

Feb. 11, 1969

H. C. WATERMAN

3,427,633

PAGE PRINTING DEVICE WITH MARKING MATERIAL BEARING WEB
BETWEEN SCANNING STYLI AND RECORD MEDIUM

Filed May 4, 1964

Sheet 1 of 2

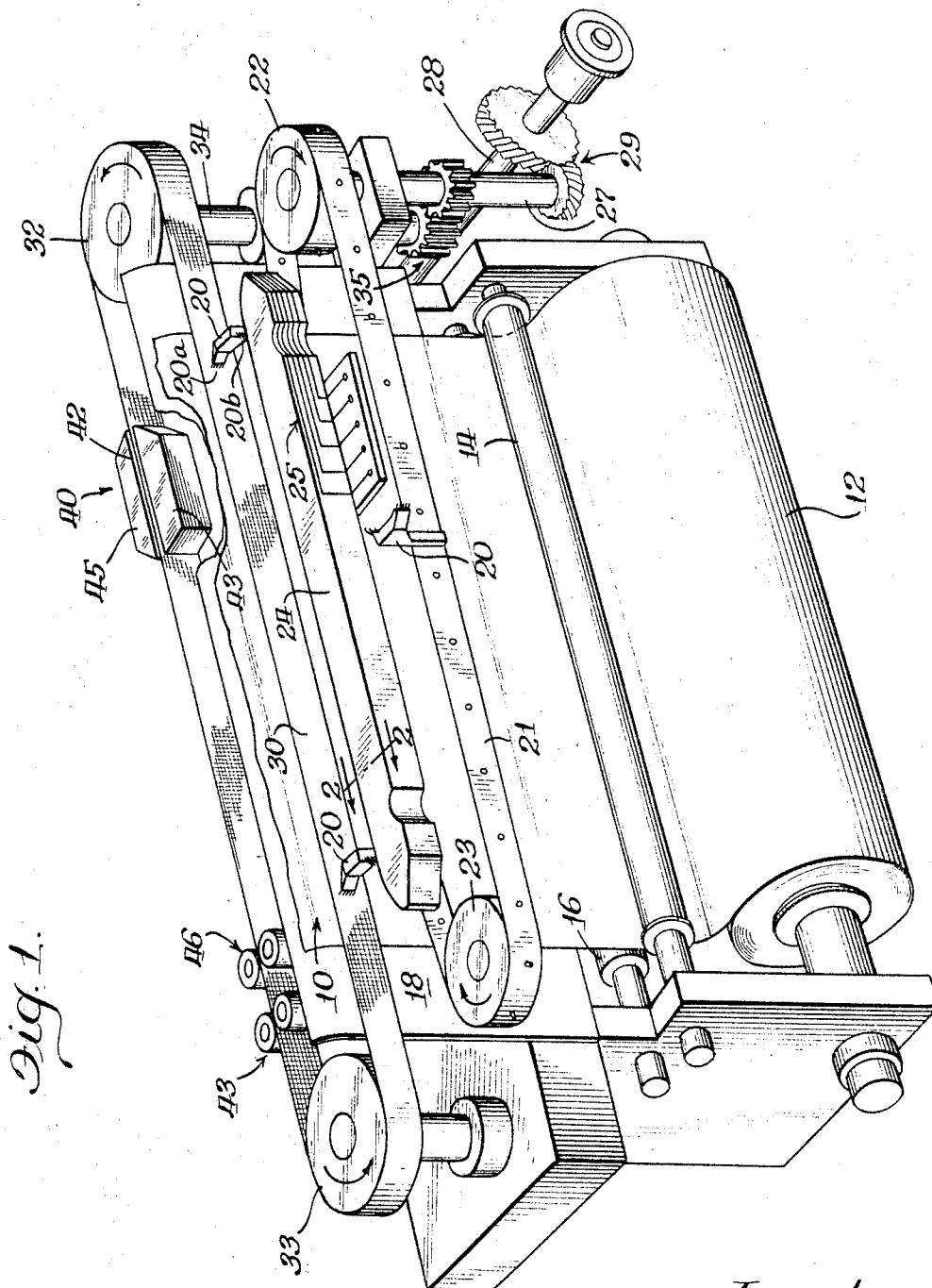


Fig. 1.

