Sept. 6, 1927. 1,641,630

J. B. HAWLEY

SOUND AMPLIFIER

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Fig. 2.

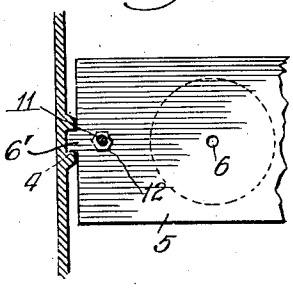

Fig. 1.

Fig. 3.

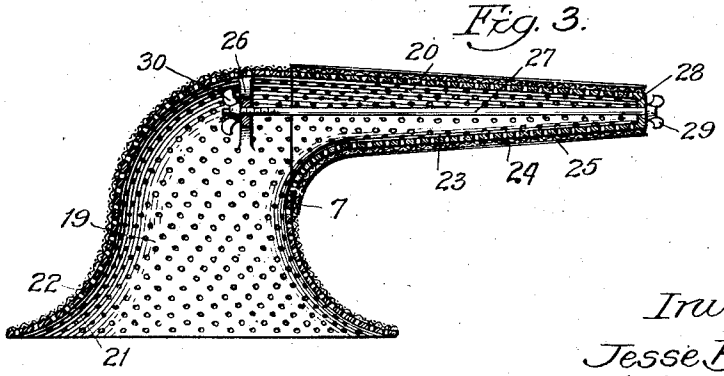

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Fig. 4.

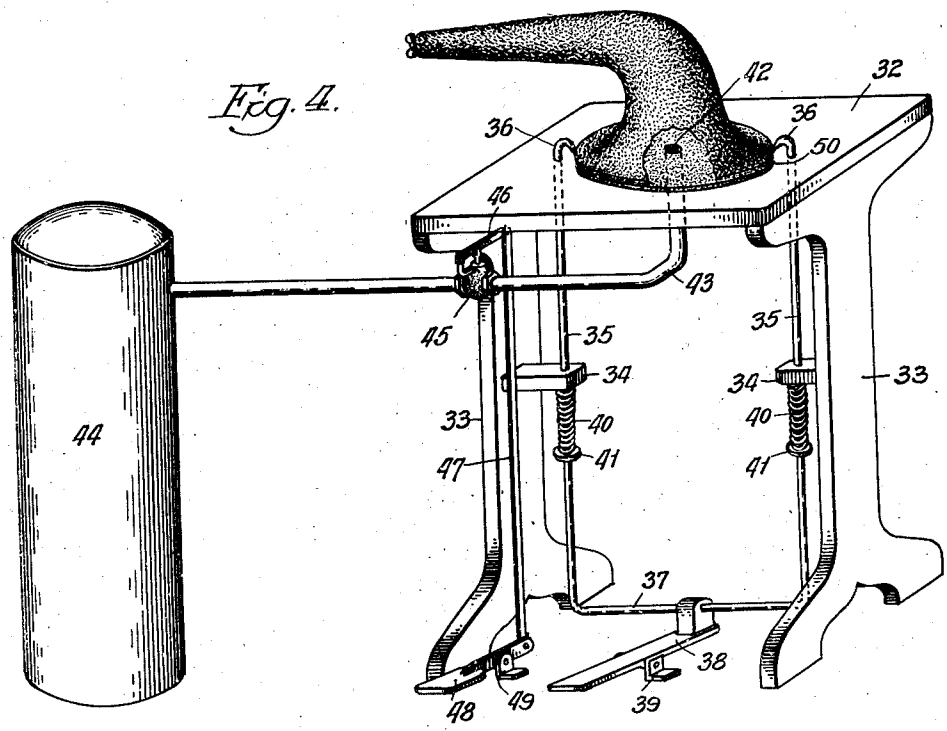

Fig. 5.

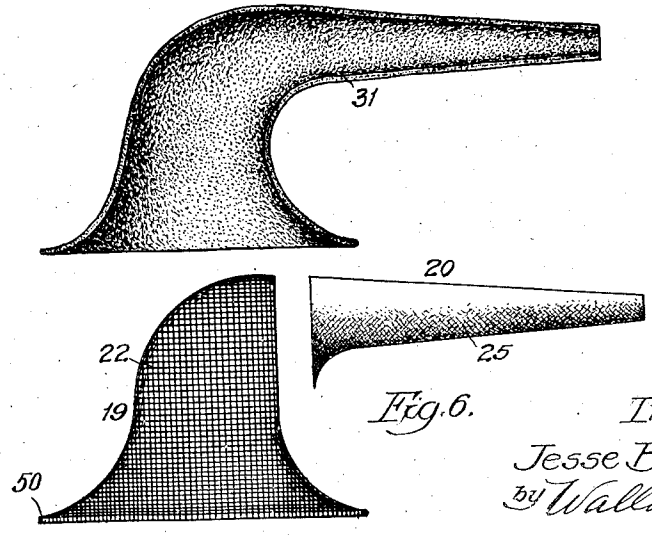

Fig. 6.

