

- [54] **MAGNETIC DOCUMENT ENCODER
HAVING MULTIPLE STAGGERED STYLI**
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- [51] **Int. Cl.** **G01d 15/12**
- [58] **Field of Search**..... **346/74 MP; 101/DIG. 13;
178/30; 360/123, 125**

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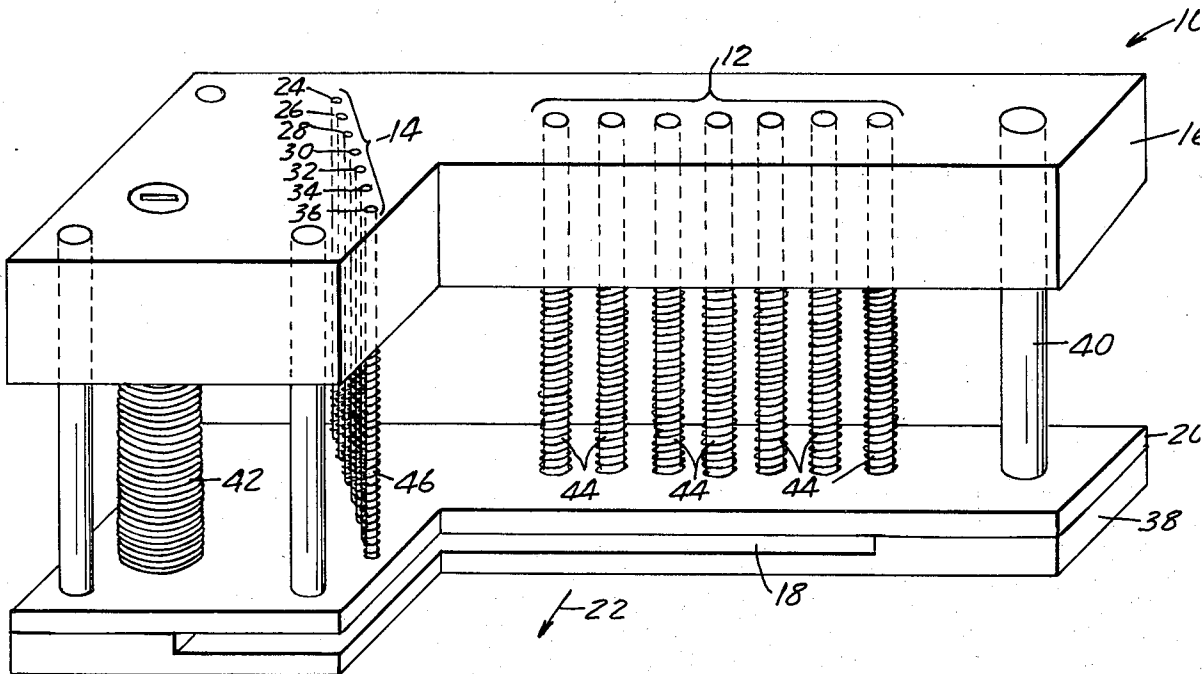
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[57] **ABSTRACT**

An apparatus for generating time-spaced intense localized magnetic fields outlining alphameric characters. The apparatus includes an array of staggered electromagnetic styli which are selectively energized by electrical pulses controlled by a dot pattern character generator, which pulses are selectively delayed prior to being applied to various styli, the amount of delay being dictated by the distance a particular stylus is offset from a reference line normal to a transport path past the styli.

