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DUPLICATE SOUND RECORD AND PROCESS OF MAKING THE SAME.

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This invention relates to improved, duplicating sound records, tablets, disks or other bodies to be used in sound recording and sound reproducing machines, one object of this invention being to produce records with sound waves impressed thereon and therein, irrespective of the type or depth of the record grooves.

The application of this invention is not limited to any particular shape or size of article to be coated, but will be described as applied to producing a substantially permanent copy of the ordinary disk record for phonographs (or graphophones).

In its broad interpretations, my improved process may be described as employing a suitable foundation or base with a relatively thin layer or layers thereon, of record material having ingredients differing from the characteristic elements of the base, which layers are united firmly and integrally to each other, and to said base.

More specifically, my improved process consists in placing upon a fibrous or non-fibrous, non-thermoplastic core or base, a relatively thin layer or plurality of layers of a composition containing a thermoplastic combination of inorganic esters of cellulosic bodies as the nitrated celluloses. Between the substantially non-thermoplastic foundation and the cellulose ester coating composition or compositions, I may apply what may be termed a "filler" or "sizing" for the purpose of filling the pores or interstices of the base, one object of such application being to reduce the quantity of relatively expensive cellulose ester composition required to impart the result desired.

Sound records made by my improved process are superior in that the obtained impression is provided with a true cast surface, the material having no tendency to alter in composition, condition or form, and therefore retaining the record impression unimpaired in accuracy and tonal qualities for an indefinite period; and furthermore that the record may be made of less thickness and lighter weight than has been customary heretofore, with perfectly solid and homogeneous walls, there being no observable tendency in the finished record to crack, flake, peel or warp, or to soften at normal summer temperatures.

By my process, I am able to produce a record which combines the desirable properties of flexibility, toughness, elasticity, resiliency, water-insolubility and relative non-inflammability, possessing also great strength and hence satisfactory wearing qualities coupled with desirable acoustics and sound reproduction properties.

Shellac at the present time is employed in large quantities in this art, but it has its limitations. Shellac possesses the desirable property of thermoplasticity, softening at a temperature slightly above the temperature of boiling water and being sufficiently rigid at ordinary atmospheric temperature to render sound waves impressed thereon, quite durable. But shellac is a natural product of uncertain and varying composition, and on this account is subject to extensive adulteration. It must be imported from long distances and is prone to market manipulation. In recent years the cost of shellac has risen to a point where its continued use is almost prohibitive, and forms a menace to the continued expansion of the phonograph record industry.

While many substitutes for shellac have been brought forward, the majority of these are deficient in the desirable property of thermoplasticity, or are obtainable in insufficient commercial quantities and at a prohibitive price.

Synthetic resins, as the phenol-aldehyde condensation products while admirably adapted for general molding purposes, when used as phonograph masses require too long a time in the impression molds to render their use in sound records useful on account of materially diminished speed of production.

Solid composition records, from the relatively large amounts of barytes, and other fillers normally contained therein of high specific gravity, result in the formation of a record of considerable weight, necessitating high transportation charges in marketing the product.

Heretofore it has been usual to place the title of a phonograph record upon the same by a separate operation, or, less frequently by stamping the same upon the finished record. It is obvious, that the only portion of the record which may be used for this purpose, is that relatively smaller central por-

tion carrying no sound wave impressions. This portion is ordinarily of sufficient area to receive only the title of the selection and the catalogue number of the reproduction.

The disadvantages hereinbefore mentioned are substantially non-existent in the phonograph record material and phonograph records produced by my improved process, which may be described as consisting of a light-weight foundation, a sizing layer (if used) placed upon one or both sides of said foundation; an intermediate, highly thermoplastic cellulose ester layer superposed upon the foundation, or upon the sizing which has been placed upon the foundation, if sizing has been used; and a surface coating or coatings of cellulose ester of diminished thermoplasticity relative to the intermediate cellulose ester layer; said surface coating composition giving a hard, tough, durable exterior, admirably adapted to successfully withstand long continued usage.

As a base or foundation for phonograph record manufacture, I preferably employ a compacted body of fibrous or non-fibrous material substantially non-thermoplastic, and which is suitable to receive thereon and therein, the composition or compositions about to be described, and satisfactory for the purposes intended. The foundation if of, or similar to, pasteboard, cardboard or laminated cellulose material, is preferably previously compacted and the major portion of the moisture and volatile matter contained therein, removed by evaporation at ordinary or elevated temperatures, and in any suitable manner. One or both sides of the foundation may have printed or illustrated thereon, in monochrome or polychrome, information of any kind or character, said printing, or illustrating, or both, covering the entire or as much of the foundation surface as desired. This information may be placed on the foundation by printing or photographically, or otherwise.

Upon the foundation, for purposes of economy or otherwise, I may place a suitable sizing composition for the purpose of filling the pores or interstices of the foundation, any sizing being suitable which will penetrate the foundation substance, dry at a moderately elevated temperature, and leave as a layer, a non-hygroscopic material upon which the supernatant layer or layers may anchor satisfactorily. As an example, I have found casein preparations suitable for this purpose. The sizing may be applied in any suitable manner, mechanically or by hand, and the volatile portion contained therein allowed to evaporate spontaneously or with assistance, as by artificial heat. The sizing or filling composition must be transparent or nearly so that there may be no serious interference with the clearness or legibility of the printed or illustrated matter placed on the foundation, upon examination of the finished record.

The sizing should also be practically insoluble in the volatile solvents employed in the subsequent (intermediate and surface) coats, that is, the sizing (when used) should function as a protective or "buffer" layer, between the foundation and the intermediate and surface layer cellulose ester compositions.

My researches have demonstrated to me, that it is preferable ordinarily, to place upon the sized or filled foundation, first a composition in one or more coats relatively high in thermoplasticity, following this with a surface composition in one or more coats, which is relatively low in thermoplasticity and harder, tougher and more resistant to wear than is the intermediate cellulose ester layer. By manipulating the coatings or layers in this manner, I am able to obtain a high degree of thermoplasticity or moldability, coupled with great toughness and long wearing qualities, and at the same time produce an apparently unitary composition, —at least a composition, so far as observable, of entire homogeneity.

As an intermediate coating, I have obtained satisfactory results by employing a highly thermoplastic nitrated cellulose composition, dissolved in volatile and suitable solvents and solvent combinations now known, which solution of thermoplastic nitrated cellulose may be applied to the foundation, or sized foundation in a single or plurality of coats, being applied by brushing, by rolling, by a doctor blade, by immersion or otherwise, the volatile portion being allowed to evaporate in any suitable manner, spontaneously or otherwise. I do not confine myself to a particularly named nitrocellulose plasticizer, but to a nitrocellulose combination high in thermoplasticity. The nature and amount of plastifier employed will depend upon the solubility, viscosity and other physical characteristics of the nitrated cellulose employed, and the ratio of solvent to non-solvent portion in the volatile solvent combination used to dissolve the thermoplastic nitrocellulose, as well known to those skilled in the art. Whether it is advisable to employ one or more coatings in this intermediate layer, will depend upon the total solids (nitrated cellulose and plastifier) in the composition used, and the depth of the individual coatings placed upon the base. Manipulation will also be varied depending upon the amount and nature of the plasticizing body or bodies associated with the esterified cellulose, and the percentage of non-evaporable solids in the intermediate coating composition. In general, however, the intermediate and surface coating compositions are adjusted, that the total thickness of the same will be measureably greater than the depth

of the sound record undulations, so that, upon subjecting the coated foundation to the usual pressure and heat treatment process for sound record impression, the phonograph matrix will not appreciably cut into the foundation or foundation sizing, and a record of substantially maximum thermoplasticity, and maximum permanency and exterior toughness will result.

After the application of the intermediate coating, the record blank is preferably placed in a warm atmosphere for the volatile portion of the composition to be removed, after which the relatively low thermoplastic nitrated cellulose solution is applied in a manner similar to that of the intermediate coating composition. The number of coats of surface composition to be applied will be governed by the method of application, the total solids present in the surface composition, the viscosity of the nitrocellulose dissolved therein, and the nature, number, and relative proportion of solvents and non-solvents constituting the volatile portion of the surface coating composition. I prefer to employ little or no plastic-inducing body or bodies in the surfacing composition, in order to obtain the maximum toughness and wearing qualities, as has been set forth. The precise composition of the cellulose ester composition or solution will depend upon the avidity with which the solvents selected will dissolve the particular nitrated cellulose being used, and the proportion (for reasons of cheapness) of the non-solvent portion of the cellulose ester solution. As is well known, the percentage composition in nitrogen of a nitrated cellulose is not a function of its solubility in a given solvent or solvent combination; neither can the nitrogen percentage in a nitrated cellulose be determined from its viscosity or conversely. The "flowing qualitities" of a pyroxylin are not dependent upon its nitrogen percentage. It therefore is obvious, that to suggest a specific solvent or solvent combination herein, without knowledge as to the viscosity or solubility of the specific nitrated cellulose ester used, might be misleading.

Upon the application of the nitrated cellulose surfacing composition in one or more layers, depending upon the total solids in said surfacing composition, and the method of application of said surfacing solution, the volatile portion is allowed to dissipate in any known manner until a dry, hard layer is formed. So long as the transparency or translucency of the combined layers is not interfered with to the extent that the printing or illustrating upon the foundation or base is not seriously impaired in legibility, coloring matter, fillers, etc. may be added to any or all of the coats, as desired. While I have used small amounts of non-drying vegetable oils in the various layers, such as castor oil, cottonseed oil, olive oil and the like, to impart softness and pliability; and while I have employed relatively small quantities of such materials as Canada balsam, Venice turpentine, other oils, lacquers and varnishes in conjunction with the cellulose ester compositions, in general, I prefer to obtain the plasticity and toughness by means of a plurality of layers of cellulose ester in conjunction with thermoplasticizers of the same, being applied to the foundation in such a manner that the maximum properties of moldability coupled with exterior toughness will result, as set forth herein. The total depth of coatings to be applied, will depend upon, and be governed by the nature of the matrix and the treatment to which the record is to be subjected in impressing sound waves therein and thereon. And the number of coatings to be applied will depend upon the nature and composition of the individual coatings and their method of application, and the proportion of total solids to liquids present in the cellulose ester solution or solutions.

Having applied as the intermediate portion, a highly thermoplastic cellulose ester in solution to obtain the thermoplasticity desired: and having applied as a surface layer a sufficient amount of relatively low nitrocellulose thermoplastic solution to obtain the surface toughness and wearing qualities of the film deposited; and having used in the so doing solutions which upon evaporation to dryness do not seriously impair the transparency or translucency of the combined coating compositions, and having removed from the coatings substantially all of the volatile solvent contained therein, the resultant article, comprising the treated or sized foundation or base (if such base was sized), the intermediate coating of relatively high moldability, and the surface portion of relative lower thermoplasticity, comprises the completed record tablet, and is then ready to have impressed therein and thereon, by ways now known, record grooves upon one or both sides. The time and temperature of pressure will be governed by the physical characteristics of the coated foundation, and forms no portion claimed in this specification.

While I have exemplified my invention herein, by illustrating its application as applied to a foundation of cardboard, pasteboard or other cellulosic mass, I have obtained satisfactory results by using as a foundation, such materials as pressed wood pulp, paper, fabrics, chamois, tanned hides and skins, asbestos, etc. And while I have illustrated my invention herein by means of a specific example, it is to be understood that such example may be departed from within wide limits and still conserve the essence and spirit of my invention.

Having now described my invention, and in what manner the same may be performed, what I claim and desire to secure by Letters Patent is:

1. A method of producing sound records which consists in printing upon a base of suitable material; treating said base with a filler or sizing composition; removing substantially the volatile portion from said sizing layer; applying to said sized base an intermediate layer of a highly thermoplastic cellulose ester in solution in volatile solvents; substantially removing said volatile solvents from said intermediate layer; applying upon said intermediate layer as a surface coating a cellulose ester in solution of low thermoplasticity relative to the intermediate layer; removing substantially all the volatile solvent from said surface coating; and impressing thereon and therein by heat and pressure the ridges of a record matrix; and cooling the same to form a pressed record sufficiently transparent or translucent that the aforesaid printing may be visible thereon, substantially as described.

2. A method of producing sound records which consists in printing upon a base of fibrous material; treating said base with a filler or sizing composition which is substantially insoluble in the solvents used in the succeeding compositions; removing substantially the volatile portion from said sizing layer; applying to said sized base an intermediate layer of a highly thermoplastic nitrated cellulose in solution in volatile solvents; substantially removing said volatile solvents from said intermediate layer; upon said intermediate layer as a surface coating, applying a solution of nitrated cellulose of low thermoplasticity relative to the intermediate layer; removing substantially all the volatile solvent from said surface coating; impressing thereon and therein by heat and pressure the ridges of a record matrix; and cooling the same to produce a pressed record sufficiently transparent or translucent to admit of the aforesaid printing being visible thereon, as herein set forth.

3. The herein described method of producing sound records which consists in coating cellulosic material with a sizing or filling composition; removing substantially all of the volatile portion of said size; applying to said sized base or foundation an intermediate coating of a cellulose nitrate made highly thermoplastic and dissolved in a volatile solvent mixture; substantially removing the volatile portion from said highly thermoplastic nitrocellulose layer; applying upon said intermediate layer as a surface coating a nitrocellulose in solution in a volatile solvent combination; removing substantially the volatile solvent contained in said surface coating composition; impressing thereon and therein said coated base by heat and pressure the ridges of a record matrix; and cooling the same to form a pressed record, substantially as set forth.

4. A method for producing sound records which consists in printing upon a foundation of cellulosic material; coating said printed base with a plurality of coats of a nitrated cellulose in solution; removing the volatile portion of the nitrated cellulose solution after each layer of the same has been applied; impressing upon said printed nitrocellulose coated foundation by heat and pressure, the ridges of a record matrix; and cooling the same to form a pressed record sufficiently transparent so that the aforesaid printing may be visible thereon, substantially as described.

5. A method of producing sound records which consists in coating structureless material containing printing thereon, with a sizing or filling of a non-nitrocellulosic character; removing substantially the volatile portion of said size; applying to said sized, printed base an intermediate layer in one or more coats, of a highly thermoplastic nitrated cellulose dissolved in a volatile solvent combination; removing substantially all of the volatile portion of said nitrated cellulose intermediate layer; applying upon said intermediate layer as a surface coating, one or more layers of solution of a nitrated cellulose relatively low in thermoplasticity in respect to the intermediate layer; removing the volatile portion of the solvent combination of the surface coating; impressing thereon and therein by heat and pressure by ways now known, sound waves or indentations to form a pressed phonograph record; said pressed record being sufficiently transparent or translucent to admit of reading the printing affixed to the base or foundation, substantially as herein described.

6. The herein described method of producing sound records, which consists in printing or affixing a graphical representation upon a cardboard-like foundation or base; treating said base with a sizing or filling composition the volatile portion of which is substantially a non-solvent of nitrated cellulose in its plastic or non-plastic state; removing said volatile portion from said size; applying to said sized base in one or more coatings, a solution of a highly thermoplastic nitrated cellulose dissolved in a volatile solvent combination; removing substantially all of the volatile solvent portion of said highly thermoplastic nitrated cellulose solution; applying thereon a nitrocellulose in solution of thermoplasticity relatively low as compared with the thermoplasticity of the nitrocellulose solution applied to the sized base; removing substantially all the solvent therefrom; impressing thereon by heat and pressure sound wave indentations to form a pressed phonograph record

sufficiently transparent to admit of reading or understanding the material affixed to the base before sizing, substantially as set forth.

7. The herein method of producing sound records which consists in affixing printed or illustrated matter to a foundation or base by ways now known; coating said base with a sizing or filling material in solution or suspension; removing substantially all of the volatile portion of said size; applying to said sized base a highly thermoplastic nitrated cellulose composition in solution in a volatile solvent combination, which solvent is substantially a non-solvent of the sizing material; removing substantially the volatile solvent from the highly plastic nitrated cellulose; applying upon said nitrocellulose layer as a surface coating, a nitrocellulose in solution of viscosity relatively low as compared with the intermediate layer of nitrated cellulose; removing substantially all of the volatile solvent from the aforesaid nitrated cellulose surface coating; and impressing thereon and therein sound wave indentations by ways now known; cooling said pressed record mass, to form a merchantable record sufficiently transparent to admit of seeing the imprint affixed to the base, substantially as set forth herein.