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UNITED STATES PATENT OFFICE.

JESSE B. HAWLEY, OF WILMETTE, ILLINOIS.

SOUND AMPLIFIER.

Application filed September 26, 1924. Serial No. 740,009.

This invention relates to sound amplifying horns, particularly adapted for use with phonographs and radio apparatus, and to a new apparatus for making such horns.

The invention embodies certain improvements in the horn disclosed in my pending application Serial No. 620,579, filed Feb. 23, 1923, and in the apparatus therein set forth.

In general, the objects of my invention are to provide a sound amplifying horn which will produce the maximum, uniform amplification of the sound throughout the practical range of vibration of the sound vibrations, with minimum resonance and efficient reflection of the sound waves; to provide a novel process for manufacturing the horns on a commercial scale in a simple, cheap and practical manner and in a manner which readily lends itself to the production of any desired type or design of horn; to provide an improved sound amplifying horn composed relatively of soft material such as accretions of interlaced fiber, preferably, but not essentially, of pulp fiber, wherein the superficial fibers forming the horn walls are impregnated with a hardening agent to render the horn walls substantially non-resonant and more durable; to provide an improved process for making sound amplifying horns such that the density and, or, thickness of the horn wall can be varied at will and particularly a process for forming a horn wall of variant densities; to provide an improved horn made in accordance with such a process; to provide a sound amplifying horn composed of accretions of interlaced fiber, the superficial fibers being harder so that the fiber horn wall comprises an inner zone of relatively soft fibers and outer zone of relatively harder fibers, which construction is most efficient in dampening resonance; to further provide a horn thus constructed and wherein the harder surface fibers are suitably finished to provide smooth sound reflecting surfaces for augmenting the amplification and for rendering the fiber walls more durable; to provide a novel horn as hereinbefore set forth where the horn as thus formed of accretions of interlaced fibers is surface hardened by impregnating the superficial fibers with any desired hardening agent such as liquid glue, rosin, asphalt, drying oils or the like, whereby they are compacted to not only render the horn more durable but also to provide an exterior coating of fiber relatively harder than the central fiber portion of the horn wall; and in addition to render the horn wall surfaces relatively smooth and hard so as to reflect the sound waves emitted from the horn; to provide means for removing the blank from a former wherein such means is provided with holding members or devices such as hooks engaging with the former for holding the same upon the support when the pneumatic pressure is applied to release the blank from the former; to provide an improved surface for the preformed blank by impregnating the surface with suitable substances to provide a hard, finished and compacted surface; to provide for a hard and brilliant surface as above indicated and, further finishing if desired, by stippling the surface material, and then coating with varnish, paint or other substance upon the surface of the blank; to provide a novel construction of former preferably comprising a bell portion and a tone arm portion which may be detachably secured together at the time when the fibrous material is to be interlaced thereon; to provide such portions with preferably inner members of relatively large mesh apertures of perforations and outer members with relatively finer mesh or apertures such that the suspending liquid may readily pass through and be drawn to the interior of the formers under the suction action, the members of the finer mesh holding the fibers to be interlaced thereon to form the blanks; to provide the tone arm portion preferably with an added outer member of still finer mesh and being preferably a covering of linen or similar fabric; and, to provide for such other and further objects, capabilities and advantages as will later appear and are inherently possessed by the invention.

In the drawings, illustrating the invention, Figure 1 is a view partly in vertical elevation and partly in vertical section of the apparatus for forming the blanks upon a plurality of formers; Figure 2 is a detailed and fragmentary top plan view of a part of the same; Figure 3 is a longitudinal sectional view taken through the former with the portions thereof detachably secured together; Figure 4 is a perspective view of the apparatus for loosening or releasing the blanks from the former; Figure 5 is a longitudinal sectional view of a blank; and Figure 6 is a view in elevation of the two por-

tions of the former ready to be attached together.

The elucidation of the novel horn will perhaps be best subserved by a description of the apparatus for making the horn.