18 Claims, 3 Drawing Figures



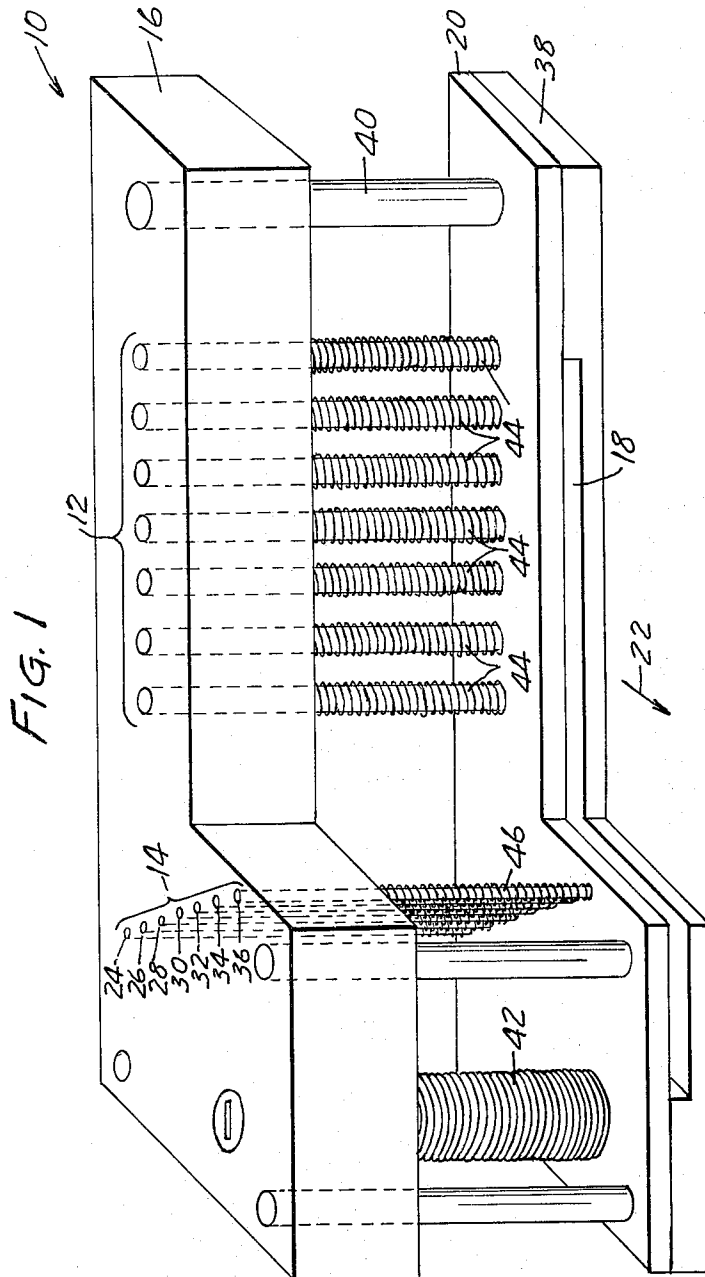


FIG. 2

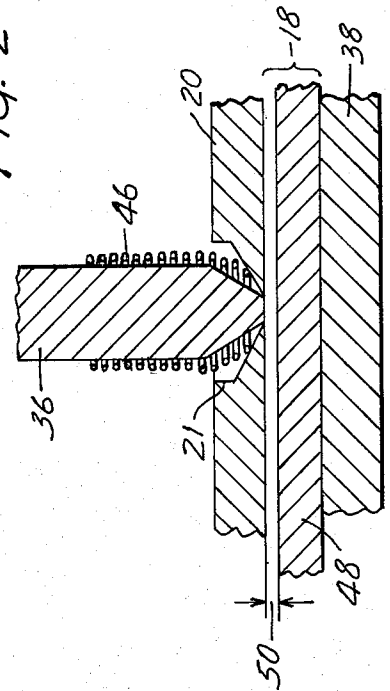
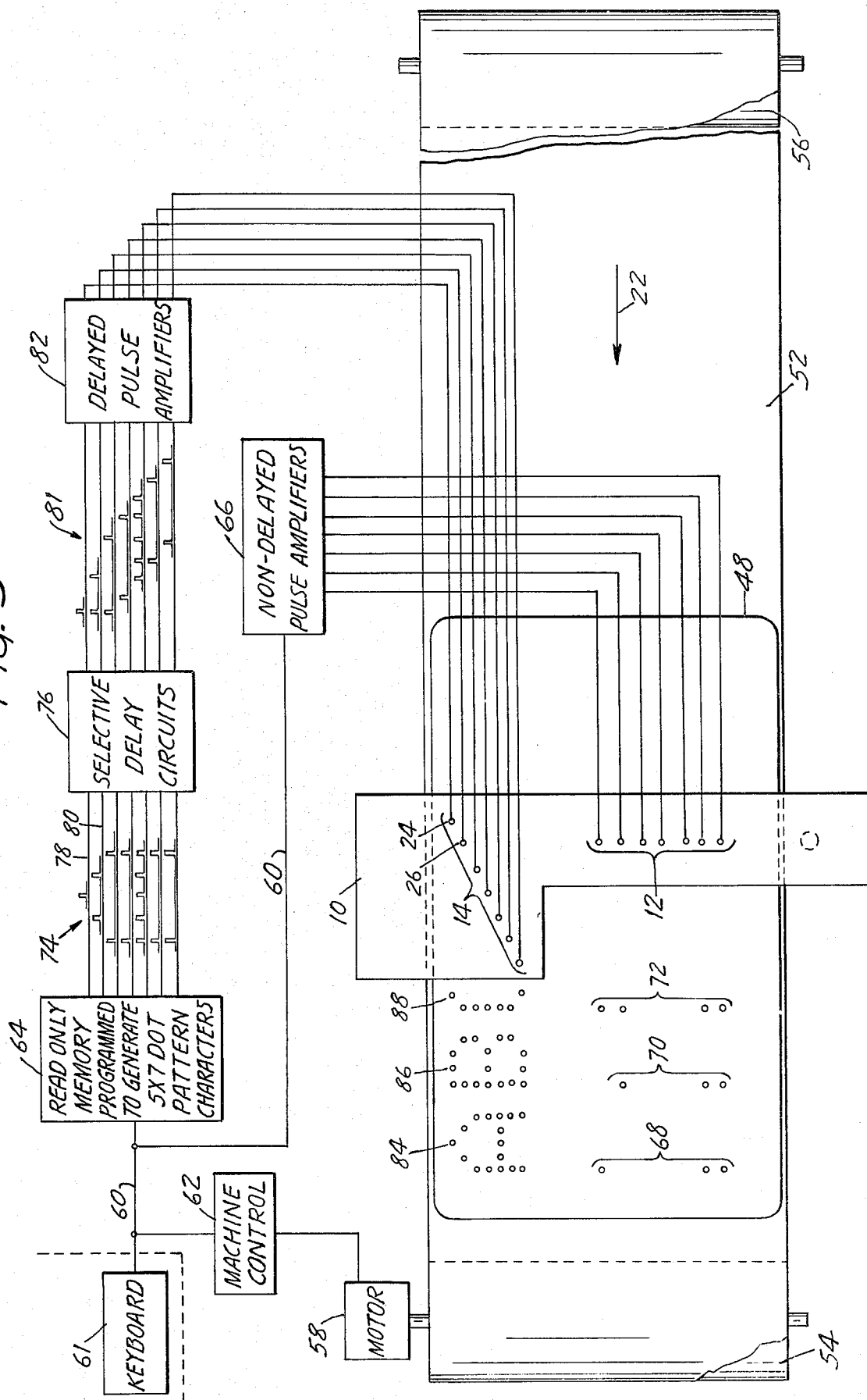


