Dec. 24, 1968 F. M. JONES 3,418,427

TELEGRAPHIC POINT PRINTER HAVING PIEZOELECTRIC STYLUS DRIVE

Filed Nov. 24, 1964 3 Sheets-Sheet 1

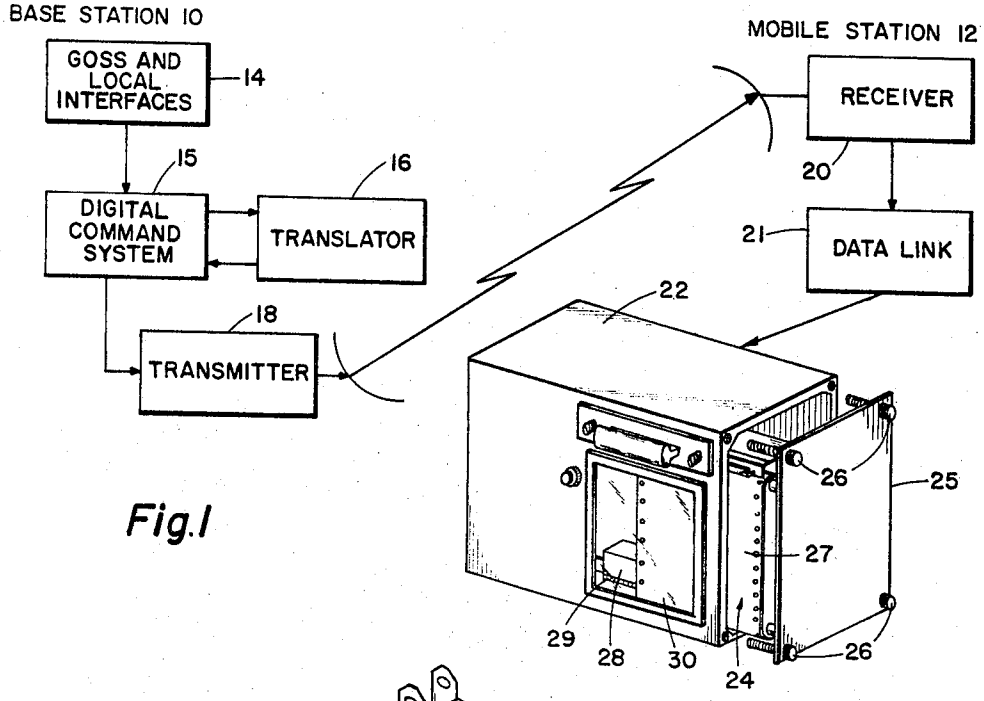



Fig.1

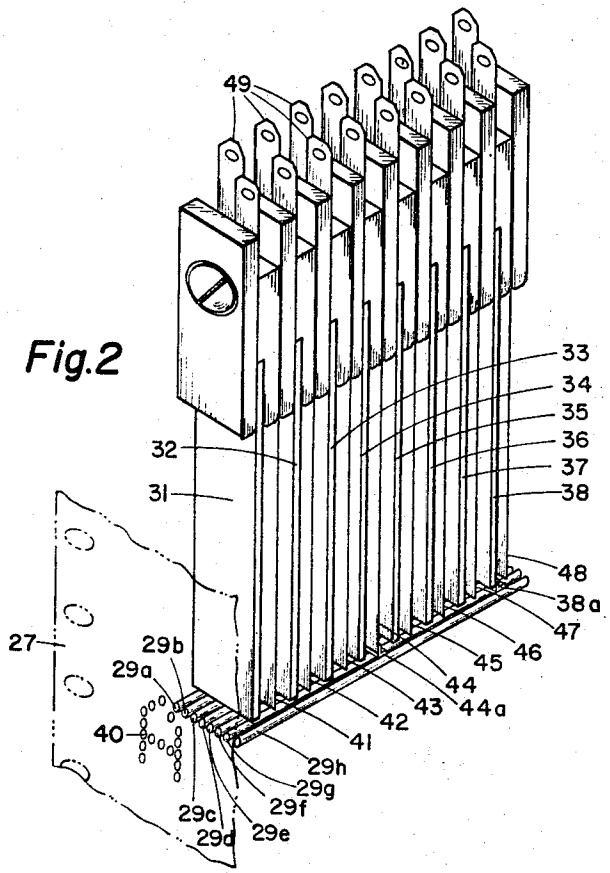



Fig.2