Referring more particularly to the drawings, an apparatus for forming the blank is shown in Figure 1 and comprises a container or tank 1 in which may be contained a fluidal mass of fibrous material 2 held in suspension in a suitable liquid, such as water, and in more or less homogeneous condition. Suitable stirring or agitating means is used to maintain a thorough suspension of the fibrous material in the solution. At the upper ends of the walls of the tank inlet conduits 3 are provided through which the fibrous material is fed to the container 1. Upon the end walls of the container are also provided channels 4 which act as guides for a support 5 having end tongues 6' capable of sliding vertically in the tracks 4. The support 5 extends the length of the container and is provided with a plurality of ports 6 over which may be located a plurality of porous horn-shaped formers 7 arranged as clearly shown in Figure 1 of the drawings. The ports 6 are connected to a common conduit 8 to an end of which may be connected a flexible tubing or hose 9 in turn connected to an outlet pipe 10 secured to and passing through an end wall of the container 1. The support 5 is suspended at the lower end of bales 11 secured to the ends of the support by nuts 12 as shown in Figure 1 of the drawings. The center portion 13 of the bale is connected by a link 14 to a hoisting means or block and tackle 15 supported by a hook 16 to an eye bolt 17 fastened to the ceiling 18 of a room. The block and tackle may be operated in an obvious manner for raising and lowering the support 5 from and into the container 1. When lowered into the container 1 the support 5 and the formers 7 thereon, are immersed in the fluidal mass 2. Upon producing a suction by the suction means so that it will be transmitted to the hose 9 and ports 6 into the space interiorly of the formers, the vacuum thus created therein will cause the fluidal mass to press against the exterior of the formers, permitting the liquid or water to pass through the perforations of the former and interiorly thereof and be drawn from the interior thereof into the pipe 8, hose 9 and pipe 10 to be drained away. The amount of fiber deposited upon the formers and the thickness of the fiber accretion may be regulated by the time or duration of the suction action and the amount of vacuum produced within the formers. In order to aid the fibers to suitably interlace on the former, the container 1 is preferably given a vibratory movement as well as the mass therein together with the formers and supports. Due to the suction the fibers will take up a definite relation with each other on the former so that the fibers will be deposited in interlaced accretions whereby to form a horn wall of substantially uniform fiber arrangement and of relatively soft texture which lends itself admirably to the modulation and amplification of the sound waves. It will be apparent that the thickness of the horn wall may be directly controlled by the degree of suction and its duration. And it is further manifest that since the initial stages of the suction are stronger, due to the fact that the pores of the former are less free from clogging the density of the wall will be greater.

The type of former illustrated is preferably made of two portions, one of bell shape or forming a bell portion of the former and the other the tone arm 20 of the former. The bell portion 19 preferably has an inner member 21 provided with relatively large perforations and an outer member 22 of foraminous or reticulated material such as wire mesh of relatively finer openings or meshes than the perforations in the member 21. The tone arm is similarly provided with an inner member 23 having relatively large perforations and an outer member 24 of foraminous or reticulated material such as wire mesh of relatively smaller mesh or openings than the inner member. Upon the exterior of the member 24 is preferably provided a covering or sheathing 25 of fine mesh, such as a strip of linen or like textile fabric. These formers are made in two portions for the purpose of facilitating the removal of the same from the interior of the blank when the blank surrounds the same. These parts are made detachable by providing the bell portion with an ear 26 suitably threaded or perforated to receive a rod 27 which extends longitudinally through the tone arm and through an end wall 28 thereof and threaded to receive thumb nuts 29 and 30. By placing the two portions of the former together and with the rod 27 extending through the ear 26 and the end member 28 the thumb nuts may then be threaded in place and tightened so as to securely hold the tone arm to the bell portion rigidly.

A plurality of these formers may be placed upon the support 5, as shown, with the tone arms extending laterally, as shown in Figure 1 of the drawings. The formers shown in this figure are in transverse section through the bell portion of the formers.

The gradual accretion of the fibers on the porous former produces the roughly shaped horn 31 as shown in Figure 1 of the drawings. The formers are now raised out of the liquid and the suction continued until the fibers are consolidated, and slightly dried.

At this stage the horns may either be smoothed as by hand rolling, to shape them more symmetrically and eliminate the rugosities, or they may be rolled with wheels having designs on their peripheries, or the horns may be left naturally rough. In some instances the horns may be subjected to a compacting, smoothing pressure by means of pneumatic rubber bags in the form of a two-part horn-shaped mould. In this case the horn is placed within the mould sections and the air pressure turned on to inflate the rubber bag sections of the mold to press the mold walls against the horn. Preferably this operation is assisted by suction. The suction being turned on after the bag mold is placed in position, which increases the sucking head and permits less bag pressure since the pores of the fiber horn are substantially closed by the rubber bag. If desired, the horn may be given any suitable design by forming the bag walls with such a design.