Inventor:
Herbert C. Waterman
By *Mueller & Aichele*
Attys.

Feb. 11, 1969

H. C. WATERMAN
PAGE PRINTING DEVICE WITH MARKING MATERIAL BEARING WEB
BETWEEN SCANNING STYLI AND RECORD MEDIUM

3,427,633

Filed May 4, 1964

Sheet 2 of 2

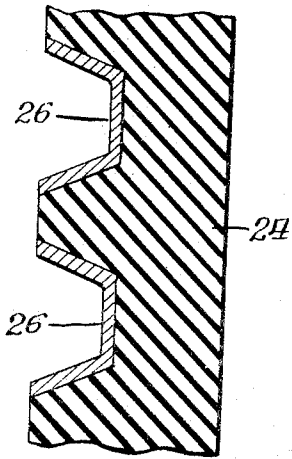


Fig. 2.

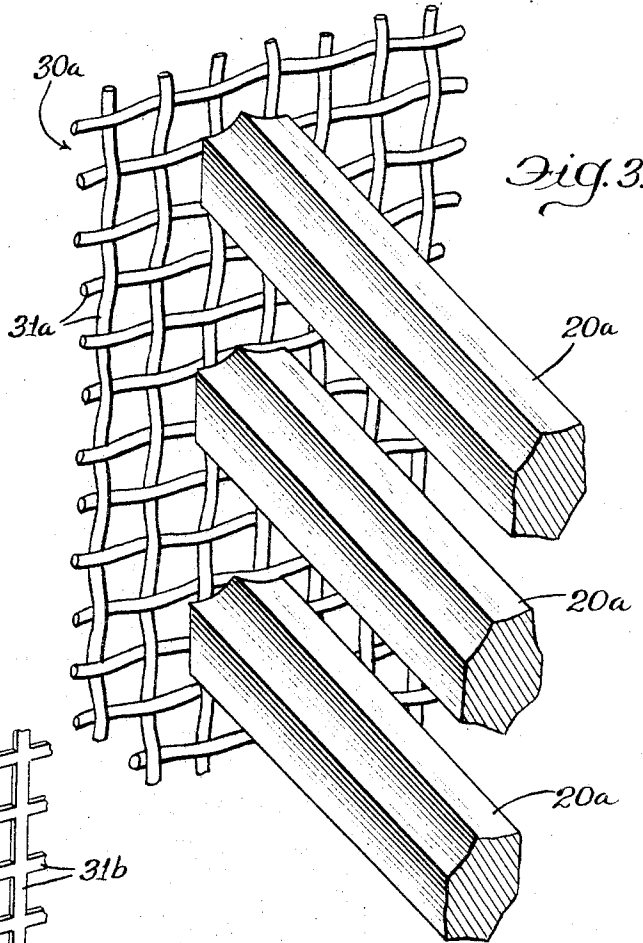


Fig. 3.

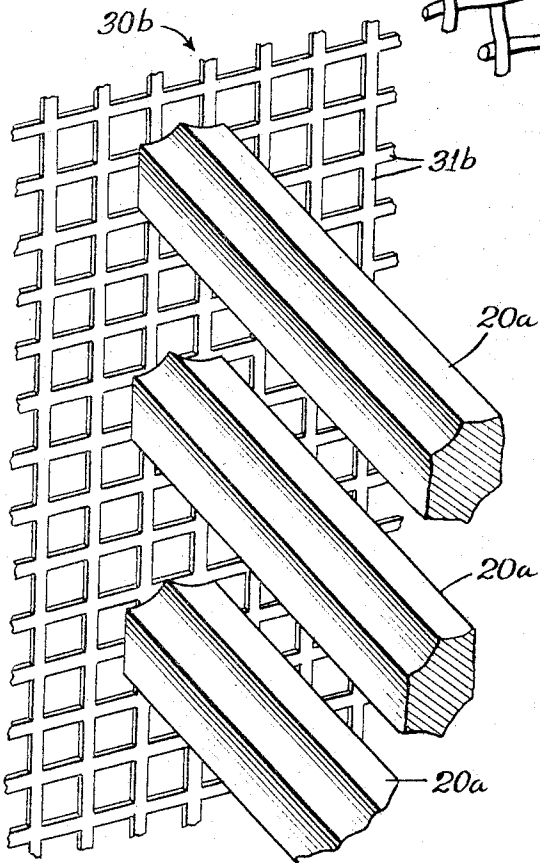


Fig. 4.

