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MAGNETIC RECORDING MEDIA

Filed Aug. 19, 1957

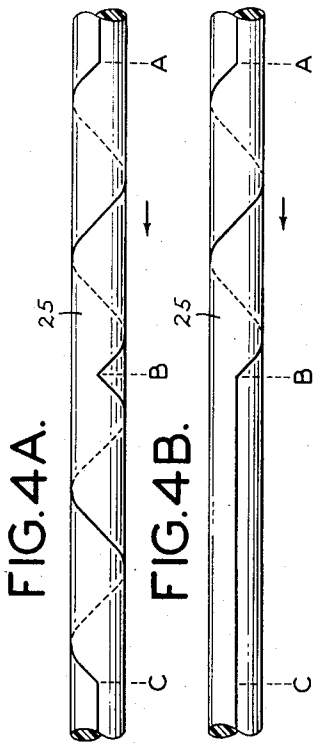


FIG.4A.

FIG.4B.

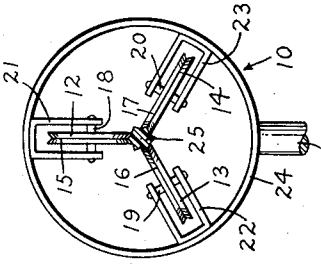


FIG.3.

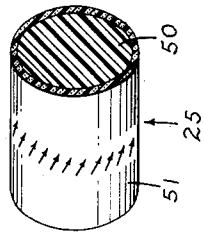


FIG.2.

FIG.1.

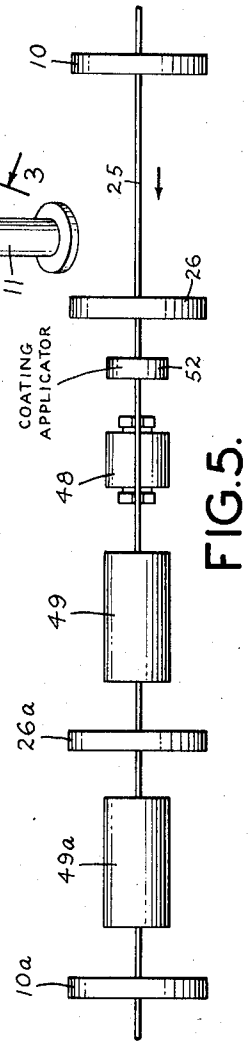


FIG.5.

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2,911,317

MAGNETIC RECORDING MEDIA

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11 Claims. (Cl. 117—7)

The present invention relates to magnetic recording media and more particularly to a new and improved recording medium of the type comprising a plastic filament carrying permanent magnet material.

It has been proposed heretofore to use as a recording medium a filament made of plastic material and coated with a suspension of a permanent magnet powder of the type commonly employed in magnetic tapes. Such filamentary recording media have not been found satisfactory for the reason that when spooled, the magnetizable coating on each filament below the top layer is in intimate contact with the coatings on six adjacent filaments. This results in a strong "print through" effect in which there is unwanted copying on each filamentary coating of the modulation patterns in each of the other filamentary coatings with which it is in intimate contact. Whereas, in coated tapes, the thickness of the support separating the magnetic coatings greatly reduces the tendency to print through, at least for the shorter wavelengths, say less than about four times the tape thickness, in the case of coated filaments or threads there is no lower limit to the wavelengths which will print through, and the printing effect of the longer wavelengths is also enhanced.

It is an object of the invention, accordingly, to provide new and improved filamentary recording media of the above character that are free from the above-noted deficiencies of the prior art.

Another object of the invention is to provide new and improved filamentary recording media of the above character in which the permanent magnet coating has a direction of easy magnetization at an angle to its longitudinal axis.

A further object is to provide a novel method and apparatus for the fabrication of filamentary recording media according to the invention.

In accordance with the invention, a filamentary support made of plastic material is provided with a coating incorporating anisotropic magnetic material, i.e., a magnetic material having a preferred direction of easy magnetization, the direction of easy magnetization being disposed at an angle, preferably in the vicinity of 45°, to the longitudinal axis of the support. When a filament of this type is wound on a spool, the directions of easy magnetization in any two adjacent coatings which are in contact will be at right angles to one another. Consequently, the two coatings will have little remanent effect on each other, and such effect as there may be will be reversible and will vanish as soon as the two adjacent turns of the recording medium are separated.

