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HIGH SPEED PRINTER IN ELECTRONIC COMPUTER SYSTEM

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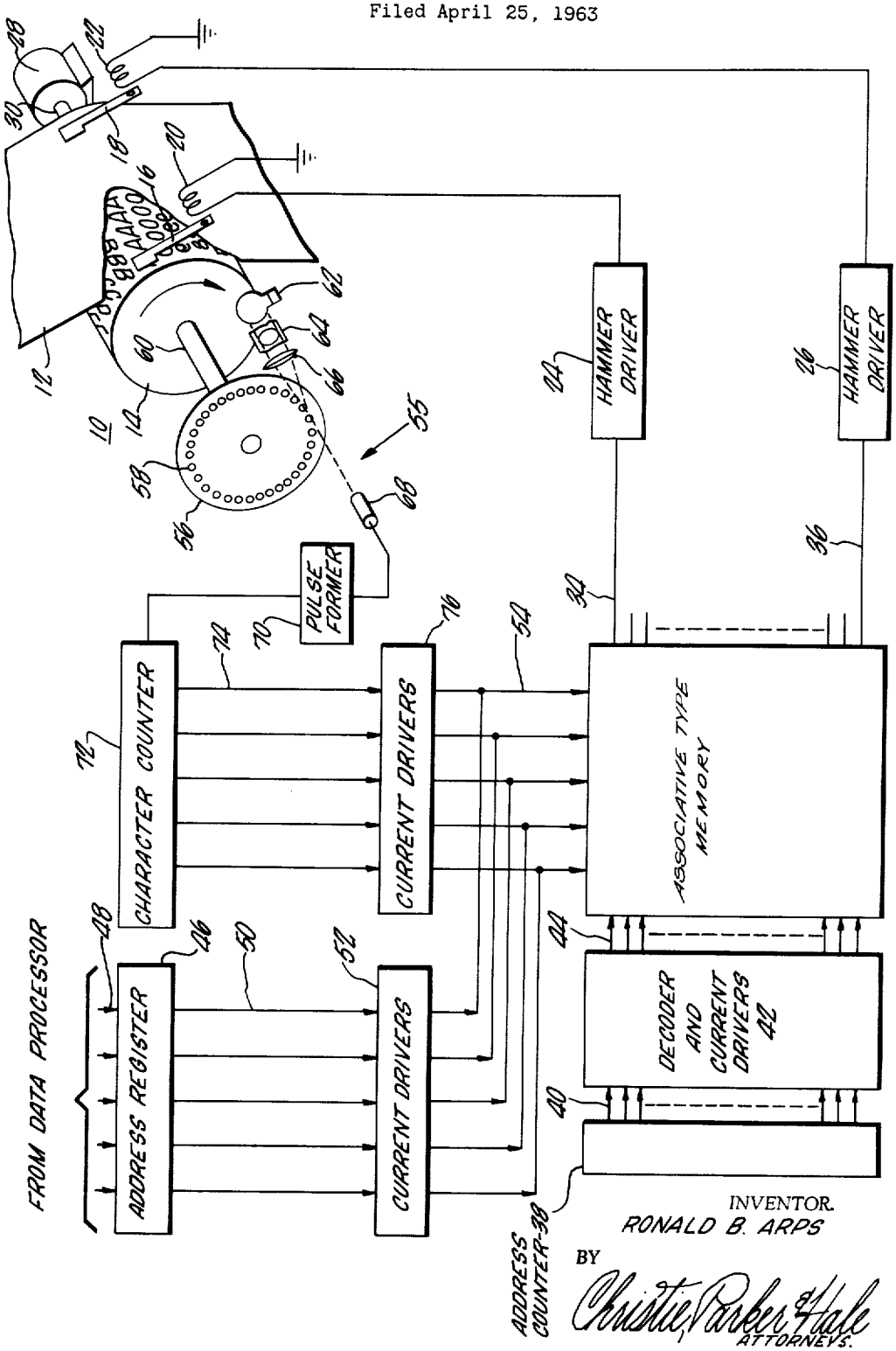

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HIGH SPEED PRINTER IN ELECTRONIC COMPUTER SYSTEM

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This invention relates to improvements in printing apparatus and, more particularly, to an improved high speed printing system.

