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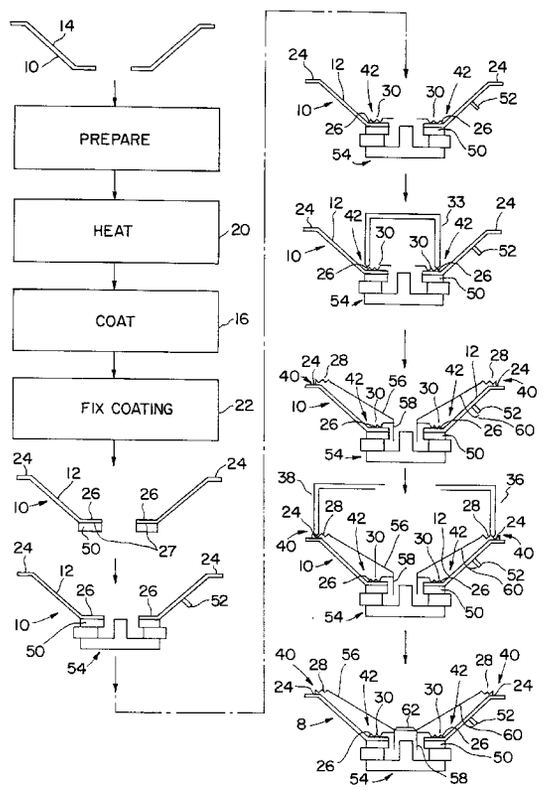
(71) Applicant : **HARMAN INTERNATIONAL INDUSTRIES INCORPORATED**
**8500 Balboa Boulevard,**
**P.O. Box 2200**
**Northridge, California 91329 (US)**

(72) Inventor : **Mango, Louis A. III**
**103 Grouse Drive**
**Trafalgar, Indiana 46181 (US)**
Inventor : **Auerbach, Richard E.**
**10958 Spring Mill Road**
**Carmel, Indiana 46032 (US)**

(74) Representative : **Allen, William Guy Fairfax et al**
**J.A. KEMP & CO.**
**14 South Square**
**Gray's Inn**
**London WC1R 5LX (GB)**

## (54) Method of manufacturing speakers and speakers made by the method.

(57) A method of assembling a speaker having first (10) and second (28, 30) components comprises coating at least selected areas of the first component (10) with a heat sensitive coating (12), applying heat (36, 38) to at least one of the first (10) and second (28, 30) components in areas where the first (10) and second (28, 30) components are to be assembled to activate the heat sensitive coating (12) and bringing the first (10) and second (28, 30) components into contact while the heat sensitive coating (12) is activated to assemble them (10, 28, 38) together.

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## Technical Field

This invention relates to improvements in the construction of transducers. It is disclosed in the context of loudspeakers, but is believed to be useful in other applications as well.

## Background Art

Presently, metal speaker frames are plated or painted before the assembly of the moving loudspeaker components, diaphragm and voice coil, surround, and spider, into them. Then the moving components are added, illustratively by attaching them using adhesives. The painting and plating processes are not as environmentally friendly as other protective coating or treating techniques. Typically the adhesives used in the assembly of speakers also contain solvents, the release of which during adhesive curing raises environmental concerns as well. Additionally, the application and curing of adhesives to couple the speaker frames and moving components requires additional process steps which have attendant process tolerances and failure rates. For example, a speaker frame to which adhesive has been applied may have to be set aside for a period of time until the adhesive reaches the appropriate tackiness for subsequent process steps to be conducted. This results in additional work in process.

