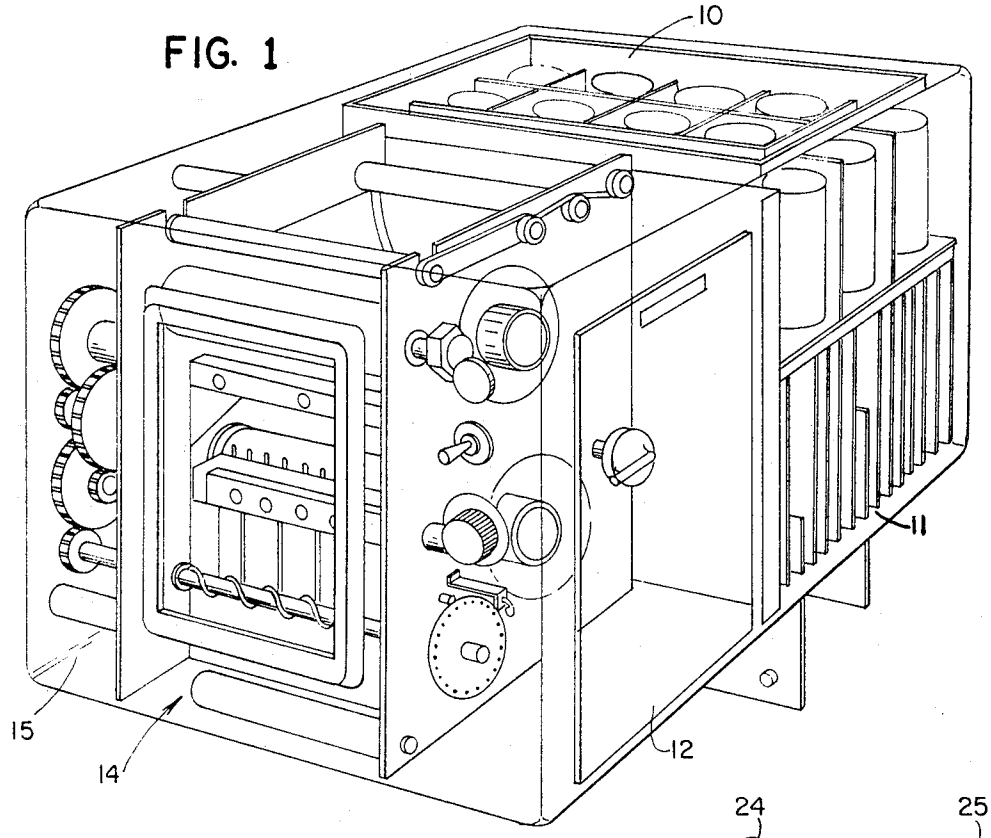
Nov. 5, 1968 K. MAIERSHOFER 3,409,904

PRINTER HAVING PIEZOELECTRIC CRYSTAL PRINTING MEANS

Filed Dec. 20, 1966 4 Sheets-Sheet 1

FIG. 1



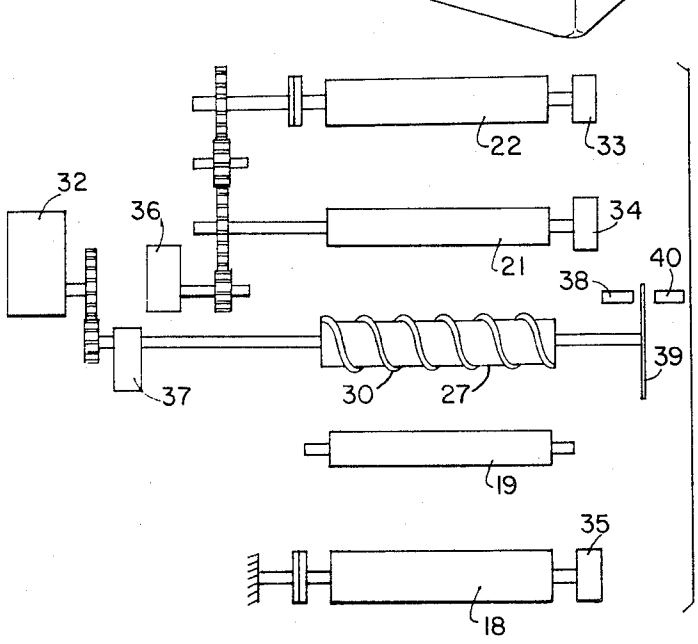


FIG. 3

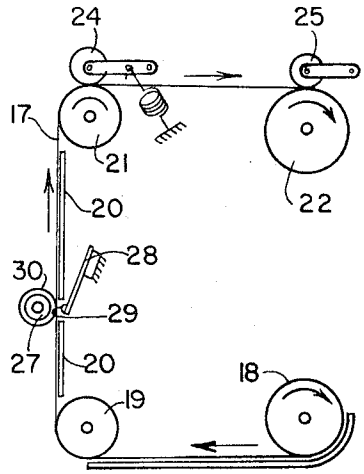


FIG. 2

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PRINTER HAVING PIEZOELECTRIC CRYSTAL PRINTING MEANS

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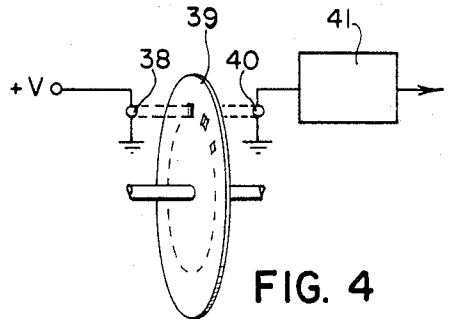