FIG. 3



MAGNETIC DOCUMENT ENCODER HAVING MULTIPLE STAGGERED STYLI

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to apparatus for presenting information in the form of localized magnetic fields for affecting magnetic documents and powders to form a magnetic replica of the localized fields.

2. Description of the Prior Art

Magnetic pole faces in the shape of alphameric characters are disclosed in U.S. Pat. No. 3,526,708 for use, a la typewriter keys, in producing magnetic patterns corresponding to the shaped pole faces. The patent also discloses the use of electromagnetic styli positioned in a line across a copy sheet, wherein each stylus is associated with a corresponding photocell, similarly positioned in a line across a previously formed master image. The photocells scan the master image and energize the matching styli to produce a replica of the master image. The physical and magnetic interference present in a closely spaced row of electromagnetic styli positioned perpendicular to the movement of a medium to be influenced upon the energization of the styli precludes the use of such positioned styli in systems requiring magnetic fields sufficient to magnetize permanent magnet materials such as barium ferrite. Further, the patent does not suggest the generation of a plurality of signals representing a given alphameric character and the use of such signals to selectively energize predetermined styli to produce a magnetic field replica of that character.

U.S. Pat. No. 2,841,461 discloses a magnetic printing apparatus in which electromagnetic styli are arranged in a two dimensional array to form alphameric characters by selective energization of appropriate styli. A permanent magnet surface to be magnetized thereby is positioned adjacent the entire array. Selected styli in the array are then simultaneously energized to form a magnetic image of the desired character. In one embodiment a number of such arrays are positioned in a staggered configuration.

In U.S. Pat. No. 3,426,338, a system is disclosed for electronically delaying a recording signal to each head within a multi-track recording head assembly to correct for misalignment of the heads. No suggestion is made that such a system could be used with an alphameric character generation apparatus.

SUMMARY OF THE INVENTION

The present invention provides an alphameric character generation apparatus which subjects a medium to time-spaced localized intense magnetic fields arranged in selective patterns outlining a given alphameric character. The apparatus comprises a mechanism for transporting and positioning the medium along a transport path, a staggered array of electromagnetic styli positioned across the transport path such that at least two of the styli are differently spaced from a reference line normal to the transport path and circuits for selectively energizing the styli in synchronization with the movement of the medium along the transport path to form a plurality of localized magnetic fields outlining an alphameric character. Each stylus comprises a substantially cylindrical body having a high permeability, high magnetic moment, and low magnetic remanence, which body terminates at one end as a shaped pole face

positioned along the transport path to concentrate the flux through said medium and terminates at the opposite end in a flux return member extending around and under said transport path. Each stylus further comprises a coil surrounding the body closely positioned adjacent the pole face to maximize the flux produced in the pole face in the medium, the coil containing not more than 500 turns. The circuits preferably provide electrical pulses representative of a given alphameric character to selectively energize the styli and synchronize the occurrence of the pulses with the movement of the medium. In the invention, pulses representing portions of a character parallel to the reference line are applied to energize each respective stylus, the pulses being offset in time by an amount proportional to the distance of each respective stylus from the reference line.