In high speed printers, such as those employed as recording devices in electronic computer systems, it is common practice to simultaneously print all like characters in a line of information to be printed. To accomplish this, high speed printers generally employ a rapidly moving type carrying member. The type carrying member has a plurality of groups of type characters impressed on an exposed surface. A group of type characters is included for each character space in a line of information to be printed. The type characters of each group are transported by the type carrying member in succession opposite a different print position on a print medium such that like type characters are simultaneously opposite all print positions. Each print position is associated with and corresponds to a character space in the line of information to be printed. Aligned with each print position is a print actuating mechanism. The print actuating mechanisms are arranged to move any selected one of the type characters of an associated group into engagement with the print medium when the selected character is opposite the associated print position.

To simultaneously print all like characters in a line of information to be printed, all print actuating mechanisms aligned with print positions in which the particular character is to be printed must be simultaneously energized when the particular character is opposite the print positions. To provide such timed control over the selective operation of the print actuating mechanisms, conventional high speed printing systems include a complex combination of character writing generators, address registers and counters, compare registers, decoders, and at least one buffer memory storage unit. In such a combination, the buffer memory unit serially receives and stores each character of a complete line to be printed and is serially interrogated to successivley read out each stored character. Each character read out of storage is compared with a signal representation of the type character appearing opposite the plurality of print positions. When a match occurs between a stored character and the type character a discrete signal is developed. The discrete signal effectively primes the print actuating mechanism aligned with the print position and character space in which the stored character is to be printed. At the end of a complete serial interrogation of the buffer memory unit each stored character has been compared with the next appearing type character. Also all print actuating mechanisms aligned with print positions in which the next appearing type character is to be printed are primed. When the type character is substantially opposite the print positions the primed actuating mechanisms are fired to simultaneously print the type character in print positions corresponding to the character spaces in the stored line of information which include the particular character.

The complete serial interrogation is repeated for each type character on the type carrying member at which time the line of information is completely printed on the print medium. The print medium is shifted and the process then repeated for the next line of information to be printed.

As described, in conventional high speed printing systems each character in a line of stored information must

be compared with the next appearing type character within the time interval between the energizing of the print actuating mechanisms and the aligning of the next type character with the print positions. Such a finite amount of time is required to read out and compare each stored character, the rate at which the print carrying member may be moved to bring consecutive type characters into alignment with the print positions is restricted. Thus, in conventional high speed printing systems the rate at which information may be printed is strictly limited. Such speed limitations are generally undesired and are particularly troublesome in high speed data processing systems wherein it is desired that information be processed and recorded as rapidly as possible by the printing systems associated therewith. There is, therefore, a pressing need for high speed printing systems which are capable of printing at rates far in excess of the capabilities of conventional high speed printing systems.

In view of this, the present invention provides a high speed printing system which is capable of printing at rates substantially faster than conventional high speed printing systems while employing a minimum number of electronic circuit elements.

Briefly, to accomplish this, the printing system of the present invention comprises a print unit for selectively printing in a plurality of print positions on a print medium. The print unit includes a plurality of groups of characters, one for each print position, together with means for moving the groups relative to the print medium to successively align each character of each group with an associated print position such that like characters are simultaneously aligned with the plurality of print positions. For each print position the print unit also includes means for transferring any selected character to the print medium when the selected character is opposite the associated print position. Coupled to the print medium is a word generator for generating a coded word indicative of the character next to be aligned with each of the print positions. Each coded word generated by the word generator is applied to an associative type memory. The memory is arranged to store a coded word for each character in a line of information to be printed such that each stored word is associated with a different and corresponding print position and transferring means in the print unit. The associative memory is also arranged to simultaneously compare the generated word with each stored word to produce a discrete output signal for each transferring means for which a match occurs between the generated word and the associated stored word. The discrete output signals are coupled through separate circuit means to their associated transferring means, the circuit means being responsive to the discrete output signals to energize the associated transferring means causing the character represented by the coded word to be transferred to the print medium. In this manner the character represented by the coded word is simultaneously transferred to the print medium in all print positions in which a like character was stored in the associative memory. This process is repeated for each different character in the print unit at which time a complete line of information is printed on the print medium.