FIG. 4

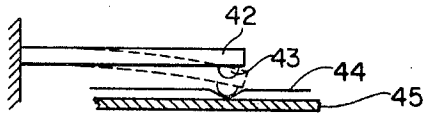

FIG. 5

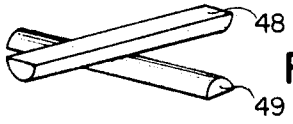

FIG. 6

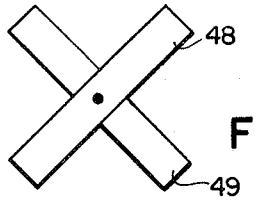

FIG. 7

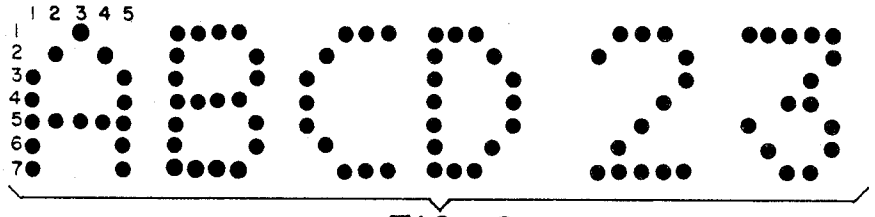

FIG. 8

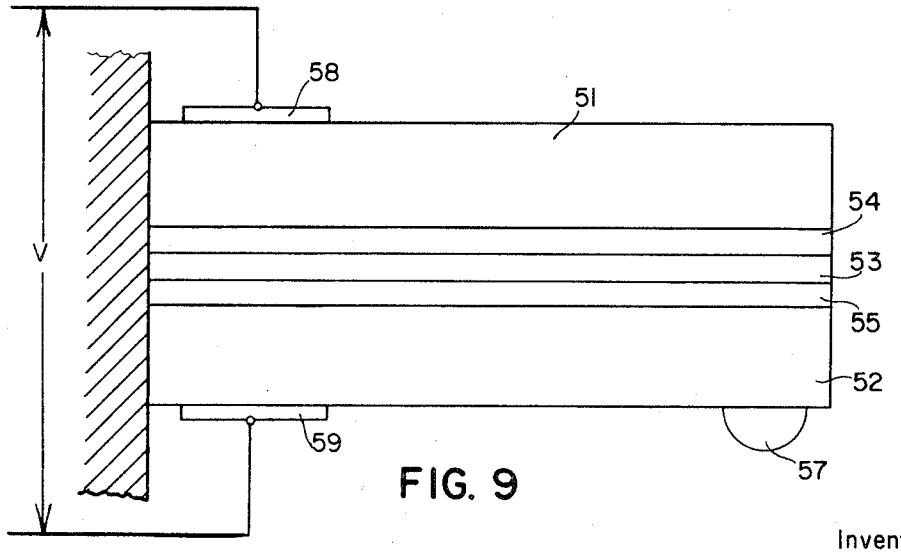

FIG. 9

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PRINTER HAVING PIEZOELECTRIC CRYSTAL PRINTING MEANS

Filed Dec. 20, 1966 4 Sheets-Sheet 3

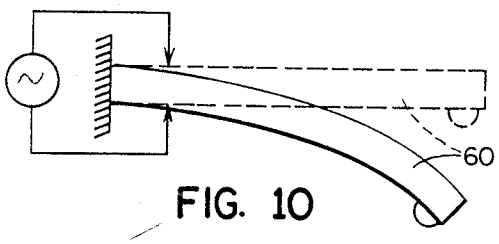