In a preferred embodiment, the styli are staggered along a row oblique to the transport path of the medium such that each stylus is a different distance from the reference line. Portions of the medium lying along a line normal to the transport path will thus pass adjacent each stylus at a different time. Electronic delay circuits are provided to accordingly selectively delay the application of energization pulses to given styli.

In contrast to the prior art, the present invention provides a compact apparatus capable of generating sufficiently intense fields to magnetize minute discrete locations within a sheet-like medium containing strongly magnetic permanent magnet materials such as barium ferrite. The discrete locations are preferably selectively positioned to establish an outline representative of a given alphameric character wherein the distance between the closest adjacent locations is less than the distance between adjacent styli. The maximum height for an alphameric character formed by the apparatus is less than the length of the row along which the styli are positioned.

The selectively magnetized medium is useful as a master source document in which the magnetized locations represent encoded information, which information is readily magnetically transferred to a transfer sheet. The present invention enables high speed encoding of such documents which has heretofore been impossible and which has imposed major restrictions on the use thereof.

As used herein, encoding means the formation of an array of magnetized locations within the medium representative of an alphameric character, wherein a given character representation consists of selected magnetized locations.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a three-dimensional view of the stylus assembly used in the apparatus of the present invention;

FIG. 2 is an enlarged cross-sectional view of the region proximate a stylus pole face and;

FIG. 3 is a combined top view and schematic of the apparatus of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

A three-dimensional view of the stylus assembly 10 for use in the apparatus of the present invention is shown in FIG. 1. The assembly contains two groups of electromagnetic styli 12 and 14 which are tightly mounted in a stylus support member 16 which provides

a return path for magnetic flux back to the styli. The styli extend to a position adjacent a recess 18 formed in base member 38 spaced from the member 16 by spacers 40 and 42. The recess 18 provides a part of a transport path 22 along which a medium may be passed. When selective styli within the groups of styli 12 and 14 are energized electromagnetic fields are generated and impressed upon the medium. The lower extremity of the styli 12 and 14 are received in appropriate openings provided in a nonmagnetic base member 20 positioned adjacent the base member 38 such that the tips of the styli pass through the openings and with the plate 20 form the top of the recess 18. The first group of styli 12 are positioned in a row extending perpendicular to the transport path 22, and are energized in a time-space relationship to a medium moved along the transport path to form machine-readable code representations of alphameric characters on the medium. In a preferred embodiment, the styli of the first group have a center-to-center spacing of 0.087 inches (2.2 mm) to correspond with the spacing of typical magnetic sensing heads in a reader for the medium, which heads are coupled to logic circuits enabling identification of a particular code representation as an alphameric character. Other spacings may similarly be used depending upon the code format selected.

The second group of styli 14 are positioned an equidistance along a row extending diagonally to the transport path 22. In a preferred embodiment, the first stylus 24 within the second group of styli 14 is positioned in line with the first group of styli 14, while successive styli 26, 28, 30, 32, 34, and 36 are spaced along the diagonal row at a center-to-center spacing of 0.089 inches (2.26 mm). The center-to-center spacing between the first and last stylus, 24 and 36 respectively, measured perpendicular to the transport path is 0.100 inches (2.5 mm).

When the medium is inserted in the recess 18, the magnetic flux created upon energization of the styli is concentrated through the medium 48 by the base member 38 which provides a portion of the flux return path back to the support member 16. Spacers 40 and 42 complete the flux return path back to the stylus support member 16. In one embodiment, the spacer 42 may comprise an electromagnetic coil to which direct current may be applied to provide a magnetic bias at the recess 18. If desired, an additional coil may be provided around the spacer 40 to improve the uniformity of the magnetic bias throughout the recess 18.