As described, in the printing system of the present invention, only one compare operation is required for each different type character in the print unit. In particular, the coded word representing the character next to be aligned with the print positions is simultaneously compared with all characters stored in the associative memory. The time required to perform the associative comparison is substantially the same as one serial comparison in the conventional printing system. Accordingly, the high speed printing system of the present invention increases the rate at which information may be printed at

least by a number of units of time required for conventional systems to read out serially and compare each character in a line to be printed. For example, if a line to be printed includes one-hundred twenty character spaces and there are thirty-two different characters in each group of characters in the print unit, it requires one-hundred twenty times thirty-two or three thousand eight hundred forty units of time just to read out and compare each character in storage with the plurality of type characters in conventional printing systems. This amount of time is reduced to thirty-two units of time in the high speed printing system of the present invention. This same time saving is provided for each line of information to be printed by the printing system. The enormity of the over-all time saving provided by the high speed printing system of the present invention compared with conventional printing systems thus becomes obvious.

Furthermore, since the simultaneous comparing operation takes place within the associative memory itself, the additional read out, compare and storage apparatus common in the conventional printing systems are not required by the present invention. Accordingly, not only does the present invention provide a system for printing at rates far in excess of the capabilities of conventional printing systems but it accomplishes the task with a minimum of equipment.

The above, as well as other features of the present invention, may be more clearly understood by reference to the following detailed description when considered with the drawing, the single figure of which is a schematic-block diagram representation of a basic form of the high speed printing system of the present invention.

As represented, the high speed printing system comprises a printing unit **10** for selectively printing in a plurality of print positions on a print medium represented by the sheet of paper **12**. The printing unit **10**, by way of example only, includes a drum **14** mounted for rotation about its longitudinal axis adjacent the surface of the paper **12**. The drum **14** carries an array of type characters on its outer surface adjacent the paper **12**. The type characters are arranged in a plurality of separate groups each having a plurality of type characters such as the letters of the alphabet and the numerals 0–9. Preferably, the groups extend in rings side by side around the periphery of the drum **14** such that like type characters lie adjacent each other to form rows of like type characters along the length of the drum. The number of groups of type characters is determined by the maximum length of line to be printed in the high speed printing system. For example, if a line to be printed has one-hundred twenty character spaces, one-hundred twenty different groups of type characters are included on the surface of the drum **14**, one associated with each character space in the line to be printed.

By arranging like type characters for each group to lie in rows along the surface of the drum, the array of type characters is arranged such that like type characters are simultaneously opposite a plurality of print positions on the paper **12**. The plurality of print positions are defined by the position of a plurality of print hammers, one associated with each print position on the paper **12**. Two of the hammers are illustrated as **16** and **18** and by way of example only, include arm members hinged to press the paper **12** against the surface of the drum **14**. The area of the paper **12** pressed into contact with the drum by the hammers defines a print position on the paper **12**.

The hammers are aligned side by side one for each ring of type characters on the drum and hence one for each character space in the line of information to be printed. The hammers such as **16** and **18** are selectively excited by an electromagnet arrangement represented by the coils **20** and **22**, respectively. The coils are electrically coupled to hammer drives **24** and **26**, respectively, which, when energized, apply a current signal to the respective coils to cause the associated print hammers to press the paper **12** into contact with the drum within an associated print position.