The horn is now ready for drying. Heretofore, it has been customary to place the blank, still on the former, in an oven or other heating apparatus. This necessitated a large number of formers. In lieu thereof the fiber horn is removed from the porous former and placed on a single drying form during the drying operation. This is cheaper because it requires fewer formers to be used.

Means is provided for quickly stripping the fiber horn from the porous former. Such means is shown in Figure 4 of the drawings. It comprises a table 32 having supporting legs 33 and brackets 34. In the brackets 34 are slidably mounted shanks 35 of hooks 36 extending above the table 32. The lower ends of the shanks 35 are connected by a cross rod 37 passing through a pedal 38 pivotally supported in floor brackets 39. Coiled springs 40 may be interposed between the brackets 34 and collars 41 secured to the shanks 35. By operating the pedal 38 the hooks 36 may be moved upwardly over the table 32 and upon releasing the pedal the springs 40 will operate to lower the hooks. In the center of the table 32 is provided a port 42 to which is connected a pipe 43 leading to a pressure tank 44 or other suitable source of air pressure, the pipe 43 being provided with a control valve 45 having an operating lever 46 connected by a link 47 pivotally connected to a foot pedal 48 pivotally supported in floor brackets 49. By operating the pedal 48 the valve 45 may be opened or closed to permit the pressure of air to pass through pipe 43 and port 42. In the operation of this device a former with a blank is placed upon the table 32 and the hooks 36 made to engage with the marginal portions of the former, such as the edge 50 of the bell portion thereof. Releasing the pedals 38 will permit the spring 40 to hold the hooks in place and hence the former upon the table. The springs 40 are sufficiently strong to hold this in place for this operation. Inasmuch as the fibers are more or less intimately in engagement with the mesh of the outer members of the former, it is ordinarily difficult to remove the blank from the former. In this invention this is easily effected by opening the valve 45 and permitting air pressure to be admitted into the interior of the former and blank. This pressure immediately slightly extends the horns, thus releasing the internal fibers of the blank from the wire mesh of the former. Inasmuch as the covering 22 is of finer mesh the tone arm portion will be easily removed by reason of there being less intimate engagement between the internal fibers of the horn and this part of the former. After the horn had thus been loosened or released, the foot pedal 38 may be operated to release the hooks 36 from the former and the thumb nuts 29 and 30 removed from the rod 27 so that the bell portion 19 of the former may be removed from the interior of the larger end of the horn. With this bell portion removed the tone arm portion may then be withdrawn toward and through the larger portion of the horn, thus leaving the horn in self-supporting and self-sustaining condition. The horns may be dried in open air or in an oven with or without heat and with or without more or less moisture content in the atmosphere or surrounding air of the horns.

The fiber horn is next given a surface smoothing operation, in which the edges of the horn mouth are sanded to smooth them and if the horn is to be of smooth finish, the horn walls both inside and outside are also given a sanding operation. In addition the stem of the horn is fitted for the ferrule.

The horn is now ready for the surface hardening treatment. This consists of a chemical treatment of the superficial fibers of the horn wall to harden them and give them tensile strength. Preferably this is accomplished by immersing the horn in the desired substance. In the present instance the horn is dipped in a vat of glue for a desired length of time suitable to impregnate these fibers, the impregnation extending substantially one-sixteenth to one-thirty-second of an inch. This treatment not only hardens these fibers but also compacts them and lays the fibers better. In lieu of liquid glue, rosin, asphalt, drying oils or equivalent substances may be used. After gluing, the horn is dried and is then again sanded to smooth condition, the ferrule is positioned and the horn is then given a surface finishing treatment, as, for instance, by stippling, and painting or by shellac, varnishing or the like to give the horn walls a hard smooth

finish best suited for reflecting the sound waves and for preventing the absorption of the sound.

