

[72] Inventors **Joachim Greiner;**
Wolfgang Eichler; Wilhelm Abeck,
Leverkusen; Erich Muller, Bergisch-
Neukirchen, Germany
 [21] Appl. No. **654,877**
 [22] Filed **July 20, 1967**
 [45] Patented **Feb. 16, 1971**
 [73] Assignee **AGFA-Gevaert Aktiengesellschaft**
Leverkusen, Germany
 [32] Priority **July 29, 1966**
 [33] **Germany**
 [31] **A53128**

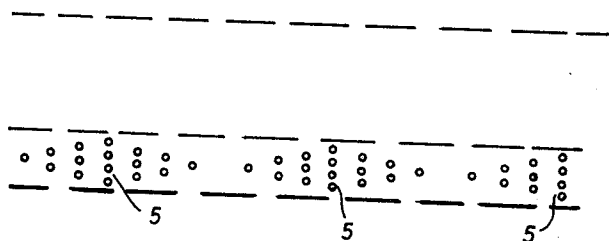
[56] **References Cited**
UNITED STATES PATENTS
 2,657,932 11/1953 Blaney..... 179/100.2
 2,943,908 7/1960 Hanna..... 346/74
 3,161,544 12/1964 Berry..... 346/74
 3,185,777 5/1965 Rheinfrank..... 346/74

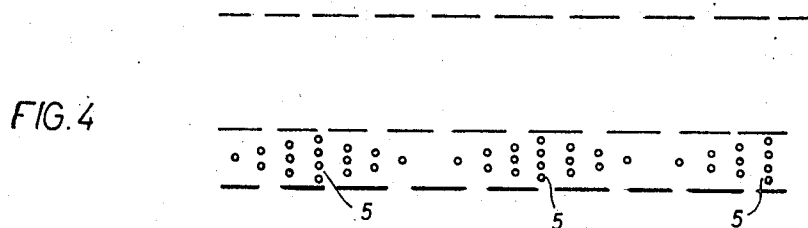
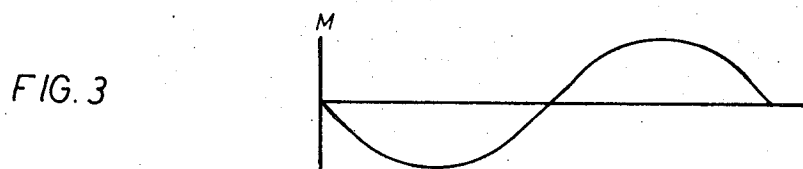
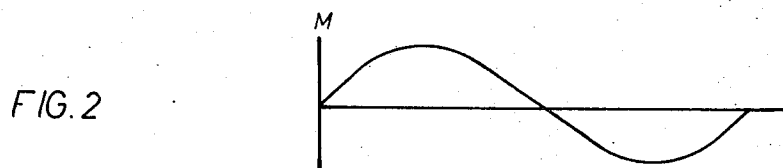
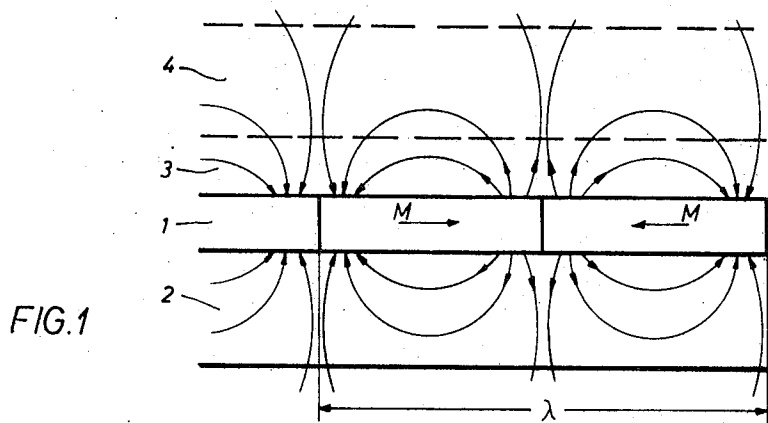
Primary Examiner—J. Russell Goudeau
Attorney—Connolly and Hutz

[54] **PROCESS FOR THE PRODUCTION OF MAGNETIC
 TAPES WHICH CANNOT BE ERASED**
6 Claims, 12 Drawing Figs.