Inventor:
Herbert C. Waterman
By
M. J. Mullen & Associates
Attys

1

3,427,633

PAGE PRINTING DEVICE WITH MARKING MATERIAL BEARING WEB BETWEEN SCANNING STYLI AND RECORD MEDIUM

Herbert C. Waterman, North Palm Beach, Fla., assignor to Motorola, Inc., Franklin Park, Ill., a corporation of Illinois

Filed May 4, 1964, Ser. No. 364,672

U.S. Cl. 346—74

Int. Cl. G01d 15/06

4 Claims

ABSTRACT OF THE DISCLOSURE

An electronic printing system uses a plurality of electrically energized scanning styli which are moved across a recording sheet. A belt having a plurality of minute apertures therein and impregnated with an opaque conductive material is interposed between the styli and the recording sheet. Energization of the styli causes a current to flow through the marking material to cause the marking material in the belt to be impinged on the recording sheet in the form of a dot to thereby mark the recording sheet as desired.

Many present day message printers used in conjunction with binary and similar information systems are provided with an electrode assembly which scans across a moving sheet of recording paper. The electrode assembly includes a number of styli which are coupled by commutation means to decoding apparatus that supplies electrical impulses to the styli in a coded sequence that results in reproduction of characters on a recording sheet. One such printer is described in copending application Ser. No. 857,444 by H. C. Waterman, filed Dec. 4, 1959, now Patent No. 3,166,752, and commonly assigned.

In printers of the above described type the recording sheet may be an electrosensitive paper of the dry burn-off type. Such paper consists of a base layer of relatively high conductivity material, usually of a black or dark color, and a coating of opaque semiconductive material, usually of a white or light color. Discharge of electrical current from the printing styli removes localized areas of the semiconductive coating of the recording paper so that the contrasting base layer is exposed in the outline of design desired characters.

Still other types of printers use special styli of iron or stainless steel which are maintained in contact with an electrochemical paper containing a moist electrolyte. An electrolytic action takes place between selectively energized styli and the paper, resulting in the formation of a pigment to thereby produce an outline of desired characters.

Both the electrosensitive and the electrochemical papers which are commonly available for message printers are expensive and require special handling and storage. The surface of electrosensitive paper is easily scratched or otherwise marred, and electrochemical paper requires a special fibrous content to limit the available types of paper. In addition, electrochemical paper usually requires that a special humidifying chamber be incorporated in the printer so that the proper moisture content can be maintained for electrolytic action.

It is readily apparent that in message printers of the above described type, wherein characters are printed on a recording sheet by applying electrical impulses to selected styli, the use of plain paper that is not required to have any special electrical or chemical properties to give rise to special treating, storage and handling, and which can be made as thin as is consistent with the mechanical feed system of the printer without wrinkling or tearing, would be highly advantageous in terms of cost and would enable

2

the design of a more versatile and compact printing system.

Accordingly, it is among the objects of the present invention to provide a message printer of the type utilizing electrically energized styli in which characters may be printed on plain paper that is not required to have any special electrical or chemical properties.

Another object is to provide an improved printer of the type wherein characters are printed by applying electrical impulses to selected styli, and including means to enable messages to be printed directly on plain, untreated paper.

A further object is to provide means to be used in conjunction with a message printer having electrically responsive printing styli, which means allows continuous and uninterrupted printing on economical paper that does not require any special treating, handling or storage.

A feature of the present invention is the provision of an arrangement for carrying marking material between the printing styli and a sheet of plain, untreated paper so that as electrical impulses are applied to selected styli dots are formed on the plain paper in a prescribed pattern.

Another feature of the invention is the provision of a continuously moving ribbon conveying a conductive marking material and adapted to move in a path between the scanning electrode assembly of a message printer and the recording sheet such that upon electrical energization the printing styli in a selected sequence dots are impinged in the form of characters on the recording sheet.

A further feature is the provision, in a message printer of the above described type, of a continuously moving belt comprised of a web having a number of minute apertures therein to act as a conveyor for a semisolid conductive marking material disposed between the printing styli and a plain paper recording sheet. The printing styli move in sliding contact over the surface of the belt, and when energized by electrical impulses an electrical discharge causes localized quantities of marking material to be expelled therefrom and deposited upon the plain paper recording sheet in the form of a dot. A plurality of such dots thus deposited form desired characters in response to a received coded message.

Still another feature is the provision, in apparatus of the above-described type, of means for continuously replenishing the moving belt with marking material so that new marking material is present at all times during the movement of printing styli thereon.

Other objects, features and attending advantages of the invention will become apparent from the following description when taken in conjunction with the accompanying drawings, in which:

FIG. 1 is an isometric view of a message printer incorporating the principles of the present invention;

FIG. 2 is a partial cross-section taken along lines 2—2 of FIG. 1;

FIG. 3 is an enlarged view of one form of a web-belt which may be used to convey the marking material; and

FIG. 4 is an enlarged view of another form of a web-belt which may be used with the printer.

The message printer of the invention includes at least one scanning electrode assembly which prints complete lines of the message on a recording medium as it scans across the medium. The recording medium, which is plain paper that does not have any special electrical or chemical properties, may be fed from a roll situated in the printer and moved at approximately right angles to the traverse of the scanning electrode assemblies. The scanning electrode assemblies each including a plurality of vertically positioned styli, and during each scan of the printing medium the styli are connected by a slip-bar commutator to a coding system which sequentially energizes se-

lected styli. Although the invention is particularly set forth with a printer having three scanning electrode assemblies and using a number of vertically spaced styli, it is to be understood that it may be used with various types of electronic printers having other electrode and styli combinations wherein selected styli are energized in response to a received signal having a coded sequence of electrical impulses.

To achieve printing on plain, untreated paper there is provided a ribbon or belt comprised of a web having a large number of minute apertures therein. Preferably the apertures are small with respect to the cross-sectional area of individual ones of the printing styli. The belt is continuously moved between the scanning electrode assemblies and the plain paper so that the printing styli makes a slight contact pressure therewith. The belt conveys a marking material, such as a wax-like binder carrying an incoherent carbonaceous substance, as for example, carbon or graphite particles, between the paper and the styli. Preferably, the belt further moves through charging apparatus so that it is replenished with marking material during scan by the electrode assembly. Thus, a new area of marking material is presented to the printing styli during each scan of the recording sheet.

When selected styli are energized with electrical impulses, current flow causes relatively intense localized heating under the styli so that an explosive effect takes place, resulting in an overpressure beneath the selected styli which expels marking material from the web to be impinged on the recording sheet. The marking material is retained as an isolated dot on the recording sheet, and a plurality of dots so formed produce the desired character.

Referring to FIG. 1, numeral 10 indicates a sheet of plain paper which may be conveniently stored on roll 12. Paper 10 passes between guide roller 14 and pressure roller 16, and is advanced over a metal backing plate 18. A drive roller (not shown for simplicity of the drawings) and suitable idler rollers may be located above backing plate 18 to produce advancement of the paper. The drive roller in turn is coupled by suitable gearing and pulley arrangements to a drive motor to cause paper 10 to be moved vertically past backing plate 18. Paper drive arrangements of this type are known in the art and may be, for example, of the type described in the aforesaid copending application Ser. No. 857,444.