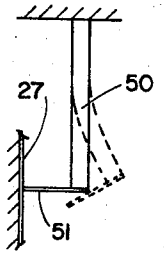



Fig.3

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TELEGRAPHIC POINT PRINTER HAVING PIEZOELECTRIC STYLUS DRIVE

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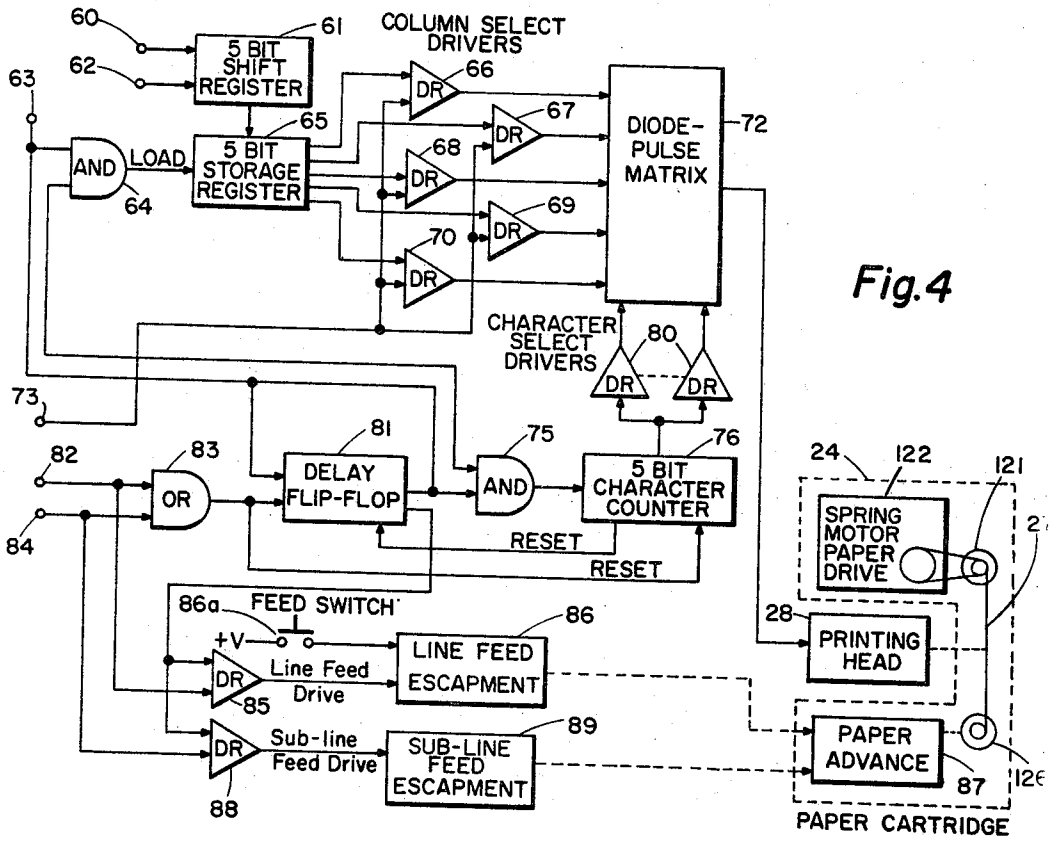