Rather recent acoustical researches and investigations have shown that the modification, distortion or other alteration of the true sound waves emitted by the diaphragm are the result of causes other than the resonance of the sound horn itself. It has been found that irrespective of the resonance of the horn or diaphragm there is another tone produced by any particular horn which tone varies with each material and is due directly to the material itself. In order to properly identify this characteristic tone modifying property of the horn wall I have termed it persistency. Investigational measurements of this characteristic have shown that this effect is directly proportional to the density of the material used in the horn and is independent of shape or size of the amplifying horn. It is also dependent upon the thickness of the horn walls; by varying the thickness of this wall or different portions thereof, it is possible to increase or decrease the effect at will. Furthermore, by varying the density of different portions of the horn wall, various effects of modifications of persistency can be secured, such for instance as varying the ratio of the relatively soft center to the harder exterior wood. These investigations have proven that persistency or variation of the true sound waves emitted by the diaphragm by the horn itself, is much less in a horn composed of interlaced fiber and especially one wherein the outer fibers are compressed or compacted, than in the case of metallic horns, wooden horns or compressed fibers. These results have been confirmed by actual use of a horn constructed in accordance with this invention which makes it quite obvious that with such a horn the music or speech is comparatively easier to listen to over a period of time and does not become tiring to the listener as in the ordinary commercial horn. Hence it must be manifest that the foregoing process is most peculiarly adapted to the production of sound amplifying horns. And this is directly due, first to the manner in which the horn is formed, that is, by accretions of interlaced fibers on a preformed mold or former, whereby a horn wall of any desired thickness may be obtained and wherein a horn wall of any desired degree of density may be secured or wherein a horn wall of varying degrees of density in different portions thereof may be obtained; and it must also be apparent that by reason of this process a horn of any desired shape or configuration may be quickly and cheaply made. Also, by reason of the construction of the inner horn walls being of relatively soft texture a horn is produced which considerably modulates the tonal qualities of the sound and tends to eliminate sustained resonance. The adaptability of the foregoing process is also due to the impregnation of the superficial fibers of the horn walls with the hardening and compacting substance, such as glue, whereby exterior layers or strata of harder, denser fibers are provided enclosing the central relatively softer fibers. This combined relatively soft and relatively hard wall construction still more reduces sustained resonance, since any vibrations which tend to be set up in the wall are substantially at once damped out by these alternate layers. This aids, much, in maintaining an even range of amplification. In addition, in those horns which are given the smooth, hard polished finish on the exterior surfaces of the walls, the reflection of the sound waves is considerably augmented. This also assists amplification and also increases the durability and strength of the horn.

In some instances instead of compacting the outer fibers of the horn wall by impregnation with liquid glue or the like, a somewhat similar tonal quality can be secured by forming the walls of an inner layer of pulp fiber and outer layers of ground leather. The latter is hard and provides a hard compact surface wall for the horn. The pulp fiber and ground leather are preferably formed by suction. The leather is first sucked on, then the pulp and then the leather, to provide an even softer zone enclosed by harder zones.

While I have herein described and upon the drawings shown one way of carrying out the invention, it is to be understood that the invention is not limited to the particular details, construction and arrangement of parts described and shown, but that the invention comprehends other constructions, details and arrangements of parts without departing from the spirit thereof.

Having thus described my invention, I claim:

1. A sound amplifying horn having walls composed of accretions of interlaced fibers, the superficial fibers of the horn walls being compacted and hardened by impregnation with a suitable material.

2. A sound amplifying horn having walls composed of accretions of interlaced fibers, the fibers of the horn walls being impregnated with a fiber hardening and compacting material.

3. A sound amplifying horn having walls composed of accretions of interlaced fibers, the superficial fibers of the horn walls being impregnated with liquid glue to harden and compact the same.

4. A sound amplifier horn composed of interlaced fibrous accretions, the superficial fibers being impregnated with a suitable liquid.

5. A sound amplifier having its walls composed of accretions of interlaced fibers, the superficial fibers forming the inner and outer surfaces of the horn walls being compacted whereby to provide a horn wall having in cross-section a relatively soft fiber zone surrounded by relatively harder fiber zones.

6. A sound amplifier having its walls composed of accretions of interlaced fibers, the superficial fibers forming the inner and outer surfaces being harder than the intermediate fibers whereby to substantially dampen resonance and provide durability.

7. A sound amplifier having its walls composed of accretions of interlaced fibers, the superficial fibers forming the inner and outer surfaces being impregnated with glue-like material.

8. A sound amplifying horn having walls composed of accretions of interlaced fibers, the superficial fibers of the walls being impregnated with a compacting and hardening agent and suitably smoothed to form efficient sound reflecting surfaces.

9. A sound amplifying horn having walls composed of accretions of interlaced fibers, the superficial fibers of the walls being impregnated with glue-like material and suitably smoothed and provided with a coat of finishing material.

10. An accoustic horn comprising walls composed of accretions of interlaced fibers, the accretions of fibers being of different densities at different points between the inner and outer surfaces of said walls.

11. An accoustic horn comprising walls composed of accretions of interlaced fibers, the accretions in one zone having a different density than the accretions in another zone.

12. A horn comprising walls composed of accretions of interlaced fibers, the accretions in various parts of the horn having different densities, and a surface of the horn being compacted to produce a hard, efficient sound reflecting surface.

In witness whereof, I hereunto subscribe my name to this specification.

JESSE B. HAWLEY.