The magnetized areas produced upon selective energization of styli within the first group of styli 12 are intended to be sensed by discrete transducers, so it is desirable that the center-to-center spacing of adjacent styli be correlated with the center-to-center spacing of the transducers intended to be used. This freedom of selection allows sufficient spacing between adjacent styli so as to avoid magnetic interference or space limitations. In contrast, the magnetized areas produced upon selective energization of the styli within the second group of styli 14 are intended to be closely spaced to outline alphameric characters, with the magnetic field at a stylus being sufficient to magnetize permanent magnet materials such as barium ferrite. The physical size of the styli and associated electromagnetic coils surrounding each stylus needed to generate an intense localized magnetic field to magnetize such permanent magnet materials can be accommodated in a structure

in which the styli are diagonally positioned relative to the transport path. The styli within the second group 14 are, therefore, staggered along the transport path to avoid magnetic interference and space limitations. Such positioning of the styli together with selective energization of the styli in timespaced relationship to the movement of a medium along the transport path provides for closely spaced magnetized areas with the distance perpendicular to the transport path 22 between the first and last styli, 24 and 36 respectively, permitting alphameric characters to be formed having the height of a standard alphameric font, i.e. 0.100 inches (2.54 mm).

FIG. 2 is an enlarged cross-sectional view of a portion of a typical one of the styli 12 and 14, e.g., stylus 36, together with base members 20 and 38. The stylus 36 is conveniently a 0.030 inch (0.76 mm) diameter ARMCO steel wire, the tip of which had been sharpened to a diameter of less than 0.012 inches (0.30 mm). Similar metals characterized by a high permeability, high magnetic moment and low magnetic remanence may likewise be employed. The nonmagnetic base plate 20 is fabricated to provide a series of equally spaced holes corresponding to the desired positions of the styli 14, each hole having a body diameter 21 tapering to an opening 0.012 inches (0.30 mm) in diameter at the bottom of the base member 20. Upon assembly of the stylus 36 into the base member 20 the tip of the stylus 36 is forced to extend through the hole in the base member 20 and is subsequently ground flush with the upper surface of the recess 18. A coil 46 is carried on the stylus 36, positioned adjacent the base member 20 as close as possible to the stylus tip to minimize flux losses. The coil is preferably less than 500 turns so as to minimize the inductance, thereby allowing the production of short duration pulses with inexpensive pulse generating circuits. In a preferred embodiment, coil 46 has 250 turns of No. 36 AWG magnet wire, only a few of which turns are shown in FIG. 2. The height of the recess 18 is such that the spacing 50 between the top of any of a variety of media used for the medium 48 and the top of the recess 18 will be less than 0.004 inches (0.1 mm).

FIG. 3 shows a preferred embodiment in which the stylus assembly 10 is used to encode a medium such as a source document containing highly magnetic barium ferrite particles. The stylus assembly 10 is positioned to allow an endless belt 52 supported by rollers 54 and 56 to pass through the recess 18. When the belt 52 is moved by the motor assembly 58, a medium 48 carried on the belt 52 is caused to pass through the recess 18 at which time the medium 48 is subjected to the magnetic fields created by the selective energization of the styli 12 and 14. The belt 52 is preferably a thin, uniformly thick web of nonmagnetic material such as polyethylene terephthalate.

Electrical signals corresponding to and initiated by the selection of an alphameric character are generated in a key board 61 or other input device and are coupled via conventional data transmission lines 60 represented by a single line for processing the apparatus of the present invention. Such input signals are directly coupled to a machine control unit 62, to a read-only memory unit 64 and to nondelayed pulse amplifiers 66. The motor assembly 58 comprises a stepping motor which is driven by the machine control unit 62 to incrementally advance the endless belt 52 each time signals cor-

responding to a selected alphameric character are fed to the apparatus. In the embodiment shown, ASCII code signals are generated by the key board 61 for processing in the apparatus. Each ASCII code signal generated in response to a selected character input causes belt 52 and the medium 48 carried thereon to move six incremented steps. It is likewise intended that any various types of transport motion and electrical signals which together produce recognizable alphameric characters may be combined in a similar manner.