Fig.4

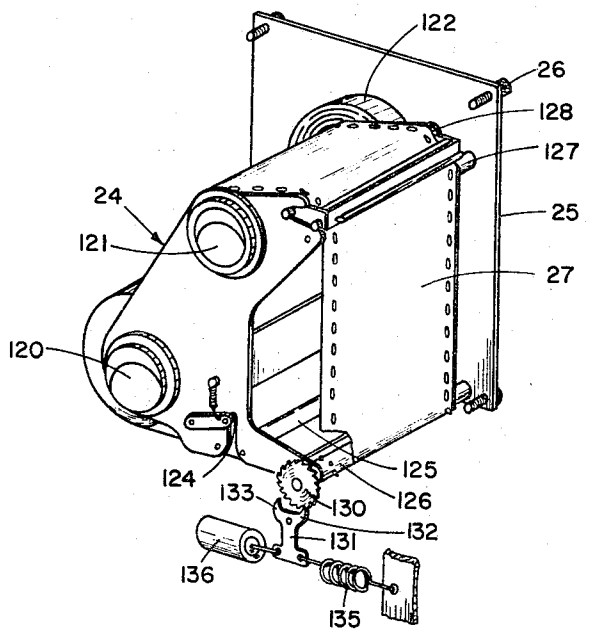



Fig.5

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TELEGRAPHIC POINT PRINTER HAVING PIEZOELECTRIC STYLUS DRIVE

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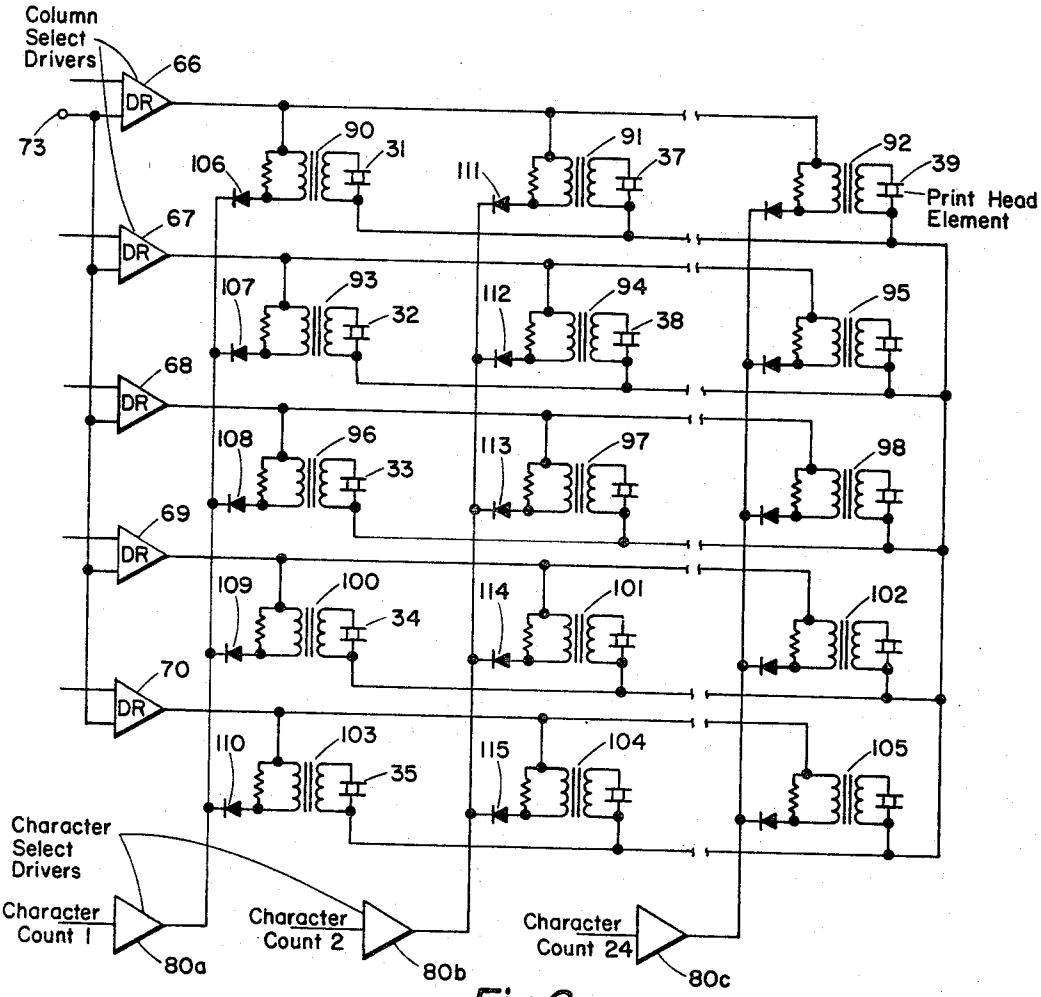



Fig. 6

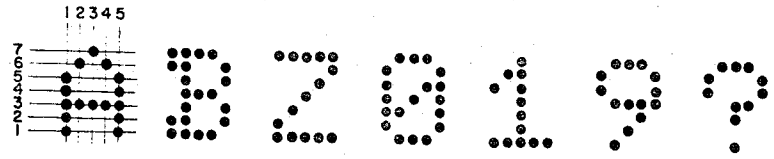



Fig. 7

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3,418,427

# TELEGRAPHIC POINT PRINTER HAVING PIEZOELECTRIC STYLUS DRIVE

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7 Claims. (Cl. 178—30)

## ABSTRACT OF THE DISCLOSURE

A plurality of styli are driven by a plurality of piezoelectric crystals attached thereto to form characters on pressure sensitive recording paper. Each of the piezoelectric crystals is operated in the bender bimorph mode.