Additionally, the adhesives are difficult to apply completely uniformly around surfaces requiring them, resulting in thicker applications of adhesive at some places and thinner applications at others. Of course, in order to assure at least a minimum application of adhesive at any point around the frame, excess adhesive results at other locations around the frame. This means not only waste in the excess amount of adhesive added to the other locations around the frame, but also complications in the curing of the excess adhesive, possible interference of the excess adhesive with the proper orientation and/or operation of the assembled speaker, and the excess volatile components of the excess adhesive needing to be dealt with environmentally during the curing process. Excess adhesive can also result in adhesive "squeeze out" rejection of assembled speakers, notably in the coupling of the surround or compliance to the frame. Non-uniform application of adhesive to the frame can affect system alignment and contribute to so-called "rub-buzz" rejection of assembled speakers.

## Disclosure of the Invention

According to the invention, a method is provided for assembling a speaker having first and second components. A heat sensitive coating is applied to the first component. If it is necessary or desirable to do so, the heat sensitive coating can be fixed on the first component. This fixing can be accomplished by the application of heat to the first component either before or after application of the coating, or both, if necessary. The second component is assembled to the first component, for example, by heating the second component and pressing it into intimate contact with the coated first component, or by applying heat selectively to the heat sensitive coating in areas of the first component where the second component is to be coupled to the first component, to activate the heat sensitive coating and couple the second component to the first component in those areas.

According to illustrative embodiments of the invention, the heat sensitive coating, comprises a powder coating or pressure molded overcoat. The step of fixing the heat sensitive coating on the first component comprises the step of applying heat to the first component to which the heat sensitive coating is applied to fuse the heat sensitive coating and render it substantially continuous over the first component.

Additionally illustratively according to the invention, the first component is susceptible to corrosion, for example, oxidation. The step of coating the first component with a heat sensitive coating comprises the step of coating the first component with a heat sensitive, corrosion-inhibiting coating.

Further, illustratively according to the invention, the second component comprises at least one of a diaphragm surround, spider, terminal board, front plate, pole plate or magnetic structure.

According to an illustrative embodiment, the step of applying heat to the heat sensitive coating in areas of the first component where the second component is to be coupled to the first component comprises the step of applying heat to the outer perimeters of the spider and surround to couple the outer perimeters of the spider and surround to the first component.

Illustratively, the first and second components, for example, a front plate and a speaker basket or frame, can be heated while they are in contact with each other to activate a heat sensitive coating previously applied to one or the other or both of them. Or, one of the first and second components, either a previously coated one or a previously uncoated one, can be heated and then pressed against the other component.

## Brief Description of the Drawings

The invention may best be understood by referring to the following description and accompanying single drawing which illustrates the invention. The drawing illustrates the various steps of a process conducted according to the invention, as well as a product made according to the process.

## Modes of Carrying Out the Invention

Referring now to Fig. 1, a loudspeaker 8 stationary component, a supporting frame or basket 10, is cast, stamped, or otherwise formed from a suitable material. Examples include stamped steel, cast aluminum and various cast or molded filled and unfilled resins. In many cases, such as when the stationary component 10 is constructed from steel or aluminum, it is subject to corrosion by, for example, oxygen in the air or chemicals in an environment. In others, such as when the stationary component 10 is constructed from certain filled or unfilled resins, corrosion is not a significant concern. However the stationary component 10 is formed, and from whatever material(s), it is coated with a heat sensitive coating 12. The coating 12 can be, for example, thermoplastic, and can be applied as a liquid by spraying the coating directly onto selected ones of the stationary component 10's surfaces 14. The coating can also be a plastic or rubber overcoat, or the like, molded on to surfaces of the component 10 by process techniques such as transfer or injection molding. The coating 12 can also be a powdered coating which is rendered fluent, for example, by the use of a fluidized bed 16. In this case, the stationary component 10 can be immersed in the bed 16 of fluidized powder coating and the coating deposited upon the stationary component 10 immersed in the bed 16, or the powder can be transported from the bed 16 to a powder spray apparatus which dispenses the fluidized powder onto the stationary component 10, using electrostatic or non-electrostatic powder coating application techniques.