A plurality of scanning electrode units 20 are secured to horizontally disposed belt 21, looped around pulleys 22 and 23. Pulley 22 and 23 in turn are arranged to carry electrode assemblies 20 in a horizontal path between paper 10 and slip-bar commutator 24. Slip-bar commutator 24 is positioned above belt 21 and in front of paper 10 by suitable brackets (not shown). Pulley 22 is supported on shaft 27 and driven by shaft 28 through gearing arrangement 29. Shaft 28, in turn, is coupled to the drive motor which advances paper 10 so that as paper 10 is moved vertically across backing plate 18, it is also scanned by electrode assemblies 20. Pulley 23 functions as an idler.

Each electrode assembly 20 includes a plurality of vertically spaced conductive electrodes, each having a number of vertically positioned marking styli 20a, and each further having finger portions 20b. Marking styli 20a are directed towards and adapted to be in sliding contact with web-belt 30. Electrode finger portions 20b are directed towards and adapted to be in sliding contact with the side of slip bar commutator 24 that faces paper 10, which side contains a plurality of horizontally disposed, insulated spaced conducting grooves 26 (FIG. 2) adapted to make electrical contact with electrode finger portions 20b. Electrode assemblies 20 are carried horizontally between paper 10 and slip-bar commutator 24 so that electrode finger portions 20b are in electrical contact with conducting grooves 26 during scan of paper 10. Electrical impulses are selectively applied to individual conductors 25 on the back side of slip-bar commutator 24. Each conductor 25 completes an electrical circuit with a respective one of conducting grooves 26. Conductors 25

and conducting grooves 26 may be formed on slip bar commutator 24 by plating or similar techniques. Details of the manner in which the electrodes of electrode assemblies 20 are energized by impulses applied to slip-bar commutator 24 and the manner in which slip-bar commutator 24 supplies the impulses to electrode assemblies 20 in response to a received binary code are fully set forth in copending application Ser. No. 857,444. As therein described, this arrangement provides a printing unit wherein the scanning electrode assemblies print complete lines of a message as a recording medium such as paper 10 is scanned by electrode assemblies 20.

In order to provide printing on plain, untreated paper, in accordance with one embodiment of the present invention, web-belt 30 is looped around pulleys 32 and 33 and is positioned to pass over paper 10 immediately opposite styli 20a as paper 10 is scanned by electrode assemblies 20. Web-belt 30 is maintained in sliding contact with or positioned a very slight distance from paper 10. Pulley 32 is supported on shaft 34 and shaft 34 is in turn driven from the shaft 27 by the gearing arrangement 35. Gearing arrangement 35 is adapted to drive pulley 32 concurrently with pulley 22 but in an opposite direction, as shown by the arrows in FIG. 1. This causes web-belt 30 to move across paper 10 in the same direction as electrode assemblies 20. In addition, and for the reasons hereinafter discussed, gearing arrangement 35 between shafts 34 and 27 is adapted to drive pulley 32 at a slower speed than pulley 22.

Web-belt 30 conveys a marking material containing carbon particles between styli 20a and paper 10 as it is revolved by pulley 32. When selected marking styli are supplied with an electrical impulse resulting current flow through web-belt 30 causes a small dot of marking material to be impinged on paper 10. The dot is opaque and when coded impulses are supplied to electrode assemblies 20 by slip-bar commutator 24 desired characters are formed on paper 10. Although the exact physical reaction is complex, it is believed that localized current flow in the carbon particles of the marking material directly beneath the energized stylus results in temperature rise under the energized localized heating and hence an overpressure to mechanically force particles included in the marking material with which web-belt 30 is impregnated onto paper 10 by a minute explosive action. Accordingly, the reaction is believed to be mechanical or thermal in nature and no known chemical reaction is involved in the actual printing process.

Web-belt 30 contains a plurality of apertures to provide a fine mesh. In order to produce localized coherent dots on paper 10, the apertures in web-belt 30 should be small with respect to the diameter of an energized stylus so that there are several apertures for one stylus diameter. For example, for a .008 inch diameter tungsten stylus a 250-300 mesh screen may be used for web-belt 30. With particular reference to FIG. 3, there is shown a greatly enlarged view of one embodiment of web-belt 30 in relation to styli 20a. Web-belt 30a of FIG. 3 may be woven from strands 31a of organic or synthetic fibers such as silk, nylon, fiber glass, and various polyester and acrylic materials, or from a metallic mesh which may be anodized where an insulated belt is desired. Alternately the web-belt may be fabricated by etching a thin metal sheet such as shown at 30b of FIG. 4. In this instance a plurality of apertures are defined by cross-ribs 31b. A thin steel sheet may be fabricated in this manner by known chemical milling or etching techniques.

