not in touch with the two capacity bodies 13 and 14 since two insulating rings 15 are provided between the meeting faces of the capacity bodies with the diaphragm supported therebetween. The spanning screws 25 are equipped with resilient washers 26 below the square heads thereof and adapted to engage in bushings 27 of insulating material provided in the ring 16, as shown, so that the metallic diaphragm and

the capacity body 13 are not electrically interconnected.

The resilient washers 26 are provided for the purpose of exerting a yielding pull on the screws 25 and this pull or draft is transmitted through the rings 16 and 17 to the diaphragm so that any expansions which might occur in the diaphragm in the course of time due to ageing or temperature influences, will at once be compensated.

The two capacity bodies 13 and 14 are interconnected by a system of screws 28 symmetrically arranged so that each single screw 28 will be located midway between two adjacent screws 25. The screws 28 are likewise equipped with resilient washers 29 in the same manner as described with reference to the screws 25. The yielding interconnection of the two bodies 13 and 14 is necessary or advisable, in order that the event of expansion of the diaphragm occurring for the above given reasons, the diaphragm will be allowed to shift between the two insulating rings 15.

The diaphragm 12 is made of a very thin and light material of great tensile strength. I preferably employ a material having a tensile strength of 20 to 40 kg. to the square mm., a specific gravity of up to 3 and a thickness of 25 to 50 thousandths of a millimetre.

The perforated capacity bodies 13 and 14 consist of a moldable material and are manufactured by a casting process with the perforations cast integrally therewith. For the purpose of facilitating the casting operation and attaining a uniform casting, I prefer to cast the capacity body with an auxiliary layer 30 thereon, see Figure 10, which is subsequently removed by machining, as shown.

The material of which the capacity bodies are made, preferably is a light metal or alloy but it goes without saying that they may be made just as well of a moldable or compressible insulating material such as bakelite, porcelain and the like and that in such a case the active surface thereof, that is the surface adjacent to the diaphragm, must be rendered conductive. To this end the said surface is to be powdered with graphite powder and subsequently galvanically coated with copper. The employment of capacity bodies made of an insulating material as above described is preferable for economy's sake, they are less expensive and still can be manufactured with great accuracy as regards configuration and adjustment. Moreover the insulating rings 15 required in case of using metallic bodies, may be entirely dispensed with, if in substitution therefor the inner peripheral edge of the body 13 and 14 is shaped to form an annular projection or rib 31, see Figure 11, for ensuring the gap between the metallic coatings 32 and 33 of the two bodies for the diaphragm 12 to be accommodated therein without contacting with the coatings 32 and 33.

The finished capacity bodies are coated, prior to assemblage, with an insulating material possessing a high dielectric constant, such as a varnish made of acetylcellulose or nitrocellulose. Also condensation products of formaldehyde and phenol may be employed for that purpose. An insulating material of this kind involves a better field distribution with ensuring increase of the field intensity in the air gap between the coatings.

In the front of and a distance apart from the outer surfaces of the perforated capacity bodies 13 and 14 there are firmly attached to the channel-shaped ends thereof protective sheets 36 and 35, respectively, for the purpose of preventing dust from penetrating through the perforations into the air gap. The sheets 36 and 35 constitute very fine thin films preferably made of cellulose or similar matter, and I prefer to fix the said sheets or films by means of resilient split rings 37 and 38 embedded in annular grooves provided for the purpose in the channel-shaped ends of the bodies 13 and 14, respectively, and in which the peripheral edges of the sheets or films have been laid in prior to the insertion of the rings.

The efficiency of the sounding condenser herein described is largely dependent on a suitable electric connection in order that the long way of the diaphragm available in this construction on account of the unloaded arrangement of the oscillating diaphragm, may be utilized. A circuit connection particularly adapted for the said purpose is shown in Figure 12. The two glow cathode tubes 42 and 43 arranged in the usual manner to operate in counter-connection, comprise grids 44 and 45, respectively, to which a voltage increased in accordance with the alternating voltage e applied to the device, is supplied by means of the translator 46, and the anodes 40 and 41 of the tubes 42 and 43, respectively, are interconnected by a lead 47 including the primary of a transformer 48. The latter has a transformation ratio of 1 to 4 and acts to step up the alternating currents flowing in the lead 47 to a voltage adapted for the operation of the loud-speaker. The extremities of the secondary of the transformer 48 are connected with the stationary bodies 13 and 14 of the condenser so that the increased alternating voltages will become active at the bodies 13 and 14 in opposite phase and thence will actuate the diaphragm 12 located therebetween. The diaphragm 12, on the one hand, and the two capacity surfaces 13 and 14, on the other hand, are loaded or charged to a high potential constituting a preliminary voltage, from a voltage source possessing a high internal resistance or provided, in case of a lower resistance, with precursion or additional high resistances 49 and 50. In charging the several members 12, 13 and 14 the one terminal of the source of voltage is