There are many applications in radio communication systems wherein it is desired to provide a written message, so that it can be received without any action on the part of an operator, and which forms a record for subsequent reference. There is a need for a teleprinter for mobile use which can be provided in a very compact form, and which uses very little power. Such a unit must be rugged to withstand the vibration and shock which may be encountered. Teleprinter units have been proposed for use with pressure sensitive sheet material. This material includes dye or ink in small cells which are part of the paper, and wherein the dye or ink is released when the cells are ruptured under pressure to provide a mark on the paper. However, a satisfactory teleprinter unit for such use has not been provided.

A teleprinter which provides high speed operation is described and claimed in U.S. Patent No. 3,166,752, issued Jan. 19, 1965, of H. C. Waterman, and assigned to the assignee of the present application. The teleprinter of the present invention is particularly suitable for use in many applications, as will become apparent.

It is therefore an object of the present invention to provide an improved compact teleprinter apparatus suitable for mobile use.

A still further object of the invention is to provide a teleprinter unit for use in a communication system wherein the equipment required at a mobile receiver is minimized, and both the electrical and mechanical equipment for the mobile equipment is of simple form.

Another object of the invention is to provide a simple teleprinter unit for use with pressure sensitive sheet material.

A feature of the present invention is the provision of a teleprinter which includes a plurality of aligned stylus members and means for moving pressure sensitive sheet material with respect to the stylus members so that selective operation of the members produces characters on the sheet.

A further feature of the invention is the provision of a teleprinter as described in the preceding paragraph wherein the stylus members are driven by crystal elements arranged in overlapping relation, so that the stylus members and the driving means therefor are provided in a compact unit.

Another feature of the invention is the provision of a teleprinter unit for use with pressure sensitive sheet material including a spring actuated driving device for the sheet material and an escapement controlled by signals to produce sub-line movements so that marks are related to each other to form characters, and to produce line movements to separate the printed characters into lines.

Still another feature of the invention is the provision of a teleprinter in which pressure sensitive paper is engaged by a plurality of stylus members to provide marks, with the paper being positioned against a transparent



member so that the marks are visible as soon as they are made.

A still further feature of the invention is the provision of a communication system wherein the signals from a central or base station are in a form so that the equipment required at a mobile station for providing driving signals for the teleprinter is minimized, with the driving signals controlling movement of the sheet material and movement of a plurality of styli in a co-ordinated manner.

The invention is illustrated in the drawing wherein:

FIG. 1 is a block diagram of the teleprinter system with the teleprinter unit shown in perspective and partly disassembled;

FIG. 2 is a perspective view of one crystal and stylus assembly of the printing head;

FIG. 3 illustrates the action of the crystal driver;

FIG. 4 is a block diagram of the electrical system of the teleprinter unit;

FIG. 5 illustrates the paper cartridge module;

FIG. 6 is a schematic diagram of the printing head selection and drive matrix; and

FIG. 7 shows examples of redundant characters which may be provided by the teleprinter.

In practicing the invention a compact teleprinter device for printing pressure sensitive paper is provided which is suitable for mobile use. Signals are transmitted from a base station for operating the mobile teleprinter, which are of a form that when received at the mobile station require very little processing. The teleprinter includes a paper roll supporting module with a spring motor for providing constant pull on the paper. As escapement apparatus controls movement of the paper under the constant pull of the spring motor. A printing head includes a plurality of styli arranged in alignment across the paper, and connected to crystal driving members. The styli are in the form of relatively long rods, and a plurality of driving crystals are mounted one behind the other with each crystal connected to one of the rods. Pulses are applied to the crystals to cause them to bend back and then forward so that the rod strikes the paper, which is of the pressure sensitive type. The paper includes ink in cells which are ruptured by the impact of a stylus so that an ink dot is formed. The characters used may be in the form of a redundant alphabet made up of a plurality of dots positioned in both the horizontal and vertical directions. A plurality of styli are used for each character, and the paper is moved to a plurality of sub-line positions for each character. The paper is then moved a greater distance between lines. To simplify the system for driving the crystals, the bits of information for one sub-line of one character can be stored and then applied to the drivers for the dots representing these bits of information. The bits for the next character are then applied by the same circuit to the next group of drivers, and so on. After one sub-line is completed the paper is moved and the same circuit and styli are again used for subsequent sub-lines.