FIG. 10

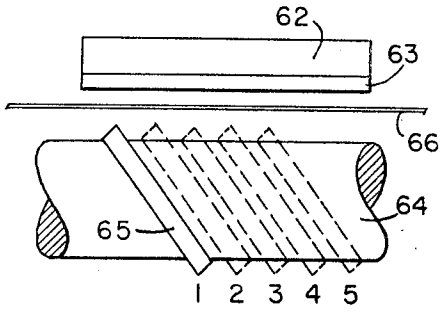

FIG. 11

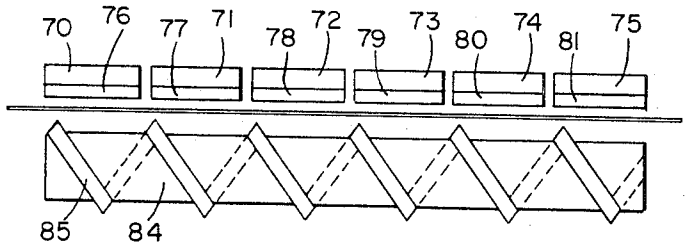

FIG. 12

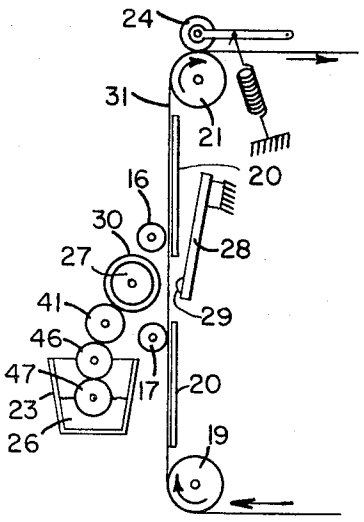

FIG. 13

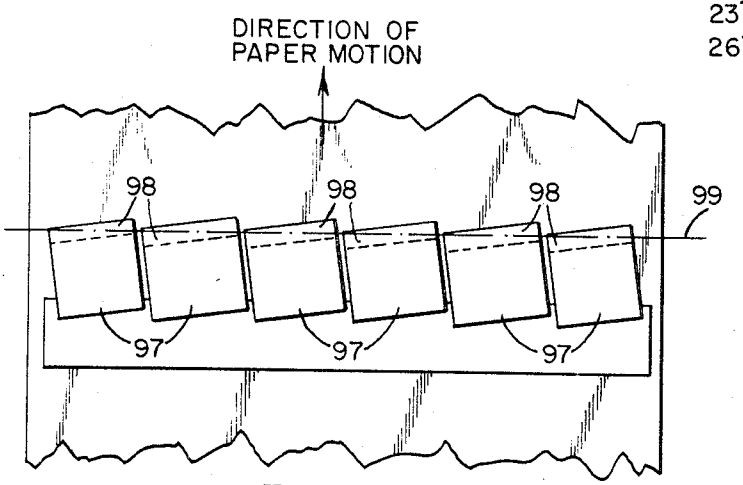

FIG. 14

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PRINTER HAVING PIEZOELECTRIC CRYSTAL PRINTING MEANS

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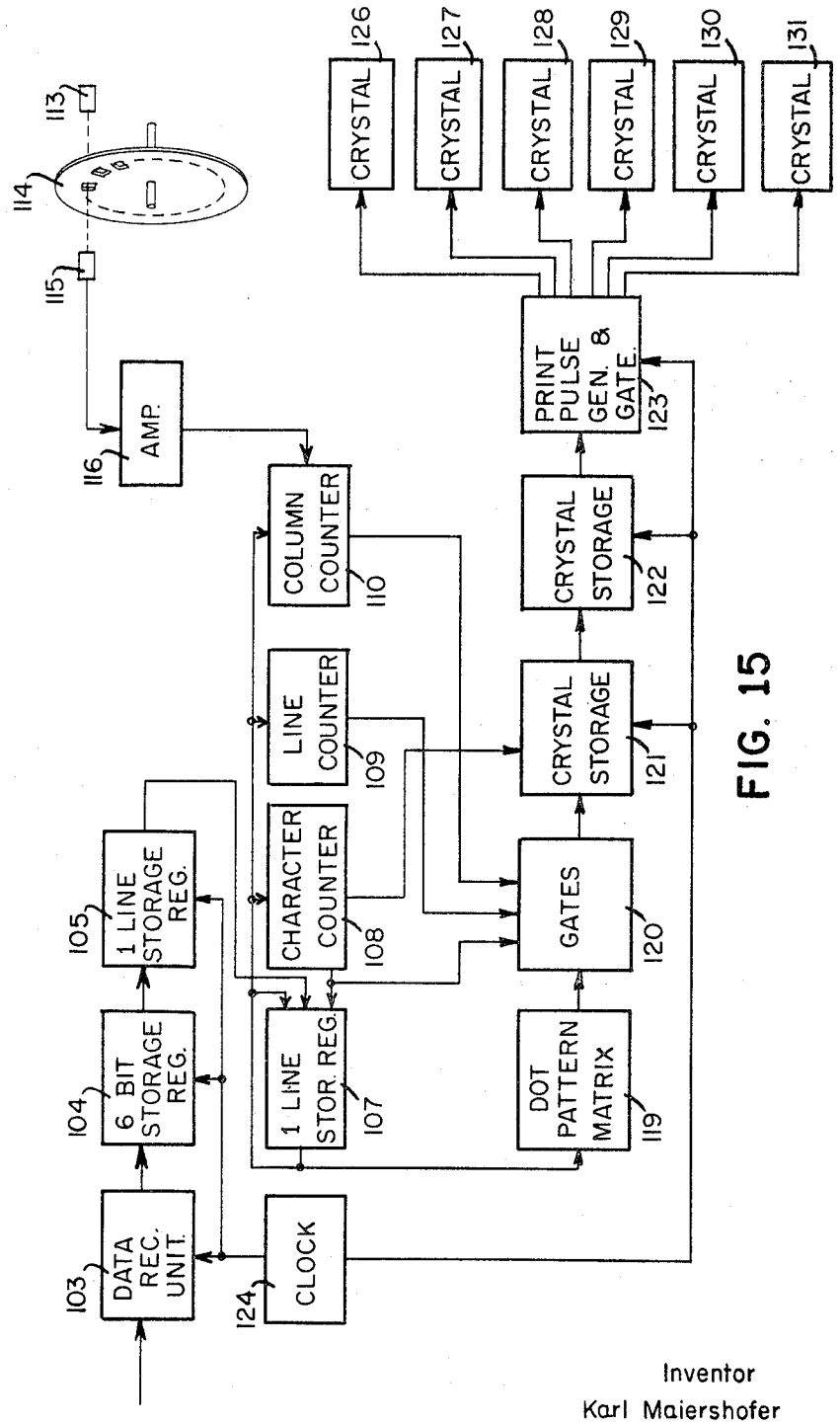