[52] U.S. Cl..... 179/100.2,
 346/74
 [51] Int. Cl..... G11b 5/86
 [50] Field of Search..... 179/100.2
 (E); 346/74 (MP)

ABSTRACT: Nonerasable copy of a magnetic recording is made by applying to the recording movable magnetizable particles to cause them to be attracted by and arranged in accordance with the stray fields of the recording, then fixing the particles in position with respect to each other, securing the fixed particles to a separate backing and removing the backing with the particles therein from the recording. When the particles are applied a magnetic field can also be impressed to render the magnetizing of the magnetizable particles more ideal, or the particles can be magnetized by cooling down from their Curie point. The application of a unidirectional magnetic field whose lines of force are perpendicular to the surface of the recording will also prevent frequency doubling.





INVENTORS:
JOACHIM GREINER, WOLFGANG EICHLER, WILHELM ABECK, ERICH MÜLLER.

BY *Connolly and Smith*
their attorneys

FIG. 5

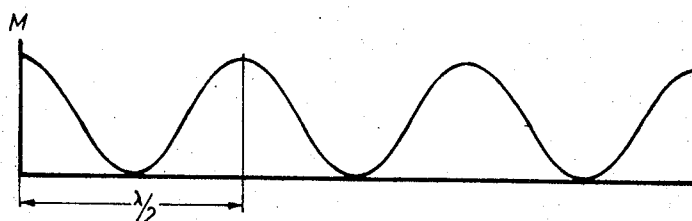


FIG. 6

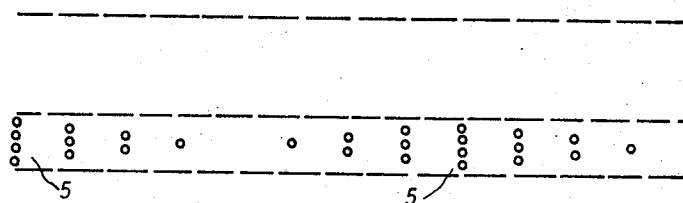
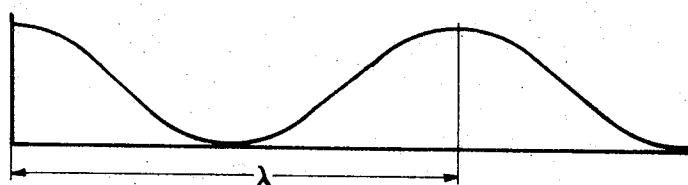


FIG. 7



JOACHIM GREINER, WOLFGANG EICHLER, WILHELM ABECK, ERICH MÜLLER.

INVENTORS.