The invention also contemplates the provision of a novel method for fabricating filamentary recording media of the type described above. It comprises generally the steps of coating a plastic filament with a suspension of anisotropic magnetic material in finely divided form; twisting the coated filament so that a straight generating line on the surface of the coating and parallel to the longitudinal axis is twisted into a helix; subjecting the coated twisted filament to a strong magnetic field directed longitudinally of the filament to position the particles of magnetic material so that their directions of easy magnetization are disposed longitudinally of the filament; untwisting the coated filament to position the magnetic particles with their directions of easy magnetization at an angle to the longitudinal axis; and applying heat to the coating to harden the same and fix the magnetic particles in their last-named positions.

For a better understanding of the invention, reference is made to the following detailed description of several representative embodiments thereof, taken in conjunction with the accompanying drawings in which:

Fig. 1 is a perspective view of apparatus suitable for fabricating filamentary recording media of the type shown in Fig. 2;

Fig. 2 is a schematic diagram in perspective of a piece of a filamentary recording medium constructed according to the invention;

Fig. 3 is a view in transverse section taken along the line 3—3 of Fig. 2 and looking in the direction of the drawings;

Figs. 4A and 4B illustrate different ways in which a filamentary recording medium according to the invention may be twisted during the fabrication thereof; and

Fig. 5 illustrates schematically a modification of the apparatus shown in Fig. 1.

Fig. 1 shows one form of apparatus suitable for fabricating filamentary magnetic recording media according to the invention. It comprises a pair of similar supporting heads **10** and **10***a* mounted in spaced apart relation on suitable standards **11** and **11***a*. Since the heads **10** and **10***a* are substantially identical in construction, it will be necessary to describe only one in detail and corresponding parts of the other will be designated by like reference numerals with the subscript letter *a*.

The supporting head **10** comprises three wheels **12**, **13** and **14** lying in planes disposed, say, 120° apart and intersecting at the longitudinal axis of the apparatus. Formed in the peripheries of the wheels **12**, **13** and **14** are annular grooves **15**, **16** and **17**, respectively. The wheels **12**, **13** and **14** are mounted on shafts **18**, **19** and **20**, respectively, which are journaled in bearings formed in substantially U-shaped brackets **21**, **22** and **23**, respectively, secured to a ring-like housing **24**. The adjacent peripheral portions of the wheels **12**, **13** and **14** cooperate to grip a filamentary magnetic record element **25** firmly as shown in Fig. 3, while allowing easy progress thereof in the longitudinal direction.

Disposed between the fixed supporting heads **10** and **10***a* is a rotatable twisting head **26** which is provided with clamping means **27** enabling it to be clamped in different angular positions. The clamping means **27** comprises a bracket **28** carried by a standard **29** to which a clamp **30** is adapted to be secured by means of a screw **31**, for example.

The twisting head **26** also carries three wheels **32**, **33** and **34** which are also mounted, say, 120° apart. However, the peripheries **35**, **36** and **37** of the wheels **32**, **33** and **34**, respectively, are preferably cylindrical surfaces concentric with the wheels or only slightly grooved so as to establish good contact with the surface of the filament or thread **25**. Also, the wheels **32**, **33** and **34** are rotatably mounted in U-shaped brackets **38**, **39** and **40** which are secured to a ring-like member **41** concentric with the thread **25** by a plurality of threaded pins **42**, **43** and **44** and bolts **45**, **46** and **47**, respectively.

Between the fixed supporting head **10** and the twisting head **26** is disposed a conventional magnetizing element **48** which is positoned to subject the thread or filament **25** to a strong magnetic field directed longitudinally thereof. Also, between the twisting head **26** and the fixed

supporting head **10***a* is disposed an electric oven **49** of conventional type which is suitably designed to generate heat to solidify the thermo setting binder in the coating on the filament or thread **25** and at the same time to speed up the elastic relaxation of the base material of which the thread **25** is formed.

The thread **25** comprises a base **50** preferably made of a plastic material such as nylon which has the property of so-called "elastic memory," i.e., when heated after deformation beyond the elastic limit, it returns to its initial undeformed state. Other materials having this property are known to the art and several other specific examples are disclosed in the Patent No. 2,566,441 to Camras. Over the base **50** is a coating **51** which may comprise, for example, high polymeric resinous material having embodied therein fine particles of ferro-magnetic material having a preferred direction of easy magnetization. Coatings of this type are well known.