Referring now to the drawing, FIG. 1 shows a system having a base station **10** and a mobile station **12**. The base station includes unit **14** for producing signals representing character information. These signals are applied to a digital command system **15** which is coupled to translator **16**. The translator decodes the character information into a series of 35 pulses which represent the presence or absence of dots in a 5 by 7 matrix. The form of character used is shown in FIG. 7. It will be apparent that other matrix dimensions can be used, and the system is applicable to a matrix formed of N horizontal dots and M vertical dots. The translator stores a whole line of characters before transmitting information to the mobile unit. The translator **16** then reads out signals for a sub-line and applies the same through the command system **15** to the transmitter

18. The transmitter may operate at any desired frequency to apply signals to receiver 20 at the mobile station 12. It will be apparent that a plurality of mobile stations or fixed stations may receive the signals from the transmitter 18. The signals from receiver 20 are applied to data link 21 which provides signals required for operation of the teleprinter 22. The form of signals required will be explained further.

The teleprinter 22 includes a paper cartridge module 24 mounted on end plate 25 secured to the housing of the teleprinter by screws 26. This module can be slid out of the housing to replace the roll of paper 27 when it must be replenished. Mounted in the housing is a printing head 28 which includes a plurality of styli 29 arranged in a line. When the paper cartridge is placed in position within the housing of the teleprinter 22, the styli are arranged across the width of the paper 27. The paper is of a pressure sensitive type so that when a stylus strikes the paper, a dot is formed. The paper moves along transparent window 30 so that the dot formed on the paper is visible through the transparent window.

The printing head 28 includes a plurality of stylus and driver crystal assemblies as shown in FIG. 2. This assembly includes eight crystals 31 to 38 inclusive. Interleaved with the crystals are eight support leaves 41 to 48 inclusive. Eight stylus rods 29*a* to 29*h* inclusive are supported under the crystals in each assembly. Each rod is connected to one crystal and to one support leaf so that as the crystal flexes, the styli are moved to engage the paper 27 to produce a dot 40 thereon. In the assembly of FIG. 2, stylus 29*a* is connected to drive crystal 31 and support leaf 45, stylus 29*b* is connected to crystal 32 and support leaf 46, and so on. As shown in FIG. 2 the stylus 29*h* is supported from the crystal 38 by bracket 38*a*, and is supported from the support leaf 44 by bracket 44*a*. These supports cause the styli to move in substantially straight lines as the crystals bend.

FIG. 3 illustrates the action of each crystal in the assembly of FIG. 2. The crystal 50 is a bender bimorph. A pulse is applied to the bimorph crystal 50 to cause the crystal to flex to move the stylus away from the paper as shown by the dotted lines. A reverse pulse is then applied which causes the crystal to swing forward so that the stylus 51 engages the paper or sheet material 27. The size of the bimorph for use in the assembly shown in FIG. 2 may be one inch long, one quarter inch wide and 0.024 inch thick. A crystal of this size has been found to provide adequate striking force for marking the pressure sensitive sheet material when a drive voltage of the order of plus and minus 200 volts is applied.

The electrical system for actuating the printing head and paper advance mechanism of the teleprinter is shown in FIG. 4. As previously stated, the system may provide signals to cause the crystal drivers for one sub-line of one character to operate simultaneously. When the characters are formed by a 5 by 7 matrix (FIG. 7), five sub-bits will be processed simultaneously. The signal bits are applied from the data link to terminal 60 connected to shift register 61. Sub-bit synchronizing pulses are applied from the data link to terminal 62 to cause the shift register to receive the sub-bits of information. After five sub-bits have been received, the bit sync pulse is applied to terminal 63 and to AND gate 64. When the gate 64 is operated, as will be described, the five sub-bits in register 61 are stored in register 65. These five sub-bits are applied to column drive amplifiers 66 to 70 inclusive and from the drive amplifiers to the pulse matrix 72. A timing signal is also applied from the data link to terminal 73, and to the drive amplifiers 66 to 70 inclusive, to control the duration of the drive pulse applied to the matrix 72. The matrix 72 is coupled to the printing head 28 in a manner to be described more fully in connection with FIG. 6.

The sync signals applied at terminal 63 are also applied to AND gate 75 connected to the character counter 76. The character counter steps after each five sub-bits have been received to energize the character select drivers 80 in turn. The number of character select drivers corresponds to the number of characters which can be printed across the sheet, and in one application 24 characters can be so printed. The drivers 80 are coupled to the diode pulse matrix 72 to route the signals from the column drivers 66 to 70 inclusive to the various groups of crystals in the printing head 28, as will be described.