BY

Connolly and Thur
their attorneys

FIG. 8

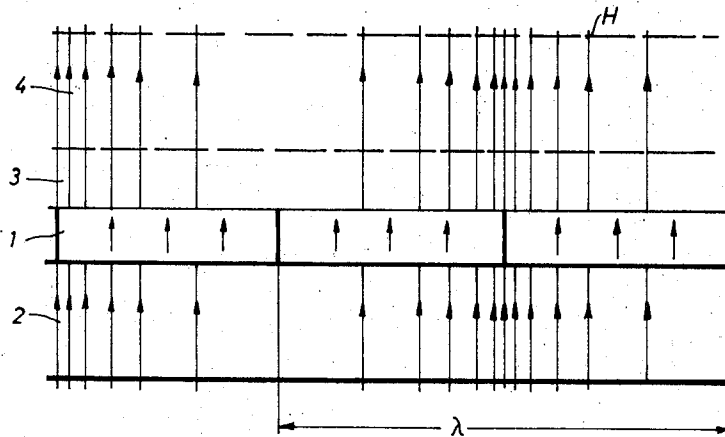


FIG. 9

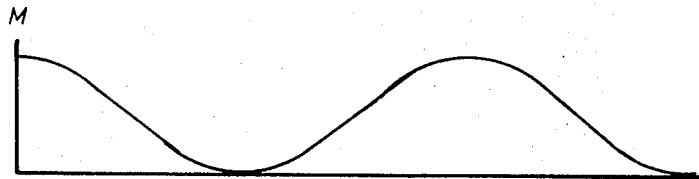


FIG. 10



FIG. 11

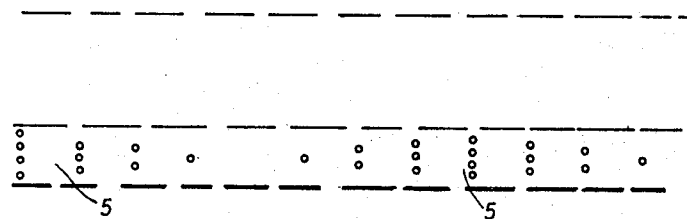
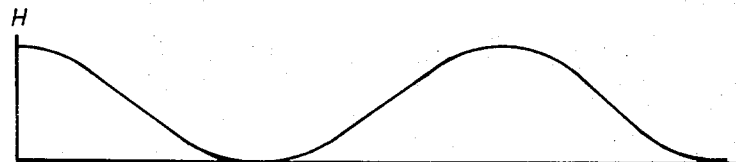


FIG. 12



INVENTORS:

JOACHIM GREINER, WOLFGANG EICHLER, WILHELM ABECK, ERICH MÜLLER.

BY

Connolly & Nutt
attorneys

PROCESS FOR THE PRODUCTION OF MAGNETIC TAPES WHICH CANNOT BE ERASED

The invention relates to a process for the production of magnetic tapes with information which cannot be erased, the magnetizable particles being spatially arranged according to the magnetic field of the information.

It is a great advantage of magnetic recording members that the information recorded can be erased, so that the recording member can be used again.

That advantage, however, excludes the use as documentation which can be used in evidence. The possibility of erasure is also undesired in connection with the production of magnetic recordings of high quality.

It is known to produce magnetic copies by playing back the original on a magnetic recording device, electrically coupling this device to a second recording device to copy the information on another recording tape. This process is made more economical by increasing the speed of the tape and coupling several devices to one playback machine.

Another copying process, the direct copying or printing process, makes use of the copying effect which is otherwise undesired in the magnetic tape art. A magnetic tape is laid on the magnetic recording member carrying the information to be copied (master tape). By the action of the magnetic stray field of the original recording, the copying tape is correspondingly magnetized. The process is improved by using for the master tape a magnetic material with a high coercive force, while the copying tape has the usual coercive force of about 150 to 300 Oe. While in contact, a magnetic alternating field acts on the two tapes to improve the copying or printing action.

Magnetic tapes are obtained by both processes which can be erased in principle without being mechanically destroyed.

The first mentioned process is very complicated and therefore uneconomical. With the direct copying process, the use of high alternating fields is restricted by the fact that the master tape may be partially erased. These two processes for the production of copies are at the present time economically inferior to the corresponding processes using disc records.

Copying processes which lead to nonerasable magnetic copies of acoustic information are not known.

It is among the objects of the invention to provide a process for the production of magnetic copies which cannot be erased.

We now have found that nonerasable magnetic copies of acoustic informations can be produced by arranging the density distribution of magnetizable particles in a layer on the original recording tape in conformity with the stray field of the original information.

The following methods can, for example, be used for carrying out the process according to the invention.

1. A suspension, consisting of magnetic particles and a liquid, which contains volatile and nonvolatile substances (e.g. a normal casting solution for a magnetizable layer) is applied to the original.

