Feb. 10, 1970 M. H. ZISSEN 3,495,070

THERMAL PRINTING APPARATUS

Filed May 29, 1967 2 Sheets-Sheet 1

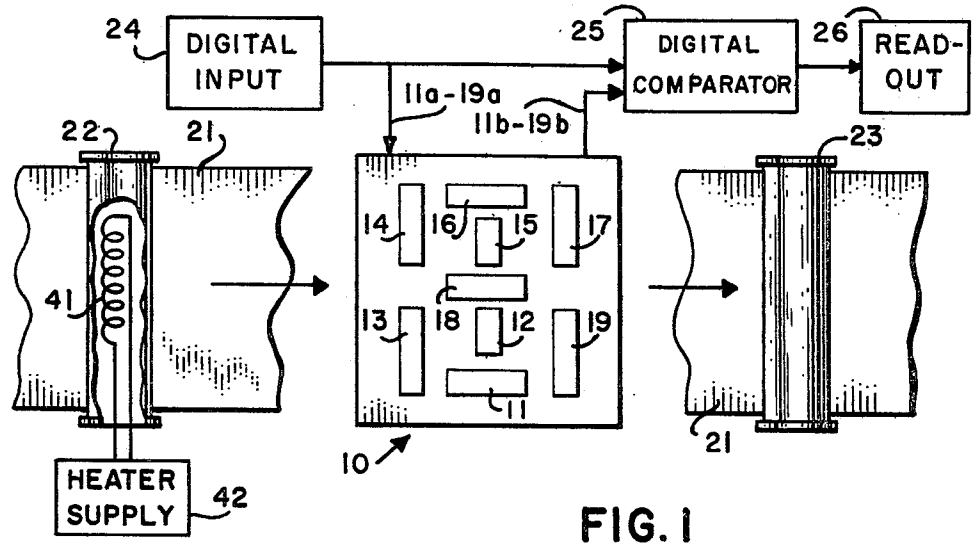


FIG. 1

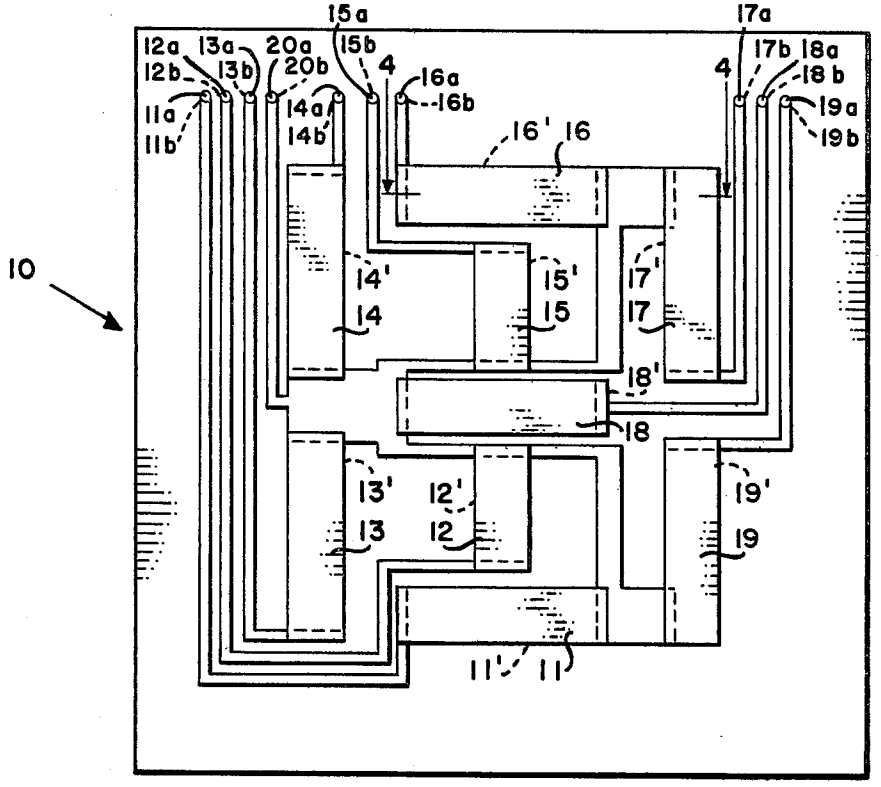


FIG. 2

THERMAL PRINTING APPARATUS

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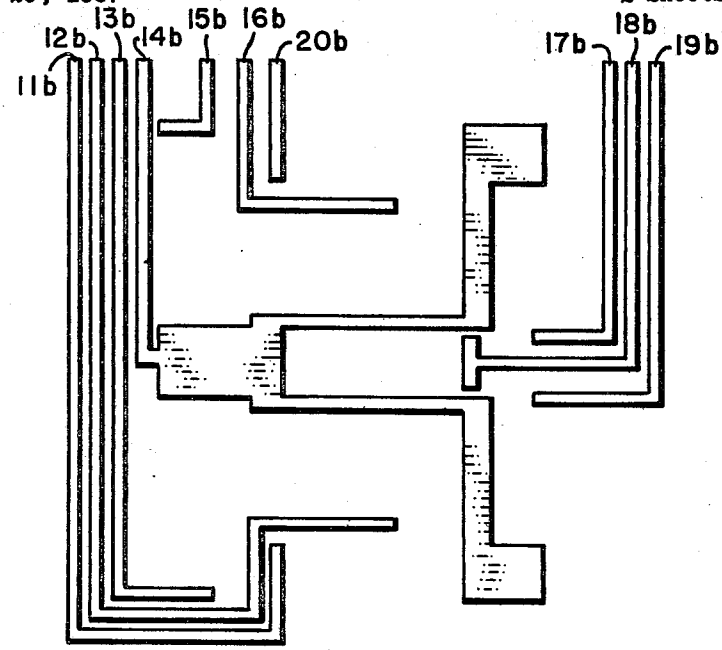


FIG. 3

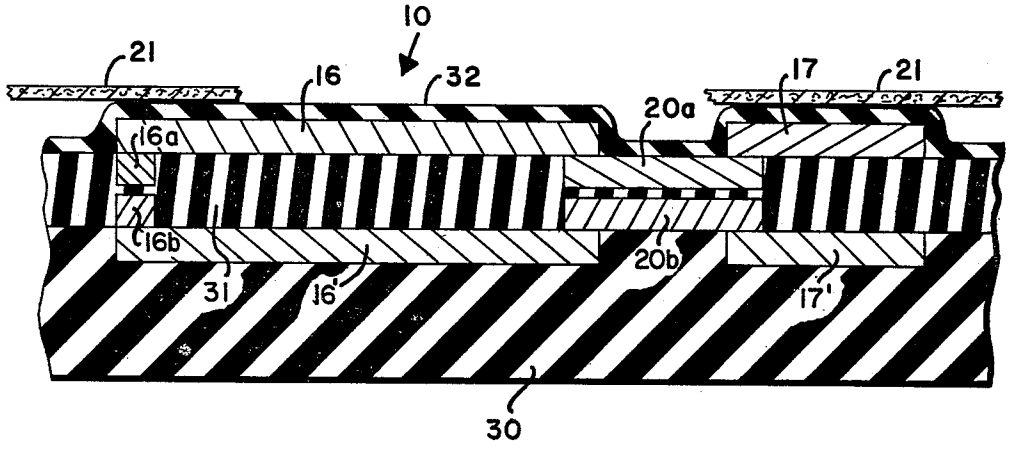


FIG. 4

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3,495,070

THERMAL PRINTING APPARATUS

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U.S. Cl. 219—216 3 Claims

ABSTRACT OF THE DISCLOSURE

Thermal printing apparatus in which thermally sensitive paper is fed to a printing unit containing elongated heating segments which sensitize visual markings on the paper. The heating segments are formed in a layer pattern on a heat-insulating substrate, superimposed on a layer pattern of monitoring segments made of thermistor material. A given combination of the heating segments are energized to produce a desired visual marking with a given distribution of digital current pulses, and the proper functioning of the heating segments is indicated by obtaining the identical distribution in the temperature response of the monitoring segments.

The present invention relates to apparatus for printing electronically processed information on thermally sensitive paper.

It has been previously recognized that the imprinting of digital information on thermally-sensitive paper, for example "Thermo-Fax" paper manufactured and sold by Minnesota Mining and Manufacturing Co., offers the inherent advantage of high-speed and quiet printing of readout information generated by a digital computer. However, previously proposed devices for this purpose are not entirely satisfactory for practical operation.

One object of the present invention is the provision in a thermal printing element of means for monitoring said printing element to insure that it is operating correctly.

Another object of the present invention is the provision of means for increasing the speed with which a thermal printing element can make a legible imprint on thermally sensitive paper.

