

UNITED STATES PATENT OFFICE

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RECORDING WIRE

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1 Claim. (Cl. 148—31)

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My invention relates both to a stainless steel product and method. More particularly, it concerns a method of producing stainless steel ribbon or wire displaying superior magnetic qualities, and to the resulting product especially adapted to sound recording.

Among the objects of my invention is to provide a stainless steel wire or generally similar article displaying advantageous magnetic qualities, adapted for sound recording in the substantial absence of detrimental characteristic noises and as well, in the substantial absence of appreciable loss of sonic side bands, harmonics and the like which, while involving a comparatively low cost for material, displays long useful life, high resistance to corrosion, rust and decay both in ordinary atmospheres and when exposed to humid or salt air and upon contact with the human hand; which is comparatively readily drawn to proper dimensions, and which displays superior magnetic qualities including but not being limited to high coercive force, high permeability, good residual induction and suitable induction at maximum field strength.

Other objects, advantages and features of my invention will in part be obvious and in part pointed out hereinafter during the course of the following disclosure, the scope of the application of all of which will be more fully set forth in the claim at the end of this specification.

Accordingly, my invention resides in the several operational and procedural steps, in the relation of each of the same to certain of the others and in the timed sequence thereof, and as well, to the products into which the steels thus treated are subsequently fabricated, and in the processed metal itself.

As conducive to a more thorough understanding of my invention, it may be noted at this point that for several decades the suggestion has been made that perhaps sound tracks could, through appropriate magnetic technique, be transferred to and recorded upon a metal ribbon or wire; the sound track being established thereon for indefinite periods of time and then employed as a record for the reproduction of audible sound as and when desired. Moreover, as desired the sound track thus produced could, by the use of proper technique, be readily removed so that the wire would be conditioned for re-use and for the application of a new sound track thereon. The advantages of such technique are apparent in that it is extremely simple and involves a minimum outlay both in equipment and in space requirements, in recording apparatus and in the

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wire ribbon or track itself. This combination of basic simplicity and low equipment cost extends over into the reproduction apparatus. The elimination of the necessity of a reproducing needle, as in mechanical and electrical reproduction, is accompanied by the removal of the source of annoyance which so frequently attends upon needle scratching.

To that extent, therefore, close adherence to the original tonal quality is achieved. Fidelity in reproduction is, therefore, enhanced. Since the sound wires can be of substantially indefinite length, the necessity of interruption to change records is in large measure eliminated. The ribbons being small, storage space is reduced to a minimum. The potentialities of such method of reproduction is thus instantly realized as being tremendous.

In its early stages of development, however, this magnetic technique was observed to carry with it a number of inherent and fundamental difficulties which had to be eliminated before the new technique could be fully exploited and utilized with appreciable satisfaction.

I find that one of the principal requirements of such wire or ribbon is that magnetically it must possess high coercive qualities. That is to say, it must immediately assume and retain the magnetism of recording and, in addition, there must be a substantial resistance to loss of magnetism in subsequent storage and the like. Otherwise, in the first place, the sounds of the higher frequencies will not be adequately assured and, in the second place, the record obtained will dissipate from the ribbon and there will be substantial loss of the sound message. Particularly where the reproduction of music is concerned even moderate leakage of magnetism is found to result in loss of the overtones and harmonics which are so essential to pleasing reproduction, and as well, the full-bodied tonal qualities of the original source are not reproduced faithfully. Detrimental ground noises inherent to the metal itself I find accompany the use of alloys of many compositions. Therefore, a first requirement of metal tape or wire is that it have satisfactory magnetic qualities.

Now, it is entirely possible to produce metals which have satisfactory magnetic qualities. In most instances, however, such metals may not be readily worked into the thin, comparatively narrow and extremely elongated flexible tape or wire which is required for sound recording according to this technique. Moreover, many of the known metals having high coercive force

require magnetization during heat-treatment to obtain best results.

To illustrate, a high cobalt steel comprising an additive of aluminum and nickel displays high coercivity, but is very expensive and difficult to work, to the extent that its use for the intended purpose is impractical. Moreover, it requires working either under cold or hot conditions or a combination thereof. This mechanical working is found in many instances to produce appreciable and detrimental variations in the magnetic qualities of the metal. Finally, even in those few instances where proper magnetic and mechanical properties are found to reside in the alloys, they are observed to be extremely sensitive to corrosion resulting from even ordinary atmospheric conditions. Particularly then, such alloys are susceptible to attack when exposed to humid or salt air conditions and when they come frequently into contact with the human hand.

An important object of my invention, therefore, is seen to comprise the elimination or suppression in substantial measure of the defects and disadvantages attendant upon the practice according to the prior art, and at the same time, to evolve a method of producing and to provide a corrosion-resistant sound wire having highly desirable magnetic properties including high coercivity, and which while easily workable, retains to an extremely high degree of fidelity the magnetic sound track imposed thereupon with minimum ground noise in reproduction, together with a method of producing such wire which involves a minimum number of procedural steps and requires minimum expenditure of time.

Pursuant to the practice of my invention, I find that it is not enough that a wire be capable of being highly magnetized. To illustrate, it is well recognized that in the case of certain metals, high magnetism can exist, such high degree of magnetism being retained, however, only during the application of a magnetizing force. Materials possessing such magnetic qualities are unsuited for retention of sound records. They are not satisfactory for the maintenance of permanent records. I experimented in this general manner with straight chrome alloys, only to be subjected to the disappointment of finding them to be unsuited for my purpose.