8. The herein described sound record tablet, comprising a waterproofed foundation which has printing upon its surface; a plurality of coats of nitrocellulose solution in volatile solvents; said waterproofing and nitrated cellulose coatings being sufficiently transparent so that the printing affixed to said waterproofed foundation is visible after the coated foundation has been impressed with sound wave indentations, substantially as set forth.

9. The herein described method of producing a light-weight, flexible, durable sound record, which consists in printing upon a fibrous base of laminated material; partially waterproofing said base by the application thereon and thereto of a sizing composition immiscible with the subsequent coating compositions; removal of substantially all of the volatile portion of said sizing composition after applying the same to the printed base; applying to said sized base as an intermediate coating, a solution of highly thermoplastic nitrated cellulose in a volatile solvent combination; removing the volatile portion of the nitrated cellulose solution by evaporation; applying to said intermediate nitrocellulose layer, a surface coating of nitrocellulose of plasticity relative low as compared with the plasticity of the intermediate composition; removing the volatile portion from said nitrocellulose surface coating; impressing by heat and pressure sound waves upon the said surface coating, to form a phonograph record sufficiently transparent so that the printing affixed upon the fibrous base of laminated material, may be visible, substantially as described herein.

10. In a method of advertising, the printing upon a flexible base which is afterwards covered with a plurality of coatings of varying plasticity containing nitrated cellulose in a transparent or translucent condition, the printed base with thermoplastic coating thereon having sound waves impressed therein by ways now known, substantially as set forth herein.

11. The herein described method of producing sound records for advertising purposes, consisting in printing or otherwise transferring the advertising matter onto a flexible base, preventing the defacement of said printing and adding to its permanency by coating said flexible base in the shape of a disk, with a plurality of substantially transparent coats of thermoplastic nitrated cellulose of varying plasticity in solution in a volatile solvent combination; removing the volatile portion of the nitrated cellulose solution; impressing upon and in said coating material by means of heat and pressure, sound wave undulations to form a phonograph record with reading matter thereon, substantially as described.

12. The method of producing sound records which consists in impressing a graphical representation upon a foundation of cellulosic composition, applying an intermediate coating of highly thermoplastic material to said foundation, subsequently applying a second layer of material possessed of low thermoplasticity over the first layer, and impressing thereon the ridges of a record matrix.

13. The method of producing sound records consisting in coating a cellulosic material with sizing, applying an intermediate coating of highly thermoplastic material, applying on said intermediate layer a surface coating of a material of low thermoplasticity and impressing thereon the ridges of a record matrix.

14. A method for producing sound records which consists in impressing a graphical representation on a base, coating said impressed base with an intermediate coating of material of high thermoplasticity, applying a surface coating of material having a low thermoplasticity and impressing thereon the ridges of a record matrix.

15. The method of producing sound records which consists in impressing a graphical representation upon a foundation of cellulosic material, coating the imprinted base with a plurality of coats of nitro-cellulose in solution, removing the volatile portions of said solution after each layer of the same has been applied and impressing the ridges on a record matrix thereby to form a record.

16. The method of producing sound records which consists in coating a base with a

plurality of layers of nitro-cellulose in solution, the first of which layers is of high thermoplasticity and the second of which is of low thermoplasticity and impressing the ridges of the record matrix, thereon.

17. The method for producing sound records consisting in coating a base with a plurality of coats of nitro-cellulose solution, removing the volatile portion of the cellulose solution after each layer of the same has been applied, and impressing the ridges of a record matrix thereon.

18. The method of producing sound records consisting in impressing a graphical representation upon a foundation of cellulosic material, applying to said foundation an intermediate coat of highly thermoplastic nitro-cellulose composition, applying upon said intermediate layer as a surface coating a nitro-cellulose composition of lower thermoplasticity and impressing on said coated base the ridges of a record matrix.

In testimony whereof I have signed my name to this specification this 6th day of February, 1924.

ROBERT QUAIT, JR.