Another object of the present invention is the provision of means for protecting a thermal printing element from abrasion and wear caused by the rubbing of thermally sensitive paper on said element.

Still another object of the present invention is the provision of a simple and practical construction for a thermal printing element.

These and other features and advantages of the present invention will become more apparent upon a consideration of the following description taken in connection with the accompanying drawing, wherein:

FIGURE 1 is a schematic diagram of a thermal printing apparatus in accordance with the present invention;

FIGURE 2 is a top plan view of the printing element in the apparatus of FIGURE 1;

FIGURE 3 is a top plan view of the interconnection pattern of the printing element of FIGURE 2; and

FIGURE 4 is an enlarged cross-sectional view taken along line 4—4 in FIGURE 2.

Referring to the thermal printing apparatus of FIGURE 1, a solid-state printing element **10** has a plurality of thermally-excitable, high-resistance segments **11**, **12**, **13**, **14**, **15**, **16**, **17**, **18** and **19**, arranging in the illustrated example in a pattern particularly suitable for the printing of arabic numerals. This pattern consists of three rows of end-wise aligned pairs of vertically-extending segments, **13** and **14**, **12** and **15**, **19** and **17**, and three parallel horizontally-extending segments **11**, **18** and **16** positioned at either end and between the middle vertically-extending pairs **12** and **15**. A sheet of thermally sensitive paper **21** is fed by guides **22** and **23** over the printing element **10** which imprints legible information thereon by means of the heat generated in the printing segments **11** through **19**. It is apparent that the printing segments of printing unit **10** can be arranged in any desired pattern, for example, for alphabetic as well as numeric characters, and that any number of such printing units may be used simultaneously for printing on the paper **21**.

A digital input source **24** energizes printing segments **11** through **19** with current pulses programmed to thermally energize particular combinations of these printing segments so as to form geometric patterns representative of particular numerals corresponding to each input, via a plurality of respective connecting leads **11***a* through **19***a*. Thermal energization of the printing segments **11** through **19** causes operation monitoring pulses to be transmitted over respective connections **11***b* through **19***b*. This operation monitoring information is compared in a digital comparator **25** with the input from digital source **24** so that any malfunction in the thermal excitation of the printing segments **11** through **19** results in a deviation between the two inputs to the comparator **25**, thereby generating an error signal which is detected by a suitable read-out device **26**.

The details of the construction of the printing element **10** are shown in FIGURES 2, 3 and 4. A substrate **30** for the element **10** is made from a material having heat-insulating properties, for example glazed ceramic. A pattern of monitoring segments **11′** through **19′**, having the same configuration as the printing segments **11** through **19** is coated on the substrate **30** (see FIGURE 4). The monitoring segments **11′** through **19′** are made of a thermistor semiconductor material. Next highly conducting interconnection strips **11***b* through **20***b*, made for example of aluminum, are coated over the monitoring segments **11′** through **19′**, to form an interconnection pattern as shown in FIGURE 3. The spaces in between and above the interconnection strips **11***b* through **20***b* are coated with a material **31** characterized by both good thermal conductivity and electrical insulating properties, for example aluminum oxide. After a thin insulating layer of the material **31** is coated over the interconnection strips **11***b* through **20***b*, a second set of highly conducting interconnection strips **11***a* through **20***a*, having the same pattern as that shown in FIGURE 3 for interconnection strips **11***b* through **20***b*, is coated directly over the interconnection strips **11***b* through **20***b*. More of the material **31** is then coated between the interconnection strips **11***a* through **20***a*. Next the printing segments **11** through **19** are coated directly above, and in the same pattern as, the monitoring segments **11′** through **19′**. Finally, an outer coating **32** is placed over the printing segments **11** through **19** and the interconnection strips **11***a* through **20***a*.

The material forming the printing segments **11** through **19** should preferably have a resistance of 300 ohms or more per unit area at a coating thickness of approximately 2000 A. A suitable material for this purpose is Nichrome. The material forming the interconnection strips **11***a* through **20***a* should preferably have a resistance which is at least two orders of magnitude less than that of the printing segments. A suitable material for this purpose is aluminum coated to a thickness of 2000 A.