From my work it appears that the grain size, orientation of grains and similar characteristics of the metal are highly important in achieving high coercivity. The required good grain size and the like are not found in the ordinary straight chromium grades of stainless steel. As well, they displayed highly detrimental characteristic ground noises.

On the other hand, the truly austenitic steels such as the 27-20 chromium-nickel stainless steel, do not possess favorable magnetic qualities. In general such steels are considered to be essentially non-magnetic.

With no encouragement from either the straight chromium steels or the austenitic chromium-nickel stainless steels, I nevertheless directed my attention to chromium-nickel stainless steels of the metastable type. The phenomenon was displayed by steels of this general type upon proper correlation of the concentrations of chromium, nickel, carbon, nitrogen, etc., that the metal is comparatively stable unless influenced by external forces, but which upon the application of such outside forces, is likely to undergo a change of structure, be the same great or small.

Thus I find that excellent results are had with a borderline metastable austenitic stainless steel containing chromium 16% to 19%, nickel 6% to 12%, carbon up to 0.30%, nitrogen up to 0.10%, and the remainder substantially all iron.

As a specific example, a steel analyzing 16.91% chromium, 7.38% nickel, 0.059% carbon, 0.46% silicon, 0.46% manganese, 0.04% nitrogen and the remainder iron is subjected to cold-treatment at sub-atmospheric temperatures. This has the effect of converting a part of the austenite into ferrite. Apparently, the ferrite is in a critical size and dispersion throughout the metal because as noted above the usual ferritic steel is inadequate for my purpose. It is to be noted, however, that the cold-treatment must be accomplished without converting the entire mass of metal from austenite into a different phase.

In accordance with my invention, I process the steel by subjecting the same to treatment at sub-atmospheric temperatures. To this end, I immerse the metastable non-magnetic austenitic stainless steel in a cold medium such as boiling liquid nitrogen or solid carbon dioxide. A mixture of solid carbon dioxide with some organic liquid such as acetone or alcohol was found to be entirely feasible. The temperature was carried to as low as -200°C . After a suitable length of time within which the steel was permitted to reach the desired bath temperature it is removed from the coolant and allowed to warm to room temperature.

Where desired, several successive cycles of cooling and warming are employed. The resulting product is found to display high coercivity, maximum permeability, good residual induction and suitable induction at maximum field strength. Sound track wire of required uniform calibrated thickness and width readily is formed of the metal. Strong, clear tones are produced therefrom. Ground noises theretofore prevailing are substantially eliminated. Corrosion resistance of high order is observed.

As modifications of the treating procedure given above, I may combine the sub-atmospheric treatment with prior external stressing treatments such as cold-working, stress-relieving and the like. I find that with the combined treatments highly satisfactory results are likewise achieved. Further, I observe that a combination of such low temperature treatment with subsequent cold-working and stress-relieving give satisfactory results. As a final variant of the treatment at sub-atmospheric temperatures, I combine such technique with both prior and subsequent external stressing as by cold-working and stress-relieving. In all instances, I observe highly satisfactory results. The cold-working and stress-relieving treatments apparently do not so change the form and dispersement of ferrite as to detract from the desired magnetic properties but, on the contrary, appear to enhance these qualities somewhat.

Thus according to the practice of my invention, a new, satisfactory and simple technique is evolved for imparting sound recording qualities to austenitic stainless steels. The method is simple and rapid. Requirement of skilled labor is reduced to a minimum. So too, is the required investment in plant, space and equipment. The metal thus produced is highly magnetic, possessing high coercivity, and is admirably suited for use in the production and storage of sound tracks. It is highly resistant to corrosion under all extremes of atmospheric conditions. It can

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be readily worked into required small dimensions with a minimum of effort. In point of fact, it is entirely feasible to shape and dimension wire so that the final cold-working of the metal into its final dimensions will bring about the required conversion from metastable austenitic condition to partly ferritic condition, so that the required good magnetic qualities are thereby imparted.

The chrome-nickel steels which I employ display high coercivity. Such steels are readily worked into a wire having a diameter of say 0.004 inch, or even smaller if desired. As much as 10,000 feet of such wire can be wound on spools operating at a linear feed obtaining of around two feet per second. Overtones and harmonics are reproduced with fidelity. Ground noises heretofore detracting appreciably from the use of wire record tapes are substantially eliminated. All these and many other highly practical results are achieved according to the practice of my invention.

It is apparent from the foregoing that once the broad aspects of my invention are disclosed, many embodiments will occur to those skilled in the art, all falling within the scope thereof. Moreover, many modifications of the embodiment herein described will suggest themselves to those skilled in this art. Accordingly, I intend that the foregoing description be construed as merely illustrative and not by way of limitation.

I claim:

A cold-worked and cold-treated stainless steel sound recording medium of about 0.004 inch maximum thickness characterized by its high coercive qualities, high residual induction and

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substantial freedom from ground noise, comprising metastable austenitic chromium-nickel stainless steel containing 16% to 19% chromium, 6% to 12% nickel, up to 0.30% carbon and remainder principally iron having a structure comprised of substantially uniform partially transformed grains achieved by cold-treatment at a temperature between about 0° C. and -200° C.

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