ASCII code signals representing alphameric characters are fed as seven parallel inputs via the transmission lines 60 to the nondelayed pulse amplifiers 66, whereon the signals are amplified and coupled directly to the coils for the first group of styli 12 for selective energization in accordance with the signals received. The resultant magnetized patterns 68, 70, and 72 shown on the medium 48 correspond to the ASCII code signals received for the characters "A", "B", and "C" respectively. At the same time, the ASCII code signals are similarly supplied by transmission lines 60 to a read-only memory unit 64 which is programmed to generate a 5×7 dot pattern character in response to a ASCII code input signal. Five possible time-sequenced pulses can thus be provided at each of seven outputs. The ASCII code signal received determines the time-sequenced pulses that will occur at the seven outputs to provide a timed pulse pattern representative of the alphameric character for the received ASCII code signal. Thus, in response to ASCII code signals representing the alphameric character A, the output of the read-only memory unit 64 will contain time-sequenced pulses shown at 74 which correspond to a dot pattern representation of the character A. The read-only memory unit 64 is preferably a standard metal oxide semiconductor integrated circuit read-only memory which had been masked at the time of manufacture to produce a 5×7 dot pattern, such as Fairchild Semiconductor, Inc., type A7K325819X. The outputs of the read-only memory unit 64 are coupled to selective delay circuits 76, which delay the signal generated at any one of the seven outputs an amount proportional to the distance that a given stylus within the second group of styli 14 is from a reference line normal to the transport path 22 formed by the row of the first group of styli 12. Signals on the first output 78 of the read-only memory 64 which are ultimately coupled to the first styli 24, pass through the selective delay circuits 76 without any delay. Similarly, signals on the second output 80 which are ultimately coupled to the second styli 26 pass through the selective delay circuits 76 after one time unit of delay, signals on the third output pass through with two time units of delay, etc. The composite delayed signals at the outputs of the delay circuits 76 for the letter A are shown at 81. The delayed pulses are amplified by the delayed pulse amplifiers 82 and are coupled to the appropriate styli within the second group of styli 14.

In a preferred embodiment, each memory unit 64 is connected through a serial shift register memory unit within the selective delay circuit 76, wherein one time unit of delay consists of six clock pulses so that each column is delayed a multiple of six clock pulses, depending upon the distance of the corresponding stylus from the reference line, i.e., the signals applied to stylus 24 are not delayed, signals applied to stylus 26 are delayed six clock pulses, etc. The distance between the

staggered styli 14 measured along the transport path 22 and the incremental motion of the belt 52, as controlled by the incremental motor 58, are interrelated such that after each incremental motion of the belt 52, the pulses delayed in the delay circuits 76 one time unit of delay are ready to be presented. The stepping motor 58 is synchronized with the time units of delay to advance the belt 52 in discrete increments of 0.0145 inches (0.37 mm) for each time unit of delay. Each stylus in the group of styli 14 is thus energized at the proper time by the control circuitry as the motor advances the belt 52, thereby magnetizing the medium 48 as shown by the dots outlining the alphameric characters 84, 86, and 88, corresponding to the alphameric characters A, B, and C.

It is readily seen that the above described technique allows the encoding of different character sizes and fonts by merely changing the read-only memory unit or the motor increments. Other dot size matrices may be selected by increasing the number of styli and modifying the associated electronics. The apparatus herein described is designed to operate at an encoding rate of 30 characters per second, however, higher speeds are possible by clocking the stepper motor 58 at higher rates. Other higher speed steppers or synchro-converters are available which will allow even faster encoding rates. The combination of the staggered styli 14, the electronic delay, stepper motor, and control circuitry allows a man readable alphameric character which is much smaller than the length of the styli array 14 to be magnetically encoded on a medium 48.

A specially desired attribute of the apparatus of the present invention is that magnetic fields are produced which are capable of reversing the magnetization in high coercivity materials such as barium ferrite. Both the fixed magnetic fields from the electromagnetic bias coil 42 and the pulsed magnetic fields produced by selective energization of the coils to styli 12 and 14 are used in an aiding fashion to develop such necessarily intense magnetic fields. The stylus shape shown in detail in FIG. 2 concentrates the flux to additionally intensify the magnetic fields at the styli pole face. The bias coil 42 (shown in FIG. 1) also allows the use of small styli coils, thus enabling closer spacing of the styli. Such biasing complements the use of low inductance styli coils, such that a high flux level can be obtained using relatively inexpensive, high-speed pulse generating circuits of conventional design to drive the styli.

In one embodiment for encoding a sheet comprising "Plastiform" brand rubber bonded permanent magnets containing barium ferrite particles, manufactured by Minnesota Mining and Manufacturing Company, the encoding pulses supplied to the second group of styli 14 have a duration of less than 100 microseconds and have an average amplitude of several amperes. Such pulses are readily produced by a capacitive-inductive circuit in which the inductive component is the coil forming a portion of each electromagnetic stylus. The time constant of the circuit is preferably selected to enable the generation of pulsed magnetic fields in the styli having a duration of less than 100 microseconds. The encoding speed may be altered by appropriate selection of pulse generator circuits and associated stylus electrical characteristics to match the type and thickness of media being encoded. The bias electromagnet 42 is preferably a 2,000 turn coil with a soft iron concentra-

tor core and is conveniently driven by a 20 volt power supply. The flux densities across the air gap 50 of FIG. 2 are typically in the range from 1200 to 7200 gauss for encoding such materials and can be increased up to the saturation level of the styli.