In any event, the coating 12 can, if required, be fixed to the surfaces 14 of the stationary component 10 to form a substantially continuous protective and bonding layer. If the coating 12 has been applied in liquid form, this fixing step can be conducted simply by permitting the coating 12 to air dry. Alternatively, an oven 22 drying may be conducted. If a powder coating 12 is employed, fixing may be conducted by heating 20 the stationary component 10 after introduction of the stationary component 10 into the fluidized bed 16 or spraying of the heat sensitive powder onto the surfaces of the stationary component 10 making the coating 12 more or less continuous and uninterrupted, particularly in the area(s) 24, 26 and 27 where moving component(s) of the speaker 8, for example, the surround 28 and the spider 30, will subsequently be coupled to the stationary component 10, and where the front plate 50 will be coupled to the stationary component 10.

Next, the moving component(s) 28, 30 is (are) assembled into the stationary component 10 and heat is applied to the fixed heat sensitive coating 12 selectively in areas 24, 26 of the stationary component 10, here at the perimeters of the spider 30 and surround 28, where the spider 30 and surround 28 are to be coupled to the stationary component 10. The heat sensitive coating 12 is thereby reactivated in these areas 24, 26 and the moving components 28, 30 are coupled to the stationary component 10 in those areas 24, 26. In the illustrated embodiment, heated staking irons 36, 38 are pressed against the perimeters 40, 42 of the surround 28 and spider 30 and the areas 24, 26 of the heat sensitive coating 12 on the stationary component 10 is activated beneath these areas 40, 42 of application of heat. The heated coating 12 flows into the interstices of the surround 28 and spider 30 and is permitted to cool there, coupling the perimeters 40, 42 of the surround 28 and spider 30 to the stationary component 10 in these areas 24, 26.

## Industrial Applicability

Low density polyethylene (LDPE) was placed in a fluidized bed 16 at room temperature 22°C. About fifty 6.35 cm diameter stamped steel speaker frames 10 were cleaned, iron-phosphate treated and preheated in a gas-fired oven 20 set to about 345°C. The preheated frames 10 were hung on wire hooks and, while still hot, immersed in the fluidized bed 16 for times ranging from one to five seconds, with three seconds appearing to provide the optimum compromise between complete coating and coating uniformity. On removal of the frames 10 from the fluidized bed 16, they were held suspended for one or two seconds and then tapped against the bed 16 tank to return non-adherent powder to the bed 16.

Fixing of the coating 12 to the frames 10 was completed by a post-bake in oven 22. The three second exposure in the fluidized bed 16 yielded a coating 12 after processing with a thickness of about 8 mils (about 0.2mm). The thus-prepared speaker baskets 10 were then assembled into speakers 8. Motor assembly front plates 50 were heated and pressed onto the frames 10. Terminal strips 52 permitting connections to be made to the speaker 8 motors were staked onto the frames 10. The remaining stationary elements 54 of the motor structure were assembled to the front plate 50 using an activated adhesive. The perimeter 42 of the spider 30 was then heat staked to the coating 12 on the back flat 26 of the speaker basket 10. The perimeter 40 of the surround 28 was then heat staked to the coating 12 on the front flat 24 of the speaker basket 10.

The rest of the speaker 8 assembly, gluing the apex of the diaphragm 56 to the coil form 58, electrical connection of the voice coil leads 60 to the terminal strips 52, gluing the coil leads 60 and dust cap 62 to the diaphragm 56, and magnetization, were then conducted according to established techniques.

Other materials with similar characteristics will be apparent to those skilled in the art. In the practice of this invention, these materials are applied to the entire surface 14 of the basket 10, or to a selected por-

tion thereof, by powder coating, insert molding, extrusion coating, sheet lamination, or other suitable application technique. The resulting coating is in the broad range of about 0.0005 to 0.010in. (about .01 mm to about .25 mm) thick and protects the basket 10 from corrosion, taking the place of painting or plating. Moving components 28, 30 and stationary components 50 are brought in contact with the coated surface 14, before or after heating, and through the proper application 36, 38 of heat and pressure, are fused onto the speaker frame 10. Upon cooling, a functional assembly results, and the need for separate adhesives and bonding operations is eliminated. Various heating techniques are quick, reliable and effective for high volume manufacturing, including, but not limited to, heat staking and induction heating. Since the coating 12 is thermoplastic, existing component 28, 30, 50-to-basket 10 bonds may be heated for re-work purposes, if necessary, and then re-assembled.