Web-belt 30, as has been noted, is driven by pulley 32 to move across paper 10 in the same direction as the scanning motion of electrode assemblies 20. Web-belt 30 is also recharged or replenished with marking materials as it revolves. Gearing arrangement 35 is adapted to drive web-belt 30 at a slower relative speed, as for example, at one-half the speed of electrode assemblies 20 carried by belt 21. This allows each electrode assembly to scan across a fresh area of marking material on web-belt 30

during the printing of each line on paper 10.

Storage vessel 40 contains a quantity of semisolid marking material which is applied to web-belt 30 by passage through a narrow, slit-like opening 42. For application to one side of web-belt 30 one side 43 of storage vessel 40 functions as a backing plate, while the sliding contact with marking material contained in side 45 of storage vessel 40 provides a coating on one side of web-belt 30. To facilitate coating storage vessel 40 may contain flexible fingers to provide a brushing action, a felt pad impregnated with the marking material, or rollers which contact web-belt 30 during its passage therethrough. After a fresh supply of marking material is applied, web-belt 30 passes between sizing rollers 46 and 48. These sizing rollers provide a hard (preferably metallic) surface in rolling contact with web-belt 30 to remove excess material and provide a smooth, nontacky surface.

Alternatively, web-belt 30 may take the form of a ribbon, treated with a carbon graphite containing marking material, and contained on a spool replacing pulley 33. The ribbon may be fabricated as illustrated in FIGS. 3 and 4, or may be more homogeneous in nature and completely impregnated with the marking material. The ribbon should have sufficient mechanical integrity so that it is not deformed by styli 20a. A takeup spool replaces pulley 32, and when driven by shaft 34 causes the ribbon to pass between electrode assemblies 20 and paper 10, with printing achieved in the described manner. When the spool is exhausted the ribbon is then replenished or recharged with the marking material.

The marking material applied to web-belt 30 may be a semisolid paste or wax-like binder containing a conductive marking dye such as graphite and carbon black. For example, the binder may be a blend of thermoplastic resins such as vinyl resins, paraffin wax, and a plasticizer such as chlorinated polyphenyl. The marking of the paper 10 is produced primarily by graphite or carbon particles or other conductive dyes incorporated in the binder as they are projected from web-belt 30 as the result of electrical impulses applied to the styli 20. The viscosity and conductivity of the marking material is controlled by the ratio of binder to graphite and carbon black, and by the particle size.

The conductivity of the marking material applied to web-belt 30 should be less than 3,000 ohms per square. Voltage impulses up to 1,000 volts may be applied to styli 20a, with 200-600 volts typical. This produces a current in the order of 15-20 ma. from each styli, and because of the small cross-sectional area extremely high current densities are produced under each styli to expel graphite particles from web-belt 30 onto paper 10 for the desired marking. Where web-belt 30 is fabricated from a non-conductive fiber, as in FIG. 3, the current return path is laterally through the sheet resistivity of the marking material applied thereto to backing plate 18 or pulleys 32 or 33, which are maintained at ground reference potential. For a lower resistance return path web-belt 30 is fabricated from a thin steel sheet by etching, as shown in FIG. 4, ground return may be provided by a flexible electrode or brush presenting a large-area sliding contact to the coated side of web-belt 30, and with the marking preventing direct shorts of the styli to the web-belt 30.