applied to the diaphragm 12 while the other terminal thereof is connected to the circuit 51 acting to interconnect the two stationary capacity surfaces 13 and 14 through the transformer 48, on the said high preliminary charge or voltage at the differential loudspeaker, there are superimposed the alternating voltages of sound frequency so as to generate a variable field adapted to vibrate the diaphragm.

The source of voltage for the preliminary potential may be a continuous current network. In case of alternating current networks, as in Figure 12, a rectifying device is to be provided, including a transformer 52 whereof the primary is subjected to the voltage E of the alternating current network, and the secondary is connected with the cathode of a rectifying tube 55 through a conduit 54 and with the anode thereof through a conduit 53, a condenser 56 being included in the conduit 53. The continuous current voltage to be conducted through the wires 57 and 58 to the sounding condenser in the manner hereinbefore set forth is gathered from the condenser 56.

The continuous current voltage formed at the condenser 56 may be utilized at the same time totally or partially as anode voltage for operating the tubes 42 and 43, by connecting the wire 57 conducting the positive potential, through the conductors 59 and 60 including choking coils 61 and 62, respectively, for the coupling purpose, with the anodes 40 and 41, respectively, of the tubes 42 and 43 and further connecting the wire 58 conducting the negative potential, through the conductor 63 with the cathodes 64 and 65 of the tubes 42 and 43.

For purpose of improving the acoustic properties of the sounding condenser I prefer to enclose the same in a sounding screen shaped to form a frame or casing 66 made of wood, sheet metal or the like, as shown in Figures 13 and 14. The front wall of the casing consists mainly of a spherically curved grid 67 covered with a suitable fabric so as to be pervious to sound, while the rear wall thereof is formed by a flat grid 68. If desired, the casing may be utilized at the same time for the accommodation of the electrical parts or equipment 69 required for the operation of the condenser.

I have herein described and shown only one practical construction of my present improvements, but it will be apparent that the device is susceptible of embodiment in various other alternative forms, and I, therefore, reserve the privilege of resorting to all such legitimate changes as may be fairly embodied within the true spirit and scope of the invention as claimed.

What I claim is:—

1. A sounding condenser consisting in a diaphragm arranged between two perforated rigid electrodes, said diaphragm having a diameter of more than six inches and consisting of a light metal foil having a thickness of 0.025 to 0.050 mm. of considerable durability of more than 20 kilos per sq. mm., said durability being suitable to sustain a very high radial tension, and the perforated rigid electrodes consisting of an insulating material, the surfaces of the rigid electrodes facing the diaphragm being coated with an electrically conducting layer.

2. A sounding condenser consisting in a diaphragm arranged between two perforated rigid electrodes, said diaphragm having a diameter of more than six inches and consisting of a light metal foil having a thickness of 0.025 to 0.050 mm. of considerable durability of more than 20 kilos per sq. mm., said durability being suitable to sustain a very high radial tension, and the perforated rigid electrodes consisting of an insulating material, the surfaces of the rigid electrodes facing the diaphragm being coated with an electrically conducting layer coated with an insulating lacquer.

3. A sounding condenser consisting of a diaphragm arranged between two perforated rigid electrodes, the diaphragm being peripherally fixed between two clamping rings with co-operating inner annular flanges, and means including a system of screws provided for interconnecting the two rings in such manner that the two co-operating flanges thereof are moved outwards and the diaphragm clamped therebetween is stretched in radial direction.

4. A sounding condenser comprising a diaphragm arranged between two perforated rigid electrodes and adapted to communicate on both sides with the air to be agitated, the diameter of the said diaphragm being greater than six inches, a system of screws for yieldingly interconnecting the two perforated rigid electrodes, and a plurality of spherically bent yielding washers for the screws.

5. A method for producing a perforated plate for sounding condensers, which comprises pressing an insulating material into a plate having a layer on one side and a plurality of depressions extending into the plate on the other side, and removing the layer from the plate to a thickness or depth to just cut through the depressions whereby the plate will be provided with the perforations.

In testimony whereof I have signed my name to this specification.

HANS VOGT.