What is claimed is:

1. An apparatus for subjecting a medium to time-spaced localized intense magnetic fields outlining alphameric characters, which apparatus comprises:

means for transporting and positioning a medium along a transport path;

a plurality of electromagnetic styli positioned in a staggered array across said transport path such that at least two of said styli are differently spaced from a reference line normal to said transport path, each of said styli comprising a substantially cylindrical body having a high permeability, high magnetic moment, and low magnetic remanence, which body terminates at one end as a shaped pole face positioned along the transport path to concentrate the flux through said medium and terminates at the opposite end in a flux return member extending around and under said transport path and further comprising a coil surrounding said body closely positioned adjacent said pole face to maximize the flux produced in the pole face in said medium, said coil containing not more than 500 turns; and means for selectively energizing said styli in synchronization with the movement of the medium to form a plurality of localized magnetic fields outlining an alphameric character.

2. An apparatus according to claim 1, wherein said means for selectively energizing said styli further comprises

means for providing electrical pulses representative of a given alphameric character to selectively energize said styli, wherein pulses representing portions of a character parallel to said reference line are applied to energize each respective stylus offset in time by an amount proportional to the distance of each respective stylus from said reference line; and control means for synchronizing the occurrence of the pulses with said movement of the medium.

3. An apparatus according to claim 2 wherein said electrical pulse providing means comprises a current pulse generator matched to the characteristics of said coil to be capable of producing a non-alternating pulsed magnetic field, the intensity of which approaches the saturation magnetization of said stylus pole face.

4. An apparatus according to claim 1, further comprising means for directing the magnetic flux associated with the magnetic fields produced by a given stylus through the medium and back to said given stylus.

5. An apparatus according to claim 4, further comprising means for subjecting the medium to a magnetic bias to supplement the magnetic fields produced by the selectively energized styli.

6. An apparatus according to claim 1 further comprising additional electromagnetic styli positioned across said transport path, which additional styli when selectively energized form another set of localized magnetic fields machine-readable as a said alphameric character, and additional means for providing electrical pulses representative of a machine-readable code corresponding to a said alphameric character to selectively energize said additional styli.

7. An apparatus according to claim 2, wherein the staggered styli are uniformly spaced along a row extending diagonally across the transport path.

8. An apparatus according to claim 7, wherein the means for transporting said medium moves said medium along said transport path at a uniform predetermined speed and wherein the means for providing said electrical pulses comprises electronic delay circuits coupled to each stylus, wherein a first stylus defines said reference line and the other styli are spaced a multiple of a predetermined distance from said reference line, and the time delay associated with the energization of each stylus to form a line of localized magnetic fields parallel to said reference line is a multiple of a predetermined time required for the medium to be transported said predetermined distance.

9. An apparatus according to claim 8, wherein said electrical pulse providing means further comprises pulse generating means for operating on input signals characteristic of a given alphameric character and for producing a set of parallel input pulse trains, wherein a given alphameric character is represented by fewer pulses within each of the parallel pulse trains than there are parallel pulse trains, and wherein each of the pulse trains is in order coupled to the electronic delay circuit associated with a given stylus in order along said oblique row.

10. An apparatus according to claim 9, wherein seven styli are positioned along said diagonal row, wherein a given alphameric character is represented by not more than five pulses within each pulse train and wherein said pulse generating means comprises a read-only electronic memory, masked to produce a five by seven dot pattern.

11. An apparatus according to claim 10, wherein said pulse generating means comprises an electronic circuit including a triggerable source of pulses having a duration of not more than 100 microseconds, and a capacitive-inductive circuit in which the inductive component is a coil forming a portion of said electromagnetic stylus, in which the time constant of the capacitive-inductive circuit is selected to enable the circuit to respond to said source of pulses to generate in said stylus a pulsed magnetic field having a duration of not more than 100 microseconds.

12. A method for subjecting a medium to time-spaced localized intense magnetic fields outlining alphameric characters, which method comprises:

transporting and positioning a medium along a transport path;

providing a plurality of electromagnetic styli, each stylus comprising a substantially cylindrical body having a high permeability, high magnetic moment, and low magnetic remanence, which body terminates at one end as a shaped pole face positioned along the transport path to concentrate the flux through said medium and terminates at the opposite end in a flux return member extending around and under said transport path and further comprising a coil surrounding said body closely positioned adjacent said pole face to maximize the flux produced in the pole face in said medium, said coil containing not more than 500 turns;

positioning said electromagnetic styli in a staggered array across said transport path such that at least two of said styli are differently spaced from a reference line normal to said transport path;

selectively energizing said styli in synchronization with the movement of the medium to form a plurality of localized magnetic fields outlining an alphameric character.