Signals received at the beginning of each line and each sub-line are applied from the data link 21 to input terminals 82 and 84 respectively, of the printer. The line signals applied to input terminal 82 are applied to drive amplifier 85 to control line feed escapement drive 86. The line feed escapement drive 86 controls the paper advance mechanism 87 in the paper cartridge 25, as will be explained. Signals applied to input terminal 84 energize sub-line drive amplifier 88 to control sub-line feed escapement drive 89. The sub-line feed escapement drive 89 causes the paper to move by small increments to provide the adjacent vertical dots in the 5 by 7 matrix. After seven lines of dots are provided, separated by six sub-line spaces, the line feed escapement 86 is operated to provide a greater space between lines. The line feed escapement 86 can also be operated by a line feed switch 86*a* on the front panel of the teleprinter.

When a message is first transmitted, a signal is applied to terminal 82 to cause the line feed escapement 86 to operate. As the printing is always in view, it is not necessary to move the paper at the end of the message, and a new message is started by movement of the paper. The line signal is applied through OR gate 83 to arm the delay flip-flop 81. This prevents application of the sync signal from terminal 63 through the AND gate 64 for the time required for the sub-bit signals to be transferred from the shift register 61 to the storage register 65. Each succeeding sync pulse applied to terminal 63 loads the next five sub-bits into the storage register and actuates the character counter 76. At the end of the twenty-four characters, the character counter 76 resets the delay flip-flop 81 to stop further loading of sub-bits into the storage register. At each operation of the character counter, five dots forming one sub-line of a character have been marked or not according to the sub-bit signals applied. The signals from the flip-flop 81 are also applied to the drive amplifiers 85 and 88 to permit pulses to drive the escapements 86 and 89. As previously stated, six sub-line operations are required to provide the seven sub-lines for each line of characters.

FIG. 6 shows the diode pulse matrix and the connection of the column select drivers 66 to 70 inclusive and the character select drivers 80 thereto. As previously stated, twenty-four character select drivers may be provided, but only three which are designated 80*a*, 80*b* and 80*c* are shown. When the first column driver 66 is energized, signals are applied to the transformers 90, 91 and 92 coupled to the crystals 31, 37 and 39. These are representative of 24 driver crystals, which include the first crystal of each of the five crystal groups which provide the 24 characters across the paper. The second column driver 67 applies signals to the transformers 93, 94 and 95 which are coupled to the second crystals of each of the five crystal groups. The third, fourth and fifth column drivers 68, 69 and 70 apply signals respectively to transformers coupled to the crystals in the third, fourth and fifth positions respectively in all the five crystal groups.

The circuits through the transformers 90, 93, 96, 100 and 103 for the five positions of the first character are completed through diodes 106, 107, 108, 109 and 110 respectively to the character select driver 80*a*. Accordingly, it is only when the character select driver 80*a* is energized to bias the diodes 106 to 110 inclusive conducting, that these circuits are completed. Under such condition, the signals from the column drivers 66 to 70 are applied to crystals 31, 32, 33, 34 and 35 respectively. The duration of the signals is controlled by the pulse applied from terminal 73 to each of the drivers 66 to 70. As previously stated, the signal applied to each crystal causes the crystal to flex and move the stylus away from the paper. When the pulse is

terminated, a reverse pulse is applied to the crystal by the transformer connected thereto, to return the crystal so that the stylus strikes the paper to form a dot.

After selected ones of the first five styli are operated by signals from drivers **66** to **70** inclusive, the character select driver **80***b* will be actuated by the character counter (**76** in FIG. 4) to connect the second set of five driver transformers **91, 94, 97, 101** and **104** through diodes **111, 112, 113, 114** and **115**. These transformers apply pulses to the five crystals **37, 38**, etc. for the five dots of the second character. The remaining 22 character select drivers operate in the same way, with the character select driver **80***c* completing the circuit to the transformers **92, 95, 98, 102** and **105** for driving the five crystals **39** etc. for the last character in the line.

After the first row of dots for all the characters of a line have been marked, the paper will be moved a sub-line space. Then the column and character select drivers will again operate to mark a second line of dots. Five lines of dots separated by six sub-line spaces will form one line of complete characters. Then the paper will be moved a full line space and the first rows of dots for the characters of a second line of printing will be marked.

In order to provide spaces between the characters in a line, the crystal unit following each group of five units which provide one character will not be connected. In this way, all of the crystal and stylus assemblies can be identical. As shown in FIG. 2, connections are made to the crystals through conductor strips **49** extending from the top of the assembly to facilitate wiring of the plurality of assemblies making up the printing head. As shown in FIG. 6, the five crystals for the first character are numbered **31** to **35** inclusive. Crystal **36** is not connected, and the crystals **37** and **38** form the first two units of the five for the second character.

FIG. 5 shows in more detail the paper cartridge **24**. As stated in connection with FIG. 1, the cartridge is supported on the end plate **25** for the printer housing. The cartridge includes a roll **120** for supporting the paper **27** before it is printed, and a take-up roll **121** on which the printed paper is wound. A spring motor **122** provides substantially constant tension on the take up roll **121** for causing movement of the paper. The paper from roll **120** passes over spring biased idler **124**, under fixed idler **125**, about sprocket roller **126**, about fixed roller **127** and about floating idler **128** to the take-up roll **121**. The spring motor **122** may be of the type manufactured by Ametek Inc., Hunter Spring Division, Hatfield, Pennsylvania and has a capacity for taking-up the entire roll of paper provided on the feed roll **120**. The sprockets of roller **126** engage openings in the paper **27** to control the feeding of the paper.

The spring motor **122** applies tension through the paper **27** to the sprocket roller **126**. Rotation of the roller **126** is controlled by an escapement mechanism including escapement wheel **130** provided on the shaft of the sprocket roller **126** and escapement lever **131**. The escapement lever has arms **132** and **133** cooperating with the teeth on the wheel **130**. In the position shown, arm **132** is moving into closed position under action of the spring **135**, and the arm **133** is moving into open position with the escapement wheel. When the solenoid **136** is energized, arm **132** will move out from the wheel **130** so that the wheel turns, and the arm **133** moves into closed position to hold the wheel **130** from further movement. When the solenoid **136** is released arm **133** will move out allowing the wheel **130** to turn further until arm **132** holds it from further movement. Accordingly, each energization of the solenoid **136** allows the escapement wheel **130** and the paper **27** to move by a small increment.

The paper feed escapement shown in FIG. 5 is controlled by the line feed escapement drive **86** and the sub-line feed escapement drive **89** in the system of FIG. 4. The sub-line feed escapement drive **89** produces a small increment of movement by applying a single pulse to the solenoid **136**. The line feed escapement drive **86** produces a greater movement of the paper by applying a plurality of pulses to the solenoid **136** so that the paper moves a greater distance.

The teleprinter unit which has been described is of simple construction so that it is reliable in operation and can be provided in compact form as required for mobile operation. The unit is light in weight and consumes relatively little power. The printing is of a type such that errors in signals or operation resulting in erroneous dots will not cause loss of readability unless a high percentage of errors occur.

I claim:

**1.** Apparatus for forming characters on pressure sensitive sheet material including in combination, a plurality of styli arranged in aligned relation, supporting means for the sheet material for holding the same in position to be engaged by said styli, said supporting means operating in response to a signal to move said material in a direction transverse to said aligned styli, a plurality of flat piezoelectric bender bimorph type crystals mounted in planes perpendicular to said styli, each of said crystals being connected to one of said styli for actuating the same to strike the material to provide a mark thereon, and control means for applying signals to said supporting means to move the material in successive positions for a plurality of adjacent lines, said control means selectively energizing said crystals so that marks are made in the adjacent lines to form the desired characters.

**2.** Apparatus for forming characters on pressure sensitive sheet material including in combination, mounting means, a plurality of elongated styli having ends arranged in aligned relation, a plurality of flat piezoelectric bender bimorph type crystals having substantially a rectangular configuration, a plurality of flat flexible support leaves having substantially the same rectangular configuration as said crystals, said crystals and said support leaves being positioned in parallel spaced interleaved relation and having adjacent edges thereof secured to said mounting means, said styli extending perpendicular to the planes of said crystals and said support leaves along the edges of said crystals and said support leaves opposite to the edges thereof secured to said mounting means, each of said styli being connected to one of said crystals and to one of said support leaves and supported thereby, supporting means for the sheet material for holding the same in position to be engaged by said styli, said supporting means being operable in response to a signal to move said material in a direction transverse to said aligned ends of said styli, and control means for applying signals to said supporting means to move the material to successive positions, said control means selectively energizing said crystals so that said ends of said styli supported thereby are moved into engagement with the sheet material to mark the same.

**3.** Apparatus for forming characters on pressure sensitive sheet material including in combination, mounting means, a plurality of elongated styli having ends arranged in aligned relation, a plurality of flat piezoelectric bender bimorph type crystals, a plurality of flat flexible support leaves, said crystals and said support leaves being positioned in parallel spaced relation and having adjacent edges thereof secured to said mounting means, said styli extending perpendicular to the planes of said crystals and said support leaves opposite to the edges thereof secured to said mounting means, each of said styli being connected to one of said crystals and to one of said support leaves and supported thereby, supporting means for the sheet material for holding the same in position to be engaged by said styli, said supporting means operating in response to a signal to move said material in a direction transverse to said aligned ends of said styli, and control means for applying signals to said supporting means to move the material to successive positions, said control means selectively energizing said crystals with the material in each position so that said ends of said styli supported thereby are moved into engagement with the sheet ma-

terial to mark the same form characters on the sheet material.