By aligning all of the print hammers side by side, a line of information may be printed by selectively energizing particular ones of the print hammers as the drum **14** is rotated. The drum **14** is rotated at a constant angular velocity about its longitudinal axis by a motor drive **28** having its drive shaft **30** coupled to the axis of rotation of the drum **14**. As the drum **14** rotates the rows of like type characters pass in succession in alignment with the print positions on the paper **12**.

In the high speed printing system of the present invention, like characters in a line of information are simultaneously printed on the paper **12** when the corresponding row of type characters on the drum **14** is opposite the print positions. This is accomplished by selectively and simultaneously energizing the print hammers associated with the character spaces in which the particular type character is to be printed when the particular type character is aligned with the print hammers. By repeating this operation for each row of characters on the drum, a line of information is completely printed on the paper **12** within a single revolution of the drum **14**.

The operation of the high speed printer of the present invention is substantially more rapid than the operation of conventional high speed printers. This is accomplished by including an associative memory **32**. The memory **32** is arranged to store coded words indicative of the characters in a line of information to be printed. The memory **32** also functions to allow the simultaneous comparison of all characters in storage with a coded word representation of the next type character to be aligned with the print positions to simultaneously excite all print hammers associated with character spaces in the line to be printed containing the next type character.

Associative memories having the above general characteristics are well known in the art. Thus, the memory **32** may take any one of a number of different forms. By way of example only, the memory **32** may be similar to the identification storage apparatus described in the copending patent application, Serial No. 780,056, filed December 12, 1958, and assigned to the same assignee as the present invention.

More particularly, associative memories of the class of which the memory **32** is a member, generally include a plurality of memory cells arranged in a preselected pattern of information groups for storing coded words. Each information group is associated with a different output circuit. An input coded word is simultaneously applied to each information group to determine the presence of like coded words by the generation of an output signal from ecah memory cell. In particular, the output signals of the cells in each information group are combined at the associated output circuit to produce a composite output signal. If a match occurs between the input and a stored word in an information group, the composite signal for the particular information group is of a discrete value.

In accordance with the present invention, such associative memories are adapted for use in a high speed printing system by (1) storing coded words indicative of the characters to be printed in a line of information in information groups associated with corresponding print positions in the print unit; (2) coupling the output circuits of the information groups to corresponding print hammers; and (3) by generating a coded input word for simultaneous comparison with the stored words which is indicative of the next type character to be aligned with the print positions.

Thus, in the memory **32**, a plurality of output leads, such as **34** and **36**, are electrically coupled to particular hammer drivers, such as **24** and **26**, respectively. By such a coupling of the respective output leads, each information group is associated with a different print position and print hammer.

When the characters to be printed are identified by binary coded words, the information groups of the memory **32** are arranged to store binary coded words. The binary coded words indicative of the characters to be printed may be serially stored within the memory by successively energizing the plurality of information groups within the memory **32**. To accomplish this, the addressing circuitry illustrated in block form may be employed. By way of example only, the addressing circuitry includes an address counter **38** having a plurality of count conditions one for each character-space in the line of information to be printed. The address counter **38** includes a plurality of output leads **40** which are selectively energized to represent the various count conditions of the counter **38**. The output leads **40** are coupled to a decoder and current driver array **42**. The array **42** is of conventional design and functions to selectively decode each count condition of the address counter **38** and to produce a current signal on a selected one of a plurality of output leads **44**. A separate output lead is associated with each information group within the associative memory. When an output lead is excited it effectively primes the particular information group to selectively store a binary coded word indicative of a character to be printed. The address counter and decoder arrangement combines to successively prime each of the information groups such that a complete line of characters to be printed may be selectively and successively stored within the plurality of information groups within the memory **32**.

To selectively store each character in succession within the memory **32** of the addressing circuitry includes an address register **46** having a plurality of input leads **48** and a plurality of output leads **50**. