

[54] **APPARATUS FOR MAGNETIC RECORDING OF ELECTRONIC SIGNALS**

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[22] Filed: **Oct. 8, 1970**

[21] Appl. No.: **79,213**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 779,393, Nov. 27, 1968, Pat. No. 3,555,556, Continuation-in-part of Ser. No. 636,729, May 8, 1967, abandoned, Continuation-in-part of Ser. No. 409,855, Nov. 9, 1964, abandoned.

[52] U.S. Cl. **346/74 MT, 179/100.2 CR, 340/173 CR, 340/174.1 M, 346/74 CR**

[51] Int. Cl. **G03g 19/00, G11b 11/04**

[58] Field of Search. **346/74 MT, 74 MC, 74 MP, 74 M, 346/74 CR; 340/174.1 M, 173 CR; 179/100.2 CR**

[56]

References Cited

UNITED STATES PATENTS

2,900,443	8/1959	Camras	179/100.2 CR
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Primary Examiner—Howard W. Britton

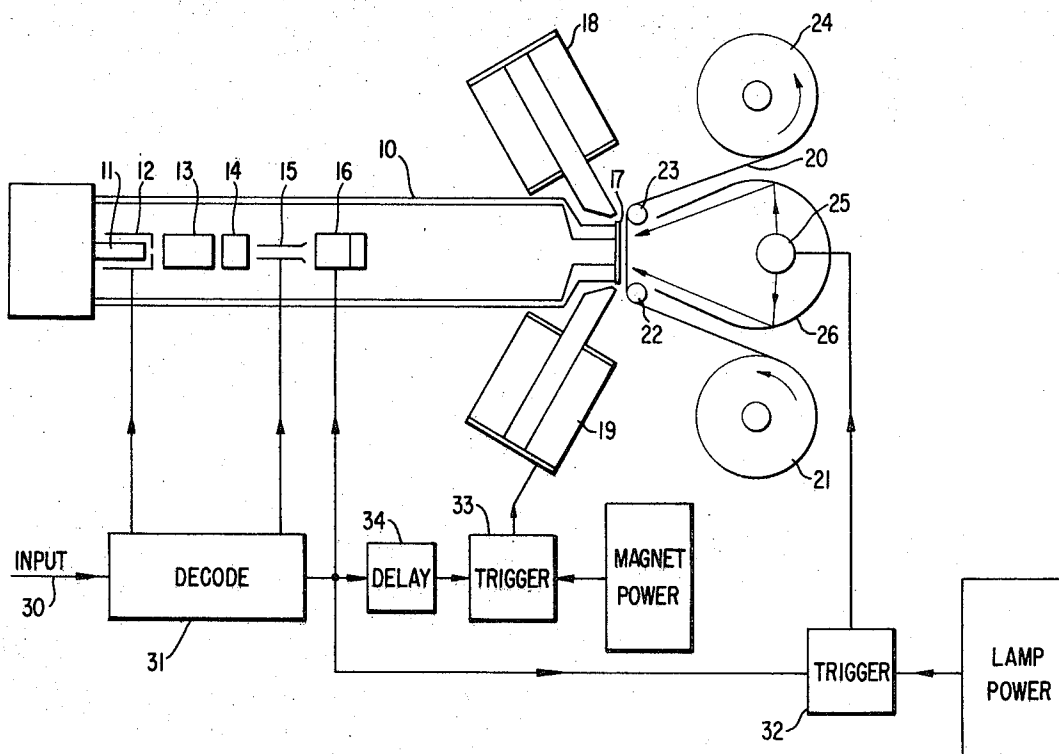
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[57]

ABSTRACT

A cathode ray tube having a faceplate composed of a thin non-magnetic gas-impermeable plate having a pattern of indentations on the innerface, the indentations being at least partially filled with a finely particulate hard magnetic material, preferably having a Curie temperature below 500° C. is described. Images in the form of a pattern of magnetization are formed on the faceplate thermomagnetically by the heating effect of the electron beam. The image on the faceplate can then be transferred to a magnetic recording member external to the cathode ray tube by thermoremanent transfer.

5 Claims, 2 Drawing Figures



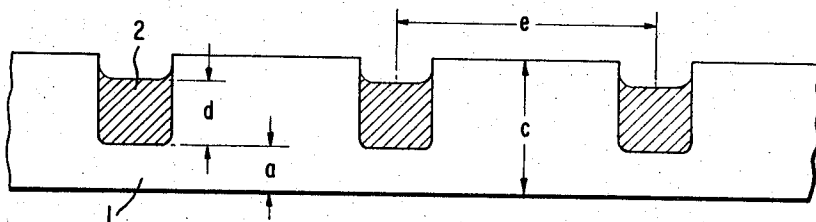


FIG. 1

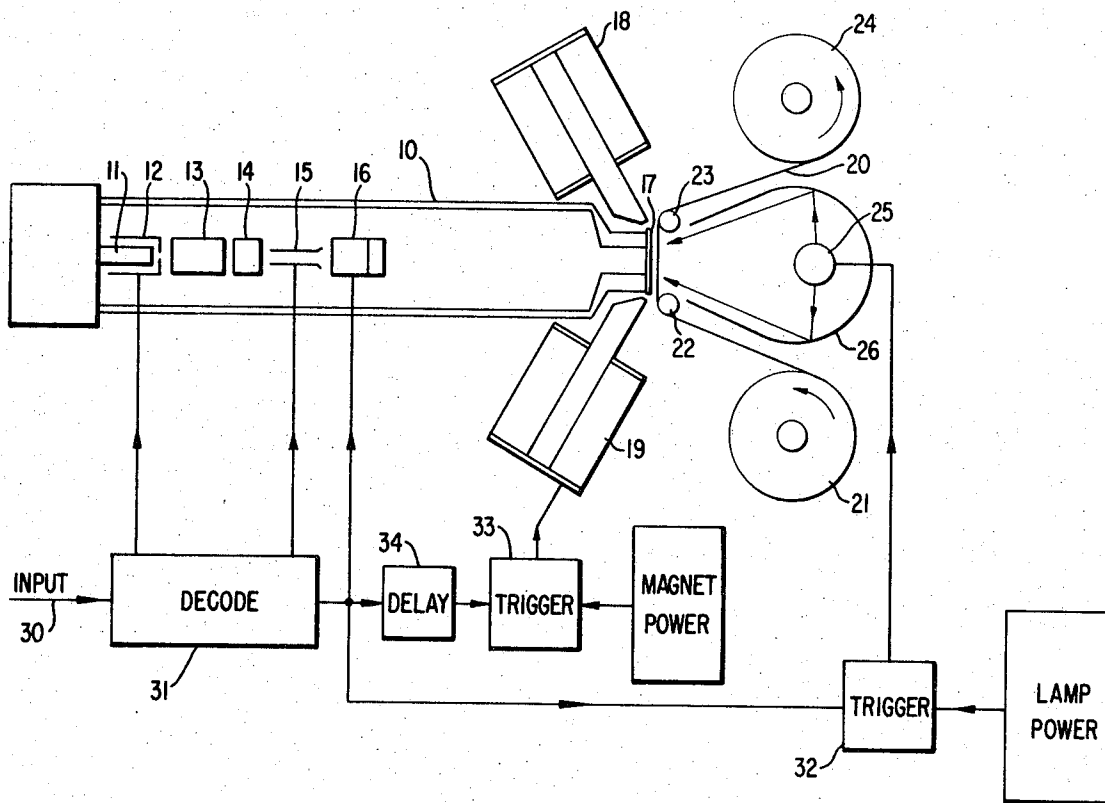


FIG. 2

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APPARATUS FOR MAGNETIC RECORDING OF ELECTRONIC SIGNALS

RELATED APPLICATIONS:

This application is a continuation-in-part of copending application Ser. No. 779,393 filed Nov. 27, 1968, now U.S. Pat. No. 3,555,556, which is a continuation-in-part of the then copending application Ser. No. 636,729 filed May 8, 1967 and now abandoned, which is a continuation-in-part of the then copending application Ser. No. 409,855 filed Nov. 9, 1964 and now abandoned.

BACKGROUND OF THE INVENTION:

1. Field of the Invention:

This invention relates to a method and apparatus for storing electronic information. More particularly, this invention relates to a method whereby an image generated by a cathode ray tube can be stored and transferred to a magnetic tape external to the tube.

2. The Prior Art:

Cathode ray tubes are used as imaging devices in several ways. The most common way utilizes a phosphor layer inside the tube face, an image is created in this phosphor with the electron beam, and the phosphor picture is imaged by suitable optics onto a photosensitive record member. Alternatively, an electron beam-sensitive recording member may be introduced inside the cathode ray tube. Such has been the manner in which, for example, Burns, U.S. Pat. No. 2,915,594; Szilikai, 2,517,808; Zworykin, 3,072,751 and Supernowicz, 3,094,699 have recorded thermomagnetically by means of an electron beam. That is to say the magnetic recording member is bombarded with electrons while the member is in the cathode tube.

Levin, U.S. Pat. No. 2,979,572 discloses the use of an electron beam-sensitive magnetic material in a cathode ray tube faceplate to permit imaging by the electron beam on record members outside the cathode ray tube. Levin shows heating in a vacuum a high permeability material by an electron beam so that the permeability of the material is changed by the heating. The flux leakage of a magnetic field passing through the material is transferred to a magnetic recording member outside of the vacuum.

Gorn, U.S. Pat. No. 2,411,155 discloses a glass faceplate coated on its interior surface with a thin film of magnetic material such as iron. This film is sufficiently thin to transmit light. In operation, the thin film is magnetized, heated by bombardment with electrons according to the information to be reproduced to produce a pattern of magnetization corresponding to the information, then a beam of polarized light is passed through. The plane of polarization of the light is selectively rotated according to the magnetic state of the film. The differences in rotation are detected by an analyzer to form an optical image which is projected onto a screen.

SUMMARY OF THE INVENTION:

The present invention comprises a cathode ray tube having means to form a beam of electrons in a vacuum, means to modulate the intensity and direction of the beam of electrons and a faceplate in the path of said beam of electrons forming part of an enclosure adapted

to maintain said vacuum; faceplate consisting of a non-magnetic, gas impermeable sheet having indentations on the face within the enclosure forming said beam, the indentations containing a hard magnetic finely particulate material preferably having a Curie temperature below 500° C. Such indentations provide for image fields at a greater distance from the magnetic layer than are provided for by a uniform magnetic layer, while providing for structural strength against high vacuum.

In use, the cathode ray tube is supplied with the necessary power and the signals are applied to a grid and deflection means conventional for cathode ray tubes thus producing a beam of electrons which is modulated spatially and intensity wise in accordance with the information.

The heating effect of the modulated beam of electrons is then employed to form a magnetic image on the faceplate. Several methods can be employed to accomplish this result.

i. premagnetizing the magnetic material of the faceplate with a magnetic field (and optionally heat supplied by the electron beam) and demagnetizing the magnetic material imagewise by controlling the maximum intensity of the electron beam to produce heating to about the Curie temperature; whereby the faceplate is demagnetized to form a pattern of demagnetized areas corresponding to the heated areas;

ii. premagnetizing the faceplate and applying a reverse magnetic field having a strength substantially smaller than the coercivity of the magnetic material. Selective heating of the faceplate by the electron beam to about a temperature at which the coercivity of the magnetic material decreases to the field strength and subsequent cooling in the magnetic field produces an image having a pattern of magnetization in the reverse direction to the initial premagnetization; and

iii. heating the unmagnetized faceplate by the electron beam in the presence of a magnetic field as in (ii) to produce a pattern of magnetization on an unmagnetized ground, i.e., an image which is reversed from that of (i) supra.

All these techniques can be described generically as thermomagnetic recording. All require a controllable means to apply a magnetic field to the faceplate either prior to recording, during recording, or both. In some cases, it is necessary to initially demagnetize the plate. If the means to magnetize the plate is a coil or coil through which electric current is passed, the same coil may be employed to demagnetize by application of a decaying a.c. current pulse to produce an alternating magnetic field having a maximum strength exceeding the coercivity of the magnetic material.

When a frame of information has been written on the faceplate of the cathode ray tube as a pattern of magnetization, it is then transferred to a magnetic recording member external to the tube by thermoremanent transfer. This is achieved by placing a magnetic recording member having a coating containing a finely particulate hard magnetic material so that the magnetic material is in the magnetic field of signals generated by the pattern of magnetization on the faceplate. The magnetic coating of the recording member is then transiently heated to a temperature above the Curie temperature of the magnetic signals, for example, by exposure to a flash of electromagnetic radiation, and

permitted to cool in the field of the signals whereby thermoremanent copying of the image on the faceplate occurs.

THE DRAWINGS AND DETAILED DESCRIPTION OF THE INVENTION

This invention will be better understood by reference to the accompanying drawings in which FIG. 1 is an enlarged view of a cross section of a faceplate.

FIG. 2 is a schematic diagram showing a cathode ray tube and associated equipment which is capable of writing a line of information sequentially as a magnetic image on its faceplate and then transferring the image to a magnetic tape.

Referring to FIG. 1, there is shown in cross section, greatly enlarged, a view of a cathode ray tube faceplate.

The faceplate consists of a thin sheet of nonmagnetic gas impermeable material, 1, such as a metal foil or ceramic and which may be simple or composite having in the face thereof which is designed to form part of the interior surface of a cathode ray tube, a pattern of indentations, 2. The indentations are at least partially filled with a finely particulate hard magnetic material, 2, having a relatively low Curie temperature together with a binder.

The indentations in the surface of the faceplate may be in the form of a regular or irregular pattern of dots or lines or the like. The spacing between elements of the pattern indicated by the dimension c in the drawing should be less than the resolution distance required for the image and in general is between about 0.01 and about 0.001 inch.

The indentations are formed in the supporting member, 1, to leave a thickness, a , between the bottom of each pit and the unmodified face of the substrate which forms the external surface of the faceplate which is sufficiently small to permit effective transfer of any pattern of magnetization imposed on the faceplate to an external recording member. Generally, this will be less than 0.001 inch, and preferably less than 0.0005 inch. Some variation in the thickness, a , will occur due to inhomogeneity in the faceplate material and to the method employed to form the indentations. It is essential, however, that the indentations do not penetrate completely through the faceplate and accordingly such variations set a minimum thickness. In practice, it has been found possible to produce faceplates having a total thickness, c , of 0.001 inch which the distance, a , is an average of about 0.0001 inch. In any event, the distance, a , should be less than the resolution distance of the image.

The lateral dimensions of the faceplate are limited in part by the thickness, b , of the material employed and its physical properties which must be sufficient to support atmospheric pressure against the vacuum of the cathode ray tube without distortion sufficient to render secondary transfer impractical. If necessary, a rigid supporting grid can be placed under the faceplate providing cells in which one character of information such as a letter or a number can be recorded, thus minimizing the lateral dimensions which are unsupported and hence the required thickness of the faceplate.

The faceplate can be formed by any suitable method. A preferred method of construction is to employ a photoresist layer, form an image of the desired pattern of indentations on the photoresist, and after hardening and removal of the excess photoresist, etching the indentations with a suitable etchant.

After forming the pattern of indentations, the faceplate is cleaned and filled with the selected finely particulate magnetic material in the form of a paste or ink with a binder material and a solvent. Filling can be accomplished using a doctor knife as in gravure printing. The paste or ink is then dried and the binder hardened if this is required. Finally, surplus ink is cleaned from the faceplate with a mild abrasive. The faceplate is then ready to be mounted on the cathode ray tube.

The finely particulate hard magnetic material which forms the magnetic working substance of the faceplate should have a Curie temperature convenient for thermomagnetic recording. Preferably the Curie temperature should be between 50° C. and 500° C. and most preferably between 70° C. and 250° C. Chromium dioxide including modified chromium dioxides which have a Curie temperature in the range between 70° C. and 170° C. depending on the modifications are particularly suitable. Methods of making these materials are described in the following list of issued U.S. Pats. Nos.: Arthur, 2,965,955; Arthur & Ingraham, 3,117,093; Cox, 3,074,778; 3,078,147, U.S. 3,278,263; Ingraham & Swoboda, 2,923,683; 2,923,684; 3,034,988; 3,068,176 and Swoboda 2,923,685.

In general, when it is desired to demagnetize the faceplate by a magnetic field in the absence of the electron beam it is desirable that the working magnetic material of the faceplate should have a coercivity substantially less than the coercivity of the recording member external to the cathode ray tube to which the pattern of magnetization representing the image is subsequently transferred. For this reason it is desirable that the coercivity of the hard, finely particulate magnetic material should have a coercivity less than about 100 Oe.

It is by no means essential that the magnetic material completely fill the indentations in the faceplate. In general, even if the indentations are perfectly filled with the paste or ink of the hard magnetic particles shrinkage will occur when solvent is lost by evaporation. The total depth of magnetic material in the indentations should be sufficient to produce an appreciable signal when the indentations are selectively magnetized to form an image. On the other hand, if the depth of the hard magnetic material is increased, increasing energy is required for imaging and the time required for recording is increased since the heating effect of the electron beam is required to penetrate substantially through the layer of magnetic particles. The depth, d , of the magnetic material indicated in FIG. 1 is preferably of the order of 0.001 to 0.0002 inch. The surface area of the magnetic material is generally from 10 percent to 90 percent of the surface area of the magnetic area of the faceplate.

FIG. 2 shows a system for writing information on the faceplate of a cathode ray tube in the form of magnetic signals and transferring the same to the magnetic tape. The apparatus is composed of an evacuated envelope,

10, in which are disposed a heated filament, 11; a grid, 12; a first anode, 13, for focussing the electron beam and a second anode, 14, for accelerating beam towards the face of the cathode ray tube. Vertical deflection plates, 15, and horizontal deflection plates, 16, are also provided. The faceplate, 17, facing the conventional electron gun and deflecting means (11, 12, 13, 14, 15, and 16), is composed of a thin sheet of nonmagnetic impervious material in which is a pattern of indentations filled with finely particulate hard magnetic material as discussed hereinabove in connection with FIG. 1. The faceplate consists of an elongated strip having a width adequate to record a line of information and a height sufficient to accommodate a single character such as a letter or a number. Disposed on both sides of the faceplate are electromagnets, 18 and 19, which are adapted to apply a magnetic field to the faceplate, 17. In front of the faceplate, a magnetic tape, 20, is disposed so that the magnetic coating of the tape is essentially in contact with the faceplate, 17, and within the field of magnetic signals recorded thereon. The tape is fed from a roll, 21, and passed over idler rolls, 22 and 23, which hold it in front of the faceplate to a take-up roll 24. A xenon flash-lamp, 25, is provided in a reflective housing, 26, so that the magnetic coating of tape, 20, can be exposed to a high intensity flash of light through the back of the tape which should be transparent.

The above apparatus can be employed to record information as a pattern of magnetization on a magnetic tape. in the following ways. Electronic signals are fed at the input, 30, and decoded by conventional means, 31, to provide signals to the grid, 12, and to the horizontal, 15, and vertical, 16, deflection plates of the cathode ray tube. The faceplate of the cathode ray tube is premagnetized using the electromagnets, 18 and 19. The intensity of the electron beam is adjusted so that the beam at maximum intensity will heat the finely particulate hard magnetic material of the faceplate, 17, to about the Curie temperature. The information is then written on the faceplate by demagnetization of the premagnetized magnetic material as a line of characters, e.g., alphanumeric characters. At the end of each line when the horizontal deflection voltage reaches a predetermined value generally the maximum value required to sweep the electron beam across the face of the faceplate, the voltage actuates a trigger, 32, which operates flash lamp, 25. Lamp, 25, is adjusted so that the flash of light, usually less than 1 millisecond in duration, is sufficient to heat the magnetic coating of the tape, 20, to its Curie temperature. On cooling back through the Curie temperature the signal recorded on faceplate, 17, is transferred by thermoremanent transfer to tape, 20. The horizontal deflection voltage is also applied to a second trigger, 33, through a delay, 34, which operates magnets, 18 and 19, so that a magnetic field having a field strength exceeding the coercivity of the magnetic material of the faceplate is applied thereto, thus ready to receive the next line or frame of information.

The magnetic material of tape, 20, should have a relatively low Curie temperature to facilitate the thermoremanent transfer of information from faceplate, 17. It is also desirable that the magnetic material of tape, 20, have a coercivity which is substantially higher

than that employed in faceplate, 17, and higher than the magnetic field employed to remagnetize, 17, so that the tape is not substantially affected by the field created by magnets, 18 and 19.

After recording one line of information on the tape, 20, adjacent to faceplate, 17, the tape must be advanced ready to receive the next line of information. This can be accomplished by an intermittent drive timed so that the tape movement occurs while the information is being written in faceplate, 17. A continuous drive can also be employed provided that the linear motion during the transfer process does not exceed the desired resolution distance.

The above embodiment of the present invention is directed to the formation of a demagnetized image on a premagnetized recording member. It will be apparent to those skilled in the art that the same apparatus can be adapted readily to forming a magnetized image on an unmagnetized recording member. In this embodiment, the magnets, 18 and 19, apply a weak unidirectional field to faceplate, 17, while a line of information is being written on the faceplate, while an alternating decaying field having a maximum strength exceeding the coercivity of the magnetic material of the faceplate, but less than the coercivity of the magnetic material of tape, 20, is applied to refresh the surface.

The information recorded on tape, 20, can be stored and transported as such and read out as desired by conventional means. For example, the tape can be decorated with a magnetic pigment or toner which is attracted only to the magnetized areas of the tape and are thus made visible. The toner image can be transferred to paper if desired to form a permanent legible copy of the information recorded on the tape.

The foregoing detailed description has been given for clearness of understanding only and no unnecessary limitations are to be understood therefrom. The invention is not limited to the exact details shown and described, for obvious modifications will occur to those skilled in the art.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A cathode ray tube adapted to record a pattern of signals thermomagnetically as a pattern of magnetization on the faceplate thereof comprising:
 - an evacuated envelope;
 - an electron gun adapted to form a focussed beam of electrons;
 - means to modulate and deflect said beam of electrons in accordance with information supplied by electronic signals; and
 - a faceplate forming a part of said evacuated envelope opposite said electron gun consisting of a non-magnetic gas impermeable material, said faceplate having a pattern of indentations on the face within said envelope, said indentations containing a finely particulate hard magnetic material having a Curie temperature less than 500° C.
2. Apparatus of claim 1 in which said indentations are spaced at a distance less than the resolution distance of the information to be recorded and said indentations extending to a point less than the resolution distance from the exterior of said evacuated envelope.
3. Apparatus of claim 2 in which said finely particulate hard magnetic material is chromium dioxide.

4. Apparatus of claim 1 additionally comprising:
means to modulate the intensity and direction of said
beam in accordance with information supplied as elec-
tronic signals, whereby a sequence of lines of informa-
tion are recorded thermomagnetically on said 5
faceplate;

means to apply a magnetic field to said faceplate in
timed relationship with said lines, electronic infor-
mation to return said recording members to its
original state after each line and to provide mag-
netic conditions for thermomagnetic recording; a 10
magnetic recording member having a coating of a
finely particulate hard magnetic material with a
Curie temperature less than 500° C.;

means to move successive portions of said magnetic 15
recording member into the field of magnetic

signals of said faceplate whereby a different por-
tion of said magnetic recording member is present
as each line is recorded on said faceplate; and
heating means adapted and arranged to transiently
heat the magnetic material of said recording
member to a temperature of about the Curie tem-
perature at the end of each line but before the
faceplate is restored to its initial condition
whereby signals on said faceplate are transferred
thermoremanently to said recording member.

5. Apparatus of claim 4 is which the coercivity of the
finely particulate magnetic material of the magnetic
recording member is greater than the coercivity of fine-
ly particulate magnetic material of the faceplate.

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