Among benefits of this process are its: elimination of metalware painting and/or plating; elimination of the surround-to-frame and spider-to-frame assembly adhesives and their attendant problems; elimination of any need for motor assembly front plate-to-frame sound deadening material; elimination of metal staking of the motor assembly to the frame, a known source of chip contamination; provision of electrical insulation of the frame from motor assembly components; rapid curing of the coating after the frame is removed from the heat source, eliminating "stacking-off" of work in process to wait for adhesives to become tacky or cure completely before a subsequent assembly step can be undertaken; use of zero percent solvents coatings, reducing costs associated with coating and eliminating costs associated with adhesives and capture and treatment of coating solvents and adhesive solvents; improvement of speaker component alignment, since moving components are coupled directly to frame surfaces without the interposition of adhesive beads; improved environmental, for example, salt spray, tolerance of the speaker assembly; and, potentially, elimination from some speaker designs of a speaker-to-baffle mounting gasket.

## Claims

1. A method of assembling a speaker having a speaker frame for supporting moving components of the speaker, the moving components including a diaphragm and at least one of a surround and a spider for connecting the diaphragm to the frame, and the method comprising the steps of applying a thermoplastic powder coating over substantially the entire surface of the frame, assembling the at least one of the surround and spider to the frame, and applying heat to the thermoplastic powder in areas where the at least one of the surround and spider is to be coupled to the frame to activate the thermoplastic powder and couple the at least one of the surround and spider to the thermoplastic powder in those areas.

2. The method of claim 1 and further comprising the step of fusing the thermoplastic powder on the frame.

3. The method of claim 2 wherein the step of fusing the thermoplastic powder on the frame comprises the step of applying heat to the frame.

4. The method of claim 1 wherein the step of applying heat to the thermoplastic powder coating in areas where the at least one of the surround and spider is to be coupled to the frame comprises the step of contacting the at least one of the surround and spider with a heat staking iron for a time and with a force sufficient to activate the thermoplastic powder coating in those areas where the at least one of the surround and spider is to be coupled to the frame.

5. The method of claims 1, 2, 3 or 4 wherein the step of assembling the at least one of the surround and spider to the frame comprises the step of assembling a terminal board to the frame.

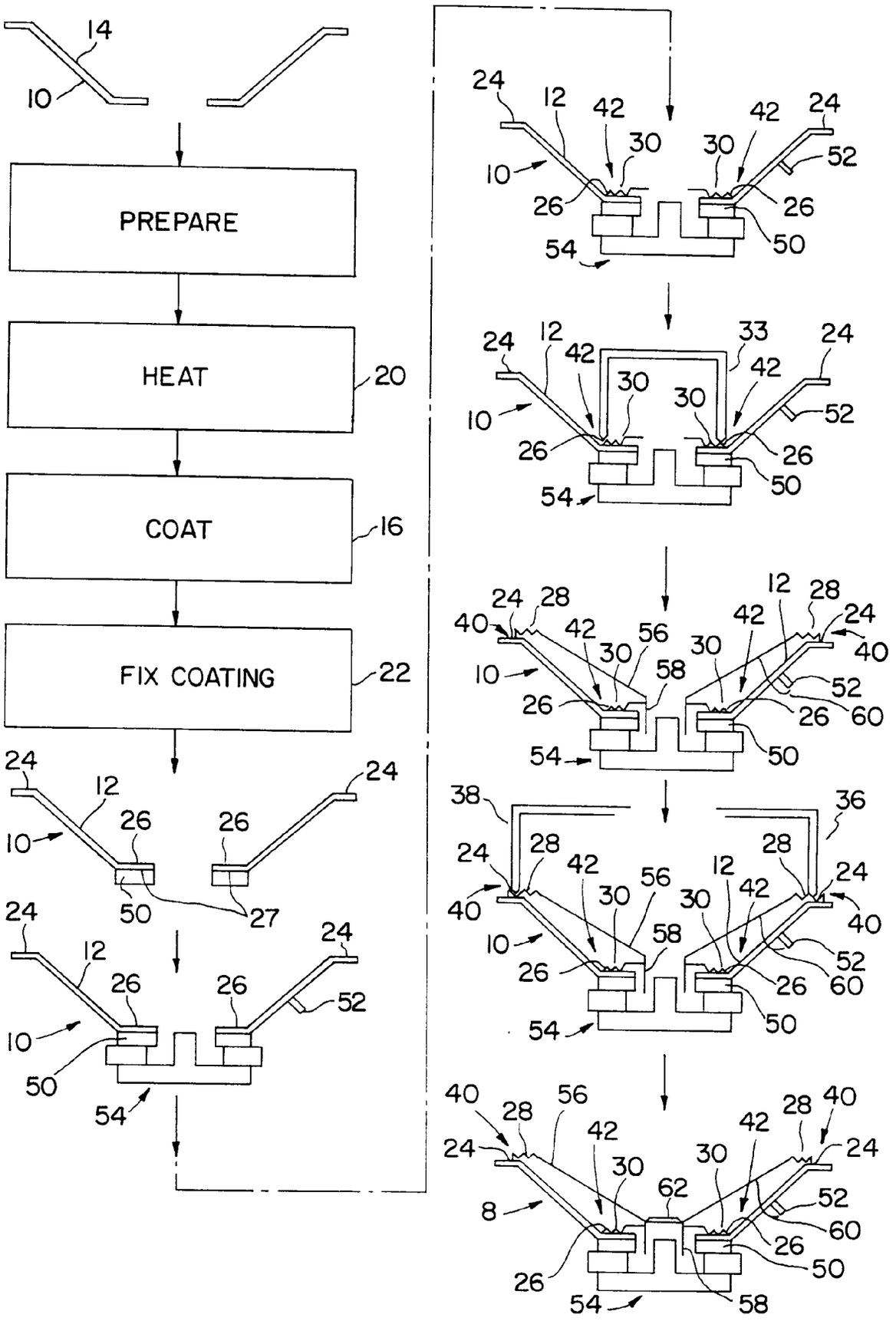
6. The method of claim 5 wherein the step of applying heat in areas where the at least one of the surround and spider is to be coupled to the frame comprises the step of applying heat to the perimeter of the at least one of the spider and surround to couple the perimeter of the at least one of the spider and surround to the frame.

7. The method of according to any preceding claim, wherein the step of applying a thermoplastic powder coating to the frame comprises the step of applying a corrosion-inhibiting thermoplastic powder coating to the frame.

8. The method of claim 7 wherein the thermoplastic power coating is a fluent thermoplastic powder coating.

9. The method of claim 8 and further comprising the step of applying heat to the frame to fuse the fluent thermoplastic powder coating and render it substantially continuous over the frame.

10. A speaker produced by the method of any preceding claim.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# EUROPEAN SEARCH REPORT

Application Number
EP 94 30 8879

## DOCUMENTS CONSIDERED TO BE RELEVANT

| Category | Citation of document with indication, where appropriate, of relevant passages | Relevant to claim | CLASSIFICATION OF THE APPLICATION (Int.Cl.6) |
|---|---|---|---|
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The present search report has been drawn up for all claims

| Place of search | Date of completion of the search | Examiner |
|---|---|---|
| THE HAGUE | 21 March 1995 | Gastaldi, G |

CATEGORY OF CITED DOCUMENTS

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