FIG. 15

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United States Patent Office 3,409,904 Patented Nov. 5, 1968

3,409,904

PRINTER HAVING PIEZOELECTRIC CRYSTAL PRINTING MEANS

Karl Maiershofer, Park Ridge, Ill., assignor to Motorola, Inc., Franklin Park, Ill., a corporation of Illinois

Filed Dec. 20, 1966, Ser. No. 603,257
11 Claims. (Cl. 346—101)

ABSTRACT OF THE DISCLOSURE

A printing device using a piezoelectric crystal including a hammer and a platen having a raised helical portion. Pressure sensitive recording means is positioned between the hammer and the raised helical portion. Actuation of the piezoelectric crystal by an electrical signal causes the crystal to move the hammer against the raised helical portion to produce marks on the pressure sensitive recording means. The platen is rotated to cause said raised helical portion to move across the paper to form a line of marks across the paper. The paper is moved transversely to the platen to develop a dot field. Selection of the particular dots to be printed at each position, in response to received information signals, causes reproduction of the characters in the information signal.

Background of the invention

In order to provide reliable communication it is often desirable to translate received information signals into printed characters in order that there be no misunderstanding of the signals. Many systems have been developed for doing this but these systems have required relatively large amounts of power and equipments having considerable weight. This has limited their usefulness in field and mobile operations where the devices must be carried from place to place and where limited amounts of power are available. Devices used in field and mobile operations must also be rugged so that breakdown due to mechanical shock and vibration will be minimized.

Summary

It is, therefore, an object of this invention to provide an improved printing device.

Another object of this invention is to provide a printing device having low power consumption.

Another object of this invention is to provide a printing device which is lightweight and rugged in construction.

In practicing this invention a printing device is provided which is adapted to receive information signals and print characters on paper in response to these signals. The printing device uses a platen having a raised helical portion thereon and a hammer driven by a piezoelectric crystal. The paper is positioned between the hammer and the raised helical portion and electrical actuation of the piezoelectric crystal causes the hammer to move toward the raised helical portion thus striking the paper to develop a mark thereon. The platen rotates moving the point of contact between the raised helical portion and the hammer along a line. Intermittent actuation of the piezoelectric crystal will therefore cause a line of dots to be produced. By moving the paper transversely to the line of dots a dot matrix can be developed which can be used to print characters.

In order to keep the piezoelectric crystal and hammer mechanism at an optimum size, a platen having a raised helical portion with a plurality of turns can be used in combination with a plurality of crystal hammer mechanisms, equal in number to the number of turns of the raised helical portion. The line could be printed by actuating the crystals in sequence or the information signals representing a line of characters can be stored and separate portions of the line read out simultaneously to actuate each of the crystals simultaneously. Motion of the paper is transverse to the line of characters and can be continuous or intermittent as desired. With continuous motion of the paper relative to the hammers the hammers are skewed in order to maintain the dot pattern in a straight line.

A piezoelectric crystal using a bender bimorph configuration can be advantageously used with this system. The bender bimorph piezoelectric crystal can be used most efficiently by applying a dual polarity signal having a period equal to the mechanical resonant period of the crystal hammer combination. The dual polarity signal causes the crystal to move away from the paper before being driven against the paper. This increases the force of the blow delivered to the paper to increase the efficiency of the printing operation. Because of the lower power requirements of the electronic circuits and the printing mechanism required in this structure, a minimum power supply is required. The power supply requirements can be further reduced by using a spring motor mechanism to drive the paper positioning mechanism and the platen. The pressure sensitive recording means used with this printing device may consist of pressure sensitive paper, paper and carbon paper interleaved, paper marked by a ribbon struck by the hammer and paper marked by ink deposited on the raised helical portion. The recording medium is not limited to these but any pressure sensitive recording means may be used.

The invention is illustrated in the drawings of which:

FIG. 1 is an isometric view of a teleprinter incorporating the features of this invention;

FIGS. 2 and 3 are mechanical schematics illustrating the operation of the paper feed and printing mechanism of this invention;

FIG. 4 is a drawing of an indexing mechanism;

FIGS. 5, 6 and 7 illustrate the means by which a hammer striking an anvil generates a dot pattern;

FIG. 8 is an illustration of a dot pattern for generating letters and numbers;

FIG. 9 illustrates the construction of a bender bimorph piezoelectric crystal used in this invention;

FIG. 10 illustrates the operation of the bender bimorph crystal;

FIG. 11 illustrates the operation of the raised helical portion of the platen;

FIG. 12 illustrates the construction of a platen having a multi-turn raised helical portion together with a plurality of bender bimorph piezoelectric crystals;

FIG. 13 illustrates the operation of the pressure sensitive recording means using an inked raised helical portion;

FIG. 14 illustrates the skewing of the crystal bender bimorph piezoelectric crystals to develop straight line printing; and

FIG. 15 is a block diagram of the control portion of the printer.

In FIG. 1 there is shown an isometric view of a printer incorporating the features of this invention. The printer is light in weight and is adapted for use under mobile and field conditions. A power supply section **10** provides space for carrying the batteries which are used to operate the electronic section of the printer. The batteries shown are standard flashlight cells although any battery desired may be incorporated in the system. Flashlight battery cells are shown since they are readily available throughout the world.

The electronics section **11** receives the incoming signals and translates them to supply control signals to the piezoelectric crystals in print section **14**. Print section **14** provides means for transporting the paper and for marking characters thereon. A manual control section **12** provides

manual controls which are used to operate the machine. A drive mechanism section **15** provides a spring motor drive for moving the paper relative to the printing head. While a spring motor is shown, an electric motor operated from the power supply section **10** may be substituted if desired.

FIGS. 2 and 3 illustrate the printing section of the teleprinted. Paper is stored on paper supply roll **18** and is positioned around paper guide roller **19**, paper guide plate **20**, paper guide roller **21** to paper takeup roll **22**. Pressure rollers **24** and **25** are spring biased against paper dive ol **21** and paper takeup roll **22** to properly position the paper.

Paper guide plate **20** causes paper **17** to bear against a rotary helical platen **27**. Piezoelectric crystal **28** is positioned so that its actuation will cause it to move hammer **29** against the raised helical portion of platen **27** thus causing hammer **29** to strike the paper **17**. A spring motor **32** is coupled to platen **27** and to paper drive roll **21** and paper takeup roll **22** to drive these elements at the required speed. Variable speed mechanisms **36** and **37** are provided so that the speed of the platen and paper can be varied as desired. By varying the speed of the paper and/or the speed of rotation of the platen, the size and form factor of the characters can be controlled. An electric drive motor may be substituted for spring motor **32** if desired. Knobs **33**, **34** and **35** are supplied for manual operation of paper takeup roll **22**, paper drive roll **21** and paper supply roll **35**.

A timing mechanism consisting of a light source **38**, a slotted disc **39** and a photocell **40** are provided for indexing the position of the raised helical portion of platen **27** for proper operation of the printing circuits. The slotted disc mechanism is also shown in FIG. 4 and includes an amplifier **41** coupled to photocell **40** for amplifying the output of the photocell. The output of amplifier **41** is coupled to the electronics section to provide indexing information thereto.

FIG. 5 illustrates the operation of the crystal as used to mark pressure sensitive recording means. A piezoelectric crystal **42** operating as a bender bimorph has a hammer **43** positioned at one end while the other end is rigidly secured to form a cantilever type of construction. The pressure sensitive recording means to be marked **44** is positioned over an anvil **45**. Electrical actuation of crystal **42** causes it to bend downward so that hammer **43** strikes pressure sensitive recording means **44** against envil **45**. The pressure sensitive recording means used can be of a special type of paper which is sensitive to pressure to develop a mark thereon or a form of inking means may be inserted between the hammer and the paper. Interleaved paper and carbon paper may also be used.

FIGS. 6 and 7 illustrate a hammer **48** and an anvil **49**. The striking surface of hammer **48** is positioned at an angle to the elongated surface of anvil **49** so that the area of contact forms a dot. By repeatedly marking the paper at different positions the dots can be used to form the desired characters. A 7 x 5 or 35 dot matrix can be used to form various letters, figures and other characters. An example of this is shown in FIG. 8 where the 35 dot matrix is used to form the letters A, B, C, D and the numbers 2 and 3. Other characters can be formed using this dot matrix or other matrices can be used.

The piezoelectric crystal used in the teleprinter of this system can be in the form of a bender bimorph. An example of this is shown in FIG. 9. The piezoelectric bender bimorph crystal consists of a sandwich having piezoelectric ceramic crystals **51** and **52** cemented to a brass plate **53** by epoxy layers **54** and **55**. In a typical bender bimorph configuration the ceramic crystals may be of the order of 9 mils in thickness while the brass and epoxy layers may be of the order of 2 mils in thickness. The bender bimorph piezoelectric crystal is not limited to these dimensions, however. One end of the bender bimorph crystal is rigidly secured to form a cantilever-type construction. The other end of the bender bimorph has a hammer **57** positioned thereon. Electrodes **58** and **59** are adapted to receive a control potential V. When the potential V is applied to the electrodes **58** and **59**, the bender bimorph crystals bend as shown in FIG. 10. The direction of movement of the bender bimorph crystal **60** of FIG. 10 is determined by the polarity of the potential V applied to the crystal.

FIG. 11 shows a bender bimorph piezoelectric crystal **62** positioned relative to the raised helical portion **65** of platen **64**. Hammer **63** is opposite raised helical portion **65** so that movement of piezoelectric crystal **62** will force hammer **63** against raised helical portion **65**. Raised helical portion **65** therefore acts as the anvil for hammer **63**. Pressure sensitive paper **66** is positioned between the hammer **63** and raised helical portion **65**, to intercept the movement of hammer **63**. When hammer **63** strikes paper **66** against raised helical portion **65** a dot is made on the paper **66**. The raised helical portion **65** represented by the solid lines is shown in the column **1** position. The dotted lines show the position of raised helical portion **65** as it moves to column positions **2**, **3**, **4** and **5**. Column positions **1–5** correspond to column positions **1–5** shown in FIG. 8. Thus as platen **64** rotates the raised helical portion underneath hammer **63** is moved to a different column position. Actuation of piezoelectric crystals **62**, with raised helical portion **65** at any of these five positions, will cause a dot to be made at that position. While five column positioning has been shown in this application, the invention is not limited to this number of positions and any number desired may be used.

FIG. 12 shows a helical platen with a raised helical portion adapted for use in the printer shown in FIG. 1. The printer of FIG. 1 is adapted to print a 30 character line. While a single piezoelectric bender bimorph crystal could be used, the crystal would have to have a width equal to the width of the line to be printed. For mechanical reasons crystals this wide are to be avoided if possible. This has been accomplished in the structure shown in FIG. 12 and in FIG. 1 by dividing the 30 character line into 6 portions of 5 characters each. Six separate bender bimorph piezoelectric crystals **70** to **75** each having a hammer **76–81** are used to print the line of characters. A platen **84**, having a multi-turn raised helical portion **85** thereon is used, in order that each hammer will have an anvil positioned opposite it at all times during the printing process. The raised helical portion has the same number of turns as there are crystals. Thus as platen **84** rotates each crystal has a helical raised portion positioned underneath it which moves along in the same manner as the raised helical portion **65** of FIG. 11. Referring again to FIGS. 2 and 3, platen **27** has a multi-turn raised helical portion **30** thereon, which acts as an anvil for a piezoelectric crystal **28**. While only one piezoelectric crystal **28** is shown in FIG. 2, there is a piezoelectric crystal together with its hammer for each of the turns of the raised helical portion of the printer. While six crystals are used in this example to form a 30 character line, the system is not limited to this configuration but any number of crystals can be used, consistent with the requirements of the system.

Referring to FIG. 13 there is shown another embodiment of the printer of FIGS. 2 and 3 in which the pressure sensitive recording means consists of paper ink deposited on the raised helical portion **30** of platen **29** and paper. Paper **31** is taken from a paper supply roll, not shown, in FIG. 13, passes around guide rolls **19** and **21** to a paper takeup roll not shown in FIG. 13. Guide plates **20** and guide rollers **16** and **17** position the paper so that it is close to the raised helical portion **30** of platen **20**, but not touching this surface. An ink reservoir **23** having an ink supply **26** is provided. Inking rollers **41**, **46** and **47** are driven by the same drive mechanism that causes platen **29** to rotate, to carry the ink **26** from reservoir **23** to the raised helical portion **30** of platen **29**. Thus the

raised helical portion has a layer of ink on its surface at all times. Movement of hammer **29** causes paper **31** to be pressed against the raised helical portion and the ink deposited on the surface thereof is picked up by paper **31** to produce a mark on the paper.

In the printer of this invention the bender bimorph piezoelectric crystals could be actuated serially to print out the desired characters. In that case only a single turn raised helical portion would be required although a multiturn raised helical portion can be used. However, in order to speed up the operation of the printer the crystals are normally operated simultaneously. Thus, in the 30 character line of this example bender bimorph crystal **70** of FIG. 12 prints characters 1–5, crystal **71** characters 6–10, crystal **72** characters 11–15, crystal **73** characters 16–20, crystal **74** characters 21–25 and crystal **75** characters 26–30. Each crystal first prints the required marking for line 1, column 1 of the first character of its group, that is, in this example, the first, sixth, eleventh, sixteenth, twenty-first and twenty-sixth characters. Then, the platen rotates, moving the raised helical portion to the second column position and the printer makes the required mark for line 1, column 2 of each of the first characters for each crystal. This continues until the first row of dot markings is completed. At this time the paper is positioned relative to the hammers so that it is ready to receive the second line of markings. This can be done by intermittently moving the paper or by applying a continuous motion to the paper. At each position of the character matrix the proper mark is made. If the mark required is a dot the crystal is actuated to strike the paper against the raised helical portion of the platen to make the dot. If no dot is required the crystal is not actuated at that particular time.

In order to provide the proper alignment of characters across the line with the paper moving at a constant speed, relative to the crystals and hammers, it is necessary to skew the crystals relative to the printing line, which is transverse to the line of paper motion. This skewing is shown in FIG. 14 where crystals **97** having hammers **98** are skewed with respect to the character line **99**. Character line **99** is transverse to the direction of paper motion.

In FIG. 15 there is shown a block diagram of an electronic system usable to operate the printer system described. Information bits are received in serial form by data receiving unit **103**. For example, the information bits may be in the form of a 7.2 baudot code consisting of a start and a stop symbol together with five character symbols. The code is processed by the data receiving unit **102** to determine whether it is a character or represents a command such as shift to letters or figures or carriage return, line feed, etc. If the data bit received is a character, it is converted to a six bit character and stored in storage register **104**. The extra bit determines whether the character is to be found in the letter or numeral portion of the code.

The bit is then transferred to line storage register **105** which stores the entire 30 characters comprising one line, used in the example illustrating the operation of this system. When an entire line is stored in line storage register **105** it is serially transferred at high speed to storage register **107**. At this time storage register **105** is available for storing the next line received by the teleprinter while the line stored in storage register **107** is processed for printing.

The first character in storage register **107** is transferred to dot pattern matrix **119** to generate the dot pattern required. The output from dot pattern matrix **119** is coupled over 35 separate lines to gates **120**. 35 separate lines are required since there are 35 dot position in the 7 x 5 matrix used in this example. Since only one column of one line of the characters is printed at a time, line counter **109** and column counter **110** actuate the proper gates to select the marking information which is transferred to the crystal storage unit **121**. Crystal storage unit **121** contains six registers, one for each crystal and the proper crystal storage register is selected by an output from character counter **108**, which keeps track of the particular character which has been transferred to dot pattern matrix **119**. Column counter **110** is also synchronized with the raised helical portion of the platen through the print position detector previously described in FIG. 4. The light source **113** is interrupted by disc **114** having holes therein. Light passing through the holes develops a potential at photocell **115** which is amplified by amplifier **116** and applied to column counter **110**.

After the marking information for the line 1, column 1, of the first character has been determined, character counter **108** operates to serially read out the single line stored in the one line storage resistor **107** until the sixth character is reached. The marking information for line 1, column 1 of the 6th character is then read and stored in crystal storage register **121**.

As the characters are read out of the storage register **107** they are read back into storage register **107** so that they will be available for further processing at a later time. When characters 1, 6, 11, 16, 21, 26 have been processed, crystal storage unit **121** has six separate units of marking information stored therein for line 1, column 1 of these characters. This information is transferred to crystal storage register **122** releasing crystal storage register **121** for receiving the next dot information, that is column 2 of the line 1 of each of characters 1, 6, 11, 16, 21 and 26.

The information stored in crystal storage register **122** is transferred to print pulse generator and gate **123**. Print pulse generator and gate **123** provides the potential to the individual crystals **126** to **131** for actuating the same. The gates apply the actuating potential only to those crystals which require that a dot be made on the paper at that particular line and column of the character being printed. Clock **124** is coupled to the various units of the electronic control system to time the operation of the units as required.

I claim:

1. A printing device for receiving information signals and recording characters representative of the received information signals, including in combination, a rotary platen having a raised helical portion with a plurality of turns thereon, a plurality of piezoelectric crystal means equal to the number of turns of said raised helical portion with each of said piezoelectric crystal means having a single hammer mounted thereon, each of said piezelectric crystal means being positioned with relation to said platen whereby movement of said crystals means will cause said hammers to strike said raised helical portion, pressure sensitive recording means, means for positioning said pressure sensitive recording means between said hammer and said raised helical portion, drive means coupled to said positioning means and said platen for rotating said platen and moving said pressure sensitive recording means relative to said platen, each of said hammers being positioned along a line tranverse to the line of motion of said pressure sensitive recording means, input circuit means for receiving and storing the information signals, output circuit means coupled to said input circuit means and responsive to said information signals to develop control signals, said output circuit means further acting to divide a single line of characters into a number of portions equal to the number of said crystal means and to develop separate control signals for each of said portions, and circuit means coupling said output circuit means to said plurality of piezoelectric crystal means and further acting to read out in parallel each of said portions of control signals to a separate one of said crystal means whereby said printing device prints each of said line portions simultaneously, each of said piezoelectric crystal means being responsive to said control signals applied thereto to develop a mechanical motion moving the hammer thereon toward said raised helical

portion whereby said hammer strikes said pressure sensitive recording means to produce a mark thereon.

2. The printing device of claim 1 wherein, said piezoelectric crystal means includes a bender bimorphy piezoelectric crystal having one end rigidly supported to form a cantilever structure and having said hammer mounted at the other end thereof.

3. The printing device of claim 2 wherein, said pressure sensitive recording means includes pressure sensitive paper.

4. The printing device according to claim 3 wherein, said pressure sensitive paper is moved between said hammers and said raised helical portion at a constant rate, each of said hammers being skewed with respect to said transverse line to offset said continuous motion of said pressure sensitive paper whereby the line of characters is printed parallel to said transverse line.

5. The printing device of claim 2 wherein, said pressure sensitive recording means includes interleaved paper and carbon paper.

6. The printing device of claim 2 wherein, said pressure sensitive recording means includes paper positioned between said raised helical portion and said hammer, and a layer of ink deposited on said raised helical portion, said movement of said hammer acting to press said paper against said ink deposited on said raised helical portion whereby a mark is made on said paper, and inking means mechanically coupled to said raised helical portion for depositing said ink thereon.

7. The printing device of claim 2 wherein, said drive means includes a spring operated drive mechanism coupled to said platen for rotating the same, said spring operated drive mechanism further being coupled to said positioning means for moving said pressure sensitive paper relative to said platen.

8. The printing device of claim 7 wherein, the speed of rotation of said platen is variable and the speed of movement of said pressure sensitive paper relative to said platen is variable whereby the size and form factor of the characters may be varied.

9. A printing device for printing characters on pressure sensitive recording means, including in combination, a rotary platen having a raised helical portion thereon, piezoelectric crystal means positioned adjacent said platen and including at least one piezoelectric crystal having a first end portion fixedly mounted with respect to said platen and a second end portion having an elongated hammer thereon with the longitudinal axis of said hammer being substantially parallel to the longitudinal axis of said platen, said crystal being responsive to a control potential applied thereto to bend, said hammer being positioned in relation to said raised helical portion whereby said bending of said crystal will cause said hammer to strike said raised helical portion, means for positioning said pressure sensitive recording means between said hammer and said raised helical portion, said pressure sensitive recording means intercepting said movement of said hammer towards said raised helical portion whereby a mark is produced on said pressure sensitive recording means, and means for rotating said platen whereby the area of contact between said hammer and said raised helical portion moves across said pressure sensitive recording means whereby the position of said mark on said pressure sensitive recording means is varied.

10. The printing device of claim 9 wherein said piezoelectric crystal means includes a bender bimorph piezoelectric crystal having electrodes positioned on opposite sides thereof for receiving said control potential.

11. The printing device of claim 10 wherein, said raised helical portion includes a plurality of turns, said piezoelectric crystal means includes a plurality of bender bimorph piezoelectric crystals equal to the number of turns of said raised helical portions with each of said bender bimorph piezoelectric crystals having a single hammer mounted on said other end thereof, each of said hammers being positioned along a line transverse to the line of motion of said pressure sensitive recording means, each of said bender bimorph piezoelectric crystals being responsive to separate control potentials applied thereto to mark said pressure sensitive recording means to form separate portions of a single line of characters thereon.

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