13. A method according to claim 12 wherein the step of selectively energizing the styli further comprises providing electrical pulses representative of a given alphameric character to selectively energize said styli, wherein pulses representing portions of a character parallel to said reference line are applied to energize each respective stylus offset in time by an amount proportional to the distance of each respective stylus from said reference line; and synchronizing the occurrence of the pulses with said movement of the medium.

14. A method according to claim 12, further comprising subjecting the medium to a magnetic bias to supplement the magnetic fields produced by the selectively energized styli.

15. A method according to claim 12, further comprising positioning additional electromagnetic styli across said transport path, which additional styli when selectively energized form another set of localized magnetic fields representing a machine-readable code identifying a said alphameric character, and providing electrical pulses corresponding to said machine readable code to selectively energize said additional styli.

16. A method for magnetically encoding man readable alphameric characters on a magnetizable medium comprising the steps of

transporting and positioning a said medium along a transport path,

providing a plurality of electromagnetic styli, each stylus comprising a substantially cylindrical body having a high permeability, high magnetic moment, and low magnetic remanence, which body terminates at one end as a shaped pole face positioned along the transport path to concentrate the flux through said medium and terminates at the opposite end in a flux return member extending around and under said transport path and further comprising a coil surrounding said body closely positioned adjacent said pole face to maximize the flux produced in the pole face in said medium, said coil containing not more than 500 turns,

positioning said plurality of electromagnetic styli in a staggered array across said transport path such that at least two of said styli are differently spaced from a reference line normal to the transport path,

providing electrical pulses representative of a given alphameric character to selectively energize said styli to produce a predetermined high intensity localized magnetic field about said styli to form a locally magnetized region within said medium proximate said styli, wherein pulses representing portions of a character parallel to said reference line are applied to energize each respective stylus offset in time by an amount proportional to the distance of each respective stylus from said reference line, and

synchronizing the occurrence of the pulses with the movement of said medium, wherein the styli are selectively energized to form in said medium a pattern of said locally magnetized regions representing a man readable alphameric character.

17. An apparatus for magnetically encoding man readable alphameric characters on a magnetizable medium comprising

means for transporting and positioning a said medium along a transport path,

a plurality of electromagnetic styli positioned in a staggered array across said transport path such that at least two of said styli are differently spaced from a reference line normal to the transport path, each of said styli comprising a substantially cylindrical body having a high permeability, high magnetic moment, and low magnetic remanence, which body terminates at one end as a shaped pole face positioned along the transport path to concentrate the flux through said medium and terminates at the opposite end in a flux return member extending around and under said transport path and further comprising a coil surrounding said body closely positioned adjacent said pole face to maximize the flux produced in the pole face in said medium, said coil containing not more than 500 turns,

means for providing electrical pulses representative of a given alphameric character to selectively energize said styli to produce a predetermined high intensity localized magnetic field about said styli to form a locally magnetized region within said medium proximate said styli, wherein pulses representing portions of a character parallel to said reference line are applied to energize each respective stylus offset in time by an amount proportional to the distance of each respective stylus from said reference line, and

control means for synchronizing the occurrence of the pulses with the movement of said medium, wherein the styli are selectively energized to form in said medium a pattern of said locally magnetized regions representing a man readable alphameric character.

18. An apparatus for high speed magnetically encoding time-spaced patterns of localized magnetized regions forming man readable alphameric characters on a magnetizable sheet-like medium having a coercivity of not less than 2,000 oersteds comprising

means for incrementally moving a said medium along a transport path and for temporarily fixing the position of said medium with respect to a reference line normal to said transport path in response to a control signal,

a plurality of electromagnetic styli positioned in a staggered array across said transport path, each of said styli comprising a substantially cylindrical body having a high permeability, high magnetic moment, and low magnetic remanence, which body terminates at one end as a shaped pole face positioned along the transport path and terminates at the opposite end in a flux return member extending around and under said transport path to concentrate the flux through said medium and further comprising a coil surrounding said body closely positioned adjacent said pole face to maximize the flux produced in the pole face in said medium, said coil containing not more than 500 turns, wherein at least two of said styli are differently spaced from said reference line along said transport path, which styli when energized form said selective pattern of localized magnetized regions,

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means for providing electrical pulses less than 100 microseconds in duration representative of a given alphameric character to selectively energize said styli in synchronization with the incremental movement of the medium to produce adjacent said energized styli and in the transport path a localized magnetic field having an intensity of not less than 2,000 gauss to form said selective pattern of localized magnetized regions, wherein pulses represent-

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ing portions of a character parallel to said reference line are applied to energize each respective stylus offset in time by an amount proportional to the distance of each respective stylus from said reference line, and control means for synchronizing the occurrence of the pulses with said incremental movement of the medium.

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