4. Apparatus for applying dots on pressure sensitive sheet material in $N \times M$ matrices to form characters, said apparatus including in combination, a plurality of parallel elongated styli having ends positioned in aligned relation, said styli being arranged in a plurality of groups each including N styli, a plurality of flat piezoelectric bender bimorph crystals individually connected to said styli for moving the same, a plurality of transformer circuits individually connected to said crystals for actuating the same so that the ends of said styli strike the material to provide dots thereon which are arranged in a line, sheet material supporting means for holding pressure sensitive sheet material in position to be engaged by said ends of said styli, said supporting means operating in response to a signal to move said material in a direction transverse to said aligned ends, and control means for applying signals to said supporting means to move the sheet material by successive increments of a first distance for M adjacent sub-lines, said control means including N drive circuits each of which is connected to said transformer circuits associated with one of said styli of each of said groups, counter means having a plurality of portions each of which is connected to all of said transformer circuits associated with said styli of one of said groups, and means applying signals in groups of N signals to said drive circuits and energizing said portions of said counter means in turn for completing energizing circuits to said transformers to thereby operate said styli of said groups in turn, whereby dots are made in each sub-line and the dots in adjacent sub-lines provided by M successive positions of the sheet material form a line of characters, said control means operating said supporting means to move the sheet material by an increment greater than said first increment after each line of characters is formed to separate successive lines of characters.

5. Apparatus for applying dots on pressure sensitive sheet material in $N \times M$ matrices to form characters, said apparatus including in combination, support means, a plurality of flat pizoelectric bender bimorph type crystals having a rectangular configuration, a plurality of flat flexible support leaves having the same rectangular configuration as said crystals, said crystals and said support leaves being positioned in spaced interleaved parallel relation and each having one edge thereof secured to said support means, a plurality of elongated styli positioned perpendicular to the planes of said crystals and said support leaves along the edge of each of said crystals and said support leaves opposite to the edge thereof secured to said support means, each of said styli being connected to one of said crystals and one of said support leaves and supported thereby, said styli having ends positioned in aligned relation and being arranged in a plurality of groups each including N styli, a plurality of transformer circuits individually connected to said crystals for driving the same so that the ends of said styli strike the material to provide dots thereon which are arranged in a line, sheet material supporting means for holding pressure sensitive sheet material in position to be engaged by said ends of said styli, said supporting means operating in response to a signal to move said material in a direction transverse to said aligned ends, and control means for applying signals to said supporting means to move the sheet material by successive increments of a first distance for M adjacent sub-lines, said control means including N drive circuits each of which is connected to said transformer circuits associated with one of said styli of each of said groups, counter means having a plurality of portions each of which is connected to all of said transformer circuits associated with said styli of one of said groups, and means applying signals in groups of N signals to said drive circuits and energizing said portions of said counter means in turn for completing energizing circuits to said transformers to thereby operate said styli of said groups in turn, whereby dots are made in each sub-line and the dots in adjacent sub-lines provided by M successive positions of the sheet material form a line of characters, said control means operating said supporting means to move the sheet material by an increment greater than said first increment after each line of characters is formed to separate successive lines of characters.

6. Apparatus for forming characters on pressure sensitive sheet material including in combination, a plurality of marking elements arranged in aligned relation, supporting means for the sheet material for holding the same in position to be engaged by said marking elements, said supporting means including drive means operating in response to a signal to move said material in a direction transvers to said aligned marking elements, a plurality of flat piezoelectric bender bimorph crystals individually connected to said marking elements for actuating the same to strike the material to provide marks thereon, and control means connected to said drive means and to said piezoelectric crystals, said control means actuating said drive means to move the material in successive positions and actuating said piezoelectric crystals to provide spaced marks which form the desired characters.

7. The apparatus for forming characters on pressure sensitive sheet material of claim 6 wherein, said control means acts to actuate said piezoelectric crystals first to move said marking elements away from the pressure sensitive sheet material and then in a continuous motion to move the marking elements toward the pressure sensitive sheet material to strike the same.

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U.S. Cl. X.R.

197—1; 178—17