Since the particles are initially still mobile, they follow the attraction of the magnetic stray field of the original recording and are concentrated at the areas of highest field intensity.

The suspension then becomes solid (evaporation of the solvent and drying). A carrier foil is now applied to the solidified magnetic layer (by being cast, coated, stuck or sealed thereon). Thereafter, magnetic layer containing the copied information is separated from the element carrying the original information. It is obvious that the liquid in which the magnetizable particles are suspended must not have any action on the magnetizable layer of the original. The same condition also applies to the process further discussed below under (2).

In order to improve the separability of the copying layer from the original tape, the surface of the original can have applied thereto additional separating layers, for example, vapor-coated layers of SiO_2 , Al_2O_3 or other solid substances. Furthermore, layers of fats, waxes or synthetic film-forming resins, for example, polymers of fluorinated ethylenes, are suitable for this purpose. The same result is also attained by

vapor-coated metal layers, for example, of aluminum, whereby a smoother surface of the copying tape is simultaneously obtained.

For technical casting reasons, the suspension of the magnetizable pigments should not be too highly viscous. The magnetizable layer for the copies information can be produced and processed under similar conditions as used in the known manufacture of magnetizable layers. It is possible therefore to use binding agents which are similar to those normally employed for the production of common magnetizable layers, for example, nitrocellulose, polyvinylchloride, polyurethanes or the like.

2. The magnetic particles are suspended in a liquid which completely vaporizes after being applied to the original. At the time of applying this suspension to the original, the magnetic particles are distributed in accordance with the magnetic stray field. The liquid vaporizes and the particles are retained by the magnetic forces on the element carrying the original information. The binding agent, e.g. cellulose ester, is applied, which penetrates into the cavities remaining free between the particles and, which after solidification allows the removal of a layer with the pattern of the magnetic particles according to the original information. This layer carrying the copied information can be applied onto a suitable support. This process has the advantage that suspensions of very low viscosity can be used, which permit the copying of very small wavelengths.

3. Dry processes are often desirable for the production of copies on a small scale. According to this embodiment of the invention, magnetic particles (e.g. $\gamma\text{-Fe}_2\text{O}_3$, carbonyl iron and iron filings) are enclosed in a thermoplastic binder, which enables the individual granules to stick together upon slight heating. It is, for example, possible to mix magnetic $\gamma\text{-Fe}_2\text{O}_3$ with a thermoplastic resin in the warm state. This mixture is ground after cooling and in this way a granulate is obtained consisting of the thermoplastic resin with the magnetizable particles distributed therein. In addition, thermoplastic granules are produced which contain no magnetic particles. A mixture of these granules is now applied to the original magnetic recording and the latter is gently shaken. The particles are arranged in accordance with the magnetic stray fields of the original information. Upon heating the granules melt or soften to form a layer containing the magnetizable particles in accordance with the original information. If desired the said layer can be applied onto a suitable support. The copy is then removed from the element carrying the original information.

With the methods indicated above, the action of the magnetic stray field of the original information can be intensified in known manner by the idealizing action of an alternating field or of heating. In this way, the magnetic particles are more strongly magnetized and the force moving them increases, so that the particles can be arranged more easily in accordance with the information on the original. Additionally the copying action of the magnetic stray field of the original information, which normally is too small for practical use, is considerably increased by the idealizing treatment. Thus, indestructible copies of the original are obtained which are of strong intensity and true frequency.

Since the original and copy lie one upon the other during the copying operation, the conditions of the ideal or partly ideal magnetization can easily be achieved. With the partial idealization, the alternating field intensity is chosen in such a way that the maximum of magnetization is obtained. The coercive force of the magnetic material of the original must be so high that there is no appreciable demagnetization of the original recording by the alternating field. $\gamma\text{-Fe}_2\text{O}_3$ and ferrites are suitable as magnetizable particles for the master tape.