In one way of fabricating a filamentary record medium according to the invention, a thread or filament **25** as described above, with the coating **51** in the soft state, is threaded through the stationary head **10**, the magnetizing head **48**, the twisting head **26**, the oven **49** and the stationary head **10***a*. It is now firmly gripped by the wheels in the supporting heads **10** and **10***a* which are supported in the position shown. The wheels **32**, **33** and **34** of the twisting head **26** are positioned to an angle of say 45° relatively to the longitudinal direction and are maintained fixed in this position by tightening down the screws **45**, **46** and **47**, respectively. With the screw **31** loosened, the ring-like member **41** is rotated in a clockwise direction until a generatrix in the surface of the coating **51** on the filament or thread **25** is twisted into a helix having a 45° elevation angle as illustrated in Fig. 4A. In this figure, the points where the heads **10**, **26** and **10***a*, respectively, grip the thread **25**, are represented by the letters A, B and C.

The thread **25** is now advanced longitudinally through the heads **10**, **26** and **10***a* by conventional means (not shown). It will be observed that because of the angular position of the wheels **32**, **33** and **34** of the twisting head **26**, the thread or filament **25** will be rotated once for every axial displacement equal to its circumference. As a result, the helical twisting initially applied to the thread or filament **25** between the points A and B in Fig. 4A will be maintained as shown in Fig. 4B. However, the twisting head **26** will simultaneously produce, in the section of the thread **25** between the twisting head **26** and the supporting head **10***a*, a twist which is opposite to the 45° helical twist initially applied between the points B and C. As a result, the generatrix at the surface of the coating in this section will come out ultimately as a straight line as shown in Fig. 4B.

In passing between the supporting head **10** and the twisting head **26**, and while twisted in the form of a helix of 45° elevation angle, the magnetic particles in the soft coating **51** are subjected to a strong polarizing field by the polarizing head **48**. This causes the magnetic particles to line up with their directions of easy magnetization in the longitudinal direction. In passing through the oven **49**, the thermosetting binder for the coating **51** is solidified so that the polarized particles tend to retain the direction of polarization imparted to them by the polarizing head **48**. At the same time, the heat applied to the thread or filament **25** in passing through the oven **49** facilitates the restoration of the deformed plastic base to its initial undeformed state. When this happens, it will be understood that the polarized articles of ferro-magnetic material on the coating **51** will now have their directions of easy magnetization disposed at an angle of 45° to the longitudinal axis as best shown in Fig. 2.

One disadvantage of the apparatus shown in Fig. 1 is that the coating **51** on the base **50** of the filament or thread **25** is soft at the time it passes through the rollers in both the supporting head **10** and the twisting head **26** so that these rollers tend to become coated with the soft coating material. This is avoided in the modification shown in Fig. 5 by interposing a second twisting head **26***a* of the same general character as the twisting head **26** in Fig. 1 between the twisting head **26** and the supporting head **10***a*. In this form of the invention, the untwisted base **50** of the thread **25** is fed to the supporting head **10** and to the twisting head **26** before the coating is applied thereto. After the base has been twisted to the desired degree, it is coated with a suspension of particles of magnetic material in a suitable plastic binder, the magnetic particles are magnetically polarized and the coating is then solidified by a conventional coating applicator **52**, a polarizing head **48** and an oven **49**, respectively, all interposed between the twisting heads **26** and **26***a*. A second oven **29***a* may be interposed between the second twisting head **26***a* and the supporting head **10***a* to apply heat of the proper temperature for a sufficient length of time to enable the deformed coated base to be restored to its initial undeformed condition.

It will be understood that the method and apparatus described above by way of illustration may be modified without departing from the spirit of the invention. For example, the portion between A and B in Fig. 4B may be twisted to a first helix, say right-handed, as described above, while the portion between B and C may subsequently be untwisted beyond the straight line to a left-handed helix. This has the definite advantage that the angle of twist need not be as great as in the exemplary technique described above in order to achieve the desired elevation angle of 45° for the axis of easy magnetization of the magnetic particles.