I claim:

1. Apparatus for electrically imprinting characters on a plain paper recording sheet, which apparatus includes means for moving said recording sheet in a predetermined direction, a plurality of electrode assemblies each having a plurality of printing styli, and means for applying electrical impulses to said styli in a coded sequence, the combination including means for causing said electrode assembly to move repeatedly in a scanning path transverse to the direction of movement of said recording sheet, with said styli in close proximity to said recording sheet during said scanning movement, a pair of pulleys, a belt looped around said pulleys and movable thereby, said

belt positioned to move between said styli and said recording sheet drive means for said pulleys to move said belt in the same direction as said electrode assemblies and slower than the scanning speed thereof whereby said styli move along said belt, said belt composed of a web having a plurality of minute apertures therein, and said belt being impregnated with an opaque marking material containing conductive particles, said marking material covering said belt whereby said marking material is disposed between said styli and said belt, whereby said electrical impulses applied to said styli cause current to flow through said marking material to cause said marking material to be expelled from said belt to produce dots on said paper, with a plurality of said dots reproducing characters on said paper according to the energization sequence of said styli.

2. The apparatus of claim 1 wherein said opaque marking material comprises a binder containing conductive incoherent carbonaceous particles.

3. Apparatus for electrically printing characters on a plain paper recording sheet, which apparatus includes means for moving said recording sheet in a predetermined direction, a plurality of electrode assemblies each having a number of spaced apart styli, a first pair of pulleys with one pulley thereof coupled to driving means, a first belt looped around said first pair of pulleys and movable thereby, said electrode assemblies being secured to said first belt and said first belt being positioned to move said electrode assemblies repeatedly in the scanning path transverse to the direction of movement of said recording sheet, with said styli in close proximity to the recording sheet during said scanning movement, a second pair of pulleys with one pulley thereof coupled to driving means, a second belt looped around said second pair of pulleys and movable thereby in the same direction and at approximately one-half speed of the movement of said first belt, said second belt being positioned to move between said styli and said recording sheet, with said styli making sliding contact therewith, said second belt composed of a web having a plurality of minute apertures therein, and said second belt being impregnated with a marking material having a semisolid binder containing carbon bearing compounds, whereby said electrical impulses applied to said styli cause said marking material to be expelled from said belt to produce marks on said paper, with a plurality of said marks reproducing characters on said paper according to the energization sequence of said styli.

4. Apparatus for electrically printing characters on a plain paper recording sheet, which apparatus includes means for moving said recording sheet in a predetermined direction, at least one electrode assembly having a plurality of vertically disposed printing styli, and means for applying electrical impulses to said styli in a coded sequence, the combination including means for causing said electrode assembly to move repeatedly in a scanning path transverse to the direction of movement of said recording sheet, with said styli in close proximity to said recording sheet during said scanning movement, a belt composed of a non-conductive web having a plurality of minute apertures therein positioned between said styli and said recording sheet, said apertures being small with respect to the cross-sectional area of individual ones of said styli, and said belt being impregnated with a marking material having a wax-like binder and containing finely divided carbon particles, means to cause said belt to move continuously in the same direction as but at a different speed than said electrode assembly, such that said styli make a sliding contact with said belt, means positioned in the path of said belt to continuously apply said marking material thereto, and means positioned in the path of said belt to remove excess marking material therefrom and to maintain said belt evenly impregnated with said marking material, with electrical impulses applied to said styli causing localized areas of said marking material thereunder to be impinged on said recording sheet in the form

of a dot, whereby a plurality of said dots causes reproduction of a desired character.

References Cited

UNITED STATES PATENTS

1,404,589	1/1922	Dixon	197—171	X
1,804,976	5/1931	Fortier	197—171	X
2,127,331	8/1938	Fulton	346—74	
2,464,970	3/1949	Finch	346—74	
2,664,043	12/1953	Dalton	101—426	10
2,893,810	7/1959	Miller	346—74	

5

STANLEY M. URYNOWICZ, Jr., *Primary Examiner*.

LEE J. SCHROEDER, *Assistant Examiner*.

U.S. Cl. X.R.

346—139; 197—168

2,901,374	8/1959	Gundlack	346—74
3,142,562	7/1964	Blake	346—74
3,182,591	5/1965	Carlson	346—74
3,234,904	2/1966	Van Wagner	101—426
3,355,743	11/1967	Capps	346—74