Particular advantages are, for example, presented in the copying process by the thermal idealizing which is described in Belgian Pat. No. 660,323. If the layer onto which the original information is to be copied is heated to above the Curie point of its magnetic material, and if this is allowed to cool while the binding agent of the said layer is still fluid and while the said layer is still under the action of the magnetic

field of the original, a strong magnetization is obtained in the copying layer, which under certain circumstances exceeds that of the original. In this way, it is for example, easily possible to reproduce magnetic information in large quantities. As described with the known processes, the Curie point of the magnetizable material of the magnetic member carrying the original information is chosen as high as possible. γ -Fe₂O₃ is suitable for example. The Curie point of the magnetizable material of the copying layer is low, preferably between 80° C. and 180° C. Modified CrO₂ can be used herein, as described for example in British Pat. Nos. 895,937 and 951,965 and French Pat. No. 1,407,333.

The copying tapes which are to be used for carrying information transferred according to the invention, may contain depending on the conditions of the copying process - hard magnetic substances, i.e. a magnetizable pigment with a coercive force which is greater than 200 Oe, or soft magnetic substances with smaller coercive forces, advantageously smaller than 15 Oe. The magnetic particles should have a length of from 0.05 to 2 μ . The advantage of the soft magnetic materials is the easier mobility by the relatively weak magnetic forces of the magnetic stray field of the original information. In this way, the copying operation is accelerated and an excellent reproduction is obtained. Suitable soft magnetic materials are, for example, mixed ferrites, such as those described in the book "Ferrite" by J. Smit and J. Wijn Philips, Techn. Bibliothek 1962.

Nickel ferrites and manganese ferrites are also suitable soft magnetic material on account of their low Curie point.

The copies produced by one of the aforementioned processes behave quite similarly to copies which have been produced by the direct copying process of the prior art, whereby copies which have been produced under idealizing conditions, have a considerably stronger intensity.

The wavelengths correspond to those of the original information or recording. The magnetic copies produced according to the invention, can be erased with an alternating field, the recorded information, however, cannot be destroyed without destroying the tape, since the magnetic particles in the copying layer are distributed in accordance with the original information. For the reproduction of the copied information the copying tape is uniformly magnetized with a magnetic unidirectional field.

This magnetizing unidirectional field can be amplified by an idealizing alternating field, whereby the quality of the copied information is improved; in particular, the background noises are reduced. Depending upon whether the unidirectional and alternating fields are allowed to decrease simultaneously or in succession (first the alternating field, then the unidirectional field), the copy is magnetized under partial or complete ideal conditions.

The unidirectional field can be produced by a permanent magnet, even a coil wound over a core fulfills this purpose. The alternating current bias and the picking up of the induced voltage are likewise effected through coils. The separate functions can be taken over by one coil for each but can also be combined in one coil.

When using the conventional originals, it is found upon reproduction after magnetization by means of a magnetic unidirectional field that the information can in fact be reproduced, but the wavelength of the copy is only half as large as that of the original information.

This disadvantage is overcome by a preferred embodiment of the invention by applying a magnetic unidirectional field perpendicularly to the original during the production of the copy. The field intensities of the unidirectional fields are between approximately 10 Oe and 100 Oe. Copies which are produced by this preferred embodiment produce information identical with the original, including the wavelength.

By using as original a magnetic recording in which the magnetization lies perpendicularly to the plane of the tape and only varies between zero and the saturation magnetization, this additional measure is unnecessary. However, such originals exist only in exceptional cases.

The operation of erasure and remagnetization can be repeated as often as desired with the copies produced according to the invention without the information content of the copying tape being lost. The information can only be altered or removed if the storage means is destroyed mechanically or chemically.

The invention is explained by reference to the accompanying drawing. FIGS. 1—7 show the copying operation on a longitudinally magnetized magnetic tape.

FIG. 1 shows in the lower part the magnetic tape carrying the information which is magnetized with the wavelength λ and which consists of the magnetic layer (1) and the carrier (2). The stray field produced by the magnetization M is also shown. The copying tape with the magnetic layer (3) and the carrier (4) lies directly on the original.

FIG. 2 shows the fluctuation of the magnetization of the original tape of FIG. 1.

FIG. 3 shows the fluctuation of the magnetization in longitudinal direction of the copy if only the known direct copying effect is taken into account.

FIG. 4 demonstrates how the magnetic particles (5) in the copying layer are arranged after the production of the copy.

FIG. 5 shows the magnetization of the copy after this has been erased and remagnetized with a unidirectional magnetic field. It is seen that the wavelength is only $\lambda/2$ as compared with the wavelength of the original information. In addition, the zero line of the sine function is displaced.

FIG. 6 shows the distribution of the particles (5) if a unidirectional field is effective perpendicular to the surface of the tape carrying original information during the copying process.

FIG. 7 reproduces the change in magnetization of a copy produced with such a vertical field after the erasure and remagnetization. The zero line of the sine function is also displaced here, the wavelength, however, of the original is maintained.

FIGS. 8—12 show the copying of an original tape on which the recording of the original information was effected by a magnetic field directed perpendicularly to the tape surface and in which the magnetization fluctuates between zero and the saturation value.

FIG. 8 shows an original which has been magnetized with a magnetic head only perpendicularly to the plane of the tape with one wavelength. The figure shows the magnetization vectors M in the layer (1), while the lines provided with arrows outside the layer represent the stray field. The copy lies directly on the original.

FIG. 9 shows the fluctuations of the transverse magnetization of the original tape of FIG. 8.

FIG. 10 shows the fluctuations of the stray field of the original in the copy.

FIG. 11 demonstrates at what places of the copy the magnetic particles are arranged during the copying process.

FIG. 12 shows the stray field of the copy with magnetization perpendicularly to the layer which does not differ qualitatively from the original.

EXAMPLE 1

ORIGINAL

On a commercial magnetic recording tape, which consists of a magnetizable layer containing γ -Fe₂O₃ dispersed in a polyurethane as described in German Pat. No. 824,244 on a support of polyethylene terephthalate, an acoustic signal is recorded which has a wavelength of 0.75 mm. in such a way that approximate saturation exists at the maxima. The magnetizable layer is thereupon provided with a thin layer of polytrifluorochloroethylene wax.

PRODUCTION OF THE COPY

A suspension of acicular γ - Fe_2O_3 in a solution of nitrocellulose in ethyl acetate is cast onto the magnetizable layer of the original. A carrier of cellulose triacetate is now applied to the tacky copying layer. This carrier adheres firmly to the copying layer, so that, after drying, the copying layer with the cellulose acetate carrier can be detached from the original tape.

The mean volume space factor of the magnetic layer of the copying tape is about 0.15—0.25. The coercive force of the particles is between about 280 Oe—300 Oe.

After the detaching operation, the acicular particles of γ -iron oxide are arranged in the copying layer in conformity with the magnetic stray field of the information in the original layer.

If a copy produced in this way is played back on a magnetic recording device at a speed $v = 38$ cm./sec., a basic frequency of 800 c/s is produced on the basis of the wavelength $\lambda = 0.475$ mm. After the copy is erased with an alternating field, there is found a residual voltage which is smaller than 2 mV. By moving the copying layer past a permanent magnet, the said layer is again magnetized. A voltage of 250 mV is now measured with the frequency of 800 c/s doubled, i.e. at 1600 c/s. After once again erasing the tape, this is magnetized with a recording head at 1600 c/s. The recording current is chosen as high as possible. On reproduction a voltage of 250 mV is again measured. It is seen from this that, in the copying layer all magnetic particles have been arranged according to the information of the original.

EXAMPLE 2

Similar results to those indicated in Example 1 are obtained by using a nickel-plated copper tape as original, the nickel layer carrying the original information. The magnetizable copying layer as described in Example 1 can be applied by means of casting devices or applicator rollers. This is effected during the simultaneous action of a magnetic unidirectional field perpendicularly to the tape surface of the original (field intensity about 10—100 Oe).

Upon replaying the copy agrees also in frequency with the original.

If a transparent support and a transparent binding agent for the magnetizable copying layer are used, then, since the magnetizable particles are arranged in accordance with the magnetic information of the signal, the layer is also transmitting light in accordance with that information pattern. It is thus possible to scan these magnetic copies with light beams. The smoothness of the surface of the copy is then not as important as with the magnetic scanning. This process is of importance for sound film, since, in this way, the photographic sound track and the magnetic sound track can be placed together. In addition, it is possible to check the copy by this optical light method, e.g. to find dropouts and splicing joints.

Using the process of the invention, it is also possible to produce test tapes as described in British Pat. No. 939,689, whereby shorter wavelengths can be produced than is possible by printing methods or by mechanical scoring.

By measuring the difference f_d between the frequency F_B ($v = \lambda f$) recorded on a tape according to the invention (v = running speed, λ = wavelength and f = frequency) and the frequency of a disturbing field F_{st} (e.g. alternating current of 50 c/s), it is also possible to detect disturbing alternating fields in magnetic recording devices.

The tapes produced according to the invention can also be used for frequency conversion. Thus, for example, a tape with a wavelength λ is prepared, whereby the carrier frequency $f_T = v$ (v = running speed) is obtained with a magnetic recording device. If now a variable frequency is recorded on that tape, the frequencies reproduced are $f_T \pm f$, presuming $f_T > f$. In addition, timed tracks, such as are necessary in computer devices can be produced in this way. However, the known pilot sound tracks or mechanical perforations of films and the like can also be replaced by magnetic tapes carrying signals applied according to the inventive process.

The magnetic copies produced according to the claimed process can again be used as an original. By the varying density distribution of the particles, it is possible in principle to employ infinitely large magnetic fields which improve the copying action without any danger of erasure. In addition, frequency doubling is avoided if an erased and newly magnetized copy according to the invention is used as the original. Furthermore, soft magnetic particles can also be employed with advantage with such an original, since it is the magnetization during the action of a field which is important in this case, and not the remanence. The linearity between the magnetization and the field which is produced is in certain circumstances greater with soft magnetic particles than with hard magnetic particles.

Since wavelengths from 0.1—0.5 mm. can be copied particularly well, the process is particularly suitable for the production of copies of computer tapes. The documentation value is equivalent to that of a written document.

We claim:

1. A process for the production of magnetic copies of a magnetic recording of acoustic signals comprising the steps of:

a. applying a layer of a suspension of movable soft magnetizable particles having a coercive force of less than 15 Oe and a length of between 0.05 and $2/\mu$ in a solution of a film-forming binder agent to the magnetic recording carrying original magnetic information to cause the magnetizable particles to be attracted by the magnetic stray field of the magnetic information of the recording and to become arranged in accordance with the magnetic stray field of the original information; and

b. drying the said layer of the suspension to fix the magnetizable particles in position with respect to each other after they have become arranged, and then removing the dried layer with the particles from the recording carrying the original magnetic information.

2. In the process of claim 1 the step of first applying to the surface of the magnetic recording a covering layer by vapor coating the surface of the magnetic recording using vapor containing a film-forming substance selected from the group consisting of vaporized aluminum, silicon dioxide, aluminum oxide and synthetic film-forming resins.

3. A process as defined in claim 1, wherein the ratio of magnetizable particle volume to the total volume of the dried layer is between 0.15 and 0.25.

4. A process as defined in claim 1, wherein step (a) is performed under idealizing magnetic recording conditions.

5. A process as defined in claim 1, wherein idealizing magnetic recording conditions are supplied by an alternating magnetic field.

6. A process as defined in claim 1, wherein a unidirectional magnetic field is applied during step (a), the field lines of the unidirectional field extend substantially perpendicularly to the surface of the recording.