This might be accomplished, for example, by stretching the filament longitudinally during the twisting process and allowing it to relax while it is being untwisted. The number of turns of twist and untwist are necessarily equal and of opposite sign, but the given number of turns will be distributed over a shorter length in the relaxed part of the filament than in the stretched part. Hence, the desired final elevation angle of 45° can be achieved with a twist of substantially less than 45°. This is an advantage because strongly twisted elastic filaments do not run straight but tend to form helices or even loops, as is well-known from experience with overwound rubber bands.

It will be apparent from the foregoing description that the invention provides novel and highly effective filamentary magnetic recording media. By aligning the particles of magnetic material comprising the coating of the filament so that their directions of easy magnetization lie at an angle of, say, 45° to the longitudinal axis of the filament, the directions of easy magnetization in any two adjacent filament sections when wound on a spool are at angles to one another so that they will have little permanent effect on one another and there will be only a small tendency to print through from one finament portion to another.

The specific apparatus and techniques described above are intended to be merely illustrative, and the invention is not to be limited thereto but is intended to comprehend all modifications coming within the scope of the following claims.

I claim:

1. A magnetic record medium comprising a filament carrier including binder material incorporating anisotropic ferro-magnetic material having its direction of easy magnetization oriented at an angle to the longitudinal axis of said filament.

2. A magnetic record medium comprising a plastic filament having a coating including binder material incorporating anisotropic ferro-magnetic material having its direction of easy magnetization oriented at an angle to the longitudinal axis of said filament.

3. A magnetic record medium comprising a filament made of a plastic material having an elastic memory and

a coating of finely divided particles of anisotropic ferromagnetic material in a binder, said particles of magnetic material having their directions of easy magnetization oriented at an angle to the longitudinal axis of said filament.

4. In a method for fabricating a magnetic record medium, the steps of providing a filament of plastic material, twisting a portion of said filament between spaced apart locations therealong, applying to an anisotropic ferro-magnetic material incorporating in a binder on said filament twisted portion a polarizing magnetic field directed along the longitudinal axis of said filament, to polarize said anisotropic ferromagnetic material with its direction of easy magnetization along said longitudinal axis, heating the filament, and untwisting it so that the direction of easy magnetization lies at an angle to the longitudinal axis of the filament.

5. A method as defined in claim 4 together with the step of affixing said anisotropic ferromagnetic material to said filament portion in said polarized position.

6. A method as defined in claim 5 in which the filament portion is untwisted to its initial position and then twisted in the opposite direction to establish the desired angle between the direction of easy magnetization of the magnetic material and the longitudinal axis of the filament.

7. A method as defined in claim 5 in which the filament portion is stretched longitudinally during the twisting thereof and is allowed to relax during the untwisting thereof.

8. In a method for fabricating a magnetic record medium, the steps of providing a filament of plastic material having an elastic memory and coated with finely divided particles of anisotropic magnetic material in a thermosetting plastic binder, twisting a portion of said filament between spaced apart locations therealong, applying to said particles of magnetic material a polarizing magnetic field directed along the longitudinal axis of said filament, heating said filament portion to set said plastic binder with said particles in the polarized position, and restoring said filament portion to its initial untwisted condition.

9. In a method for fabricating a magnetic record medium, the steps of providing a filament of plastic material having an elastic memory, twisting a portion of said filament between spaced apart locations therealong, applying to said filament portion a coating of finely divided particles of anisotropic magnetic material in a thermosetting binder, applying to said particles of magnetic material a polarizing magnetic field directed along the longitudinal axis of said filament, heating said filament portion to set said plastic binder with said particles in the polarized position, and restoring said filament portion to its initial untwisted condition.

10. In apparatus for fabricating a magnetic record medium, the combination of spaced apart support heads for gripping a record medium during the advancement thereof, a twisting head for said record medium, intermediate said support heads, magnetic polarizing means between said twisting head and one of said support heads for establishing a magnetic field in the direction of advancement of said record medium, and heating means between said twisting head and the other of said support heads for applying heat to said record medium.

11. In apparatus for fabricating a magnetic record medium, the combination of spaced apart support heads for gripping a record medium during the advancement thereof, a pair of spaced apart twisting heads interposed intermediate said support heads, means interposed between said twisting heads for coating said record medium with finely divided particles of magnetic material in a binder, and magnetic polarizing means disposed between the pair of twisting heads for magnetically polarizing the coated medium and heat generating means disposed between said twisting heads for heating said coated and polarized record medium.

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