The over-coating material **32** must have good thermal conductivity so that the heat of the printing segments **11** through **19** is transmitted to the thermally sensitive paper **21** (FIGURE 1), and, moreover, should have a hardness which is at least 50 Rockwell units greater than the thermal material used on the sensitized paper. Aluminum

oxide is a suitable over-coating material for this purpose. Under these conditions, the over-coating **32** will protect the thermal printing segments **11** through **19** from wear since the paper will bear against the over-coating **32**. To further protect against such wear, the paper guides **22** and **23** can be provided with a mechanical relief so that there will not be an excess amount of stress on either the paper **21** or the printing element **10**.

Mounted in the paper entrance guide **22** is a heating system comprising a heater coil **41** energized by a heater supply **42**. This system is preferably regulated so that the temperature of the incoming paper is maintained at 60° C. ±5° C. Thus the paper coming into contact with the printing element **10** is thermally pre-biased. This decreases the time required for the printing element **10** to make a clearly visible mark on the paper **21** to a value in range of 1 to 10 milliseconds.

The relationship between the pattern of printing segments **11** through **19** and the pattern of interconnecting strips **11***a* through **19***a* is such that: the strip **11***a* makes electrical contact with one end of the segment **11**; the strip **12***a* makes electrical contact with one end of the segment **12**; the strip **13***a* makes electrical contact with one end of the segment **13**; the strip **14***a* makes electrical contact with one end of the segment **14**; the strip **15***a* makes electrical contact with one end of the segment **15**; the strip **16***a* makes electrical contact with one end of the segment **16**; the strip **17***a* makes contact with one end of the segment **17**; the strip **18***a* makes contact with one end of the segment **18**; and the strip **19***a* makes contact with one end of the segment **19**. The strip member **20***a* is shaped so as to contact the opposite end of each of the printing segments **11** through **19**. Thus strip member **20***a* provides a common return for current flowing through the printing segments **11** through **19**.

Similarly, the relationship between the pattern of monitoring segments **11′** through **19′** is such that: the strip **11***b* makes electrical contact with one end of the segment **11′**; the strip **12***b* makes electrical contact with one end of the segment **12′**; the strip **13***b* makes electrical contact with one end of the segment **13′**; the strip **14***b* makes electrical contact with one end of the segment **14′**; the strip **15***b* makes electrical contact with one end of the segment **15′**; the strip **16***b* makes electrical contact with one end of the segment **16′**; the strip **17***b* makes contact with one end of the segment **17′**; the strip **18***b* makes contact with one end of the segment **18′**; and the strip **19***b* makes contact with one end of the segment **19′**. The strip member **20***b* is shaped so as to contact the opposite end of each of the monitoring segments **11′** through **19′**. Thus strip member **20***b* provides a common return for current flowing through the monitoring segments **11′** through **19′**.

In operation, the thermally sensitive paper **21** is fed past the printing element **10** with the temperature-sensitive surface of the paper contacting the thermally-conducting over-coating **32** as seen in FIGURE 4. The current pulses from digital source **24** are fed to the interconnecting strips **11***a* through **19***a*, thereby flowing lengthwise through the corresponding printing segments **11** through **19**. The resistance of these segments is sufficient to generate enough heat for making a visual mark on the thermally sensitive paper in the shape of the segment which is so energized.

More particularly: to print the numeral "1," current pulses are fed to interconnecting strips **13***a* and **14***a* to thereby heat up printing segments **13** and **14**; to print the numeral "2," current pulses are fed to strips **16***a*, **17***a*, **18***a*, **13***a* and **11***a* to thereby heat up printing segments **16**, **17**, **18**, **13** and **11**; to print the numeral "3," current pulses are fed to strips **16***a*, **17***a*, **18***a*, **19***a* and **11***a* to thereby heat up printing segments **16**, **17**, **18**, **19** and **11**; to print the numeral "4," current pulses are fed to strips **14***a*, **17***a*, **18***a* and **19***a* to thereby heat up printing segments **14**, **17**, **18** and **19**; to print the numeral "5," current pulses are fed to strips **16***a*, **14***a*, **18***a*, **19***a*, **11***a* and **13***a* to thereby heat up printing segments **16**, **14**, **18**, **19**, **11** and **13**; to print the numeral "6," current pulses are fed to strips **16***a*, **14***a*, **13***a*, **11***a*, **19***a* and **18***a* to thereby heat up printing segments **16**, **14**, **13**, **11**, **19** and **18**; to print the numeral "7," current pulses are fed to strips **14***a*, **16***a*, **17***a* and **19***a* to thereby heat up printing segments **14**, **16**, **17** and **19**; to print the numeral "8," current pulses are fed to strips **14***a*, **16***a*, **17***a*, **18***a*, **13***a*, **11***a* and **19***a* to thereby heat up printing segments **14**, **16**, **17**, **18**, **13**, **11** and **19**; to print the numeral "9," current pulses are fed to strips **18***a*, **14***a*, **16***a*, **17***a*, **19***a* and **11***a* to thereby heat up printing segments **18**, **14**, **16**, **17**, **19** and **11**; to print the numeral "0," current pulses are fed to strips **16***a*, **17***a*, **19***a*, **11***a*, **13***a* and **14***a* to thereby heat up printing segments **16**, **17**, **19**, **11**, **13** and **14**.

Whenever one of the strips **11** through **19** is properly energized in accordance with the above program, the heat so generated is conducted through the insulating layer **31** and raises the temperature of the corresponding monitoring strip **11′** through **19′**. The monitoring strips are made of thermistor material which experiences a large decrease in electrical resistance upon said temperature rise. Thus, if the printing unit **10** is functioning properly, a given distribution of input current pulses on the input strips **11***a* through **19***a* results in exactly the same distribution of high conductivity on the output strips **11***b* through **19***b*. Suitable conventional circuits are used to transform these pulses of high conductivity into pulses for the comparator **25**. Under these conditions, the two inputs to the digital comparator **25** are the same and thus no error signal is registered on the read-out device **26**. Conversely, if the printing unit **10** is not functioning properly, the two inputs to the comparator **25** will be different and thus the read-out device **26** will register an error signal which may be used to suspend operation until the printing unit **10** is again functioning properly.

It should be noted that the interconnecting strips **11***a* through **20***a* make electrical contact only at the ends of the elongated printing segments **11** through **19**, so that a maximum length of current path is established in these segments for advantageously obtaining the maximum temperature rise upon excitation by a digital current pulse. Similarly, the interconnecting strips **11***b* through **20***b* make electrical contact only at the ends of the elongated monitoring segments **11′** through **19′**, so that a maximum length of current path is established in these segments for advantageously obtaining the maximum increase in conductivity of these segments when they are heated by the digital pulse temperature rise in the corresponding printing strips **11** through **19**.

It is to be understood that modifications and variations of the embodiments of the invention disclosed herein may be resorted to without departing from the spirit of the invention and scope of the appended claims.

Having thus described the invention, what is claimed as new and is desired to be protected by Letters Patent is:

1. A thermal printing device, comprising: a plurality of heating elements adapted to sensitize thermally sensitive paper; and a plurality of temperature responsive elements, one of said elements being in thermal communication with each one of said heating elements, respectively, whereby a given distribution of energization of said heating elements results in the same distribution in the response of said temperature responsive elements to thereby indicate the proper functioning of said heating elements, said temperature responsive elements being formed in a first layer pattern on a heat-insulating substrate; and said heating elements are formed in a second layer pattern on said heat-insulating substrate.

2. A thermal printing device, comprising: a plurality of heating elements adapted to sensitize thermally sensitive paper; and a plurality of temperature responsive elements, one of said elements being in thermal communication with each one of said heating elements, respectively, whereby a given distribution of energization of

said heating elements results in the same distribution in the response of said temperature responsive elements to thereby indicate the proper functioning of said heating elements; said temperature responsive elements are formed in a first layer pattern on a heat-insulating substrate; and said heating elements are formed in a second layer pattern on said heat-insulating substrate superimposed on said first layer pattern.

3. A thermal printing device, comprising: a plurality of elongated, high-resistance, heating elements adapted to sensitize thermally sensitive paper; and a plurality of electrical connectors for permitting current to be conducted through any desired combination of said heating elements in order to sensitize said paper in a pattern corresponding to the spatial arrangement of said combination of heating elements, said connectors being disposed to make electrical connection only at the ends of said elongated heating elements, said elongated heating elements being formed in a layer pattern on a heat-insulating substrate, and said connectors being formed in a layer pattern on said substrate, said connector layer pattern being formed so that a separate connector contacts each elongated heating element at one end of said heating element and a single connector contacts all of said elongated heating elements at the opposite end thereof said

heating element layer pattern being superimposed over a layer of pattern of temperature responsive elements on said substrate, whereby a given distribution of energization of said heating elements results in the same distribution in the response of said temperature responsive elements to thereby indicate the proper functioning of said heating elements.

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219—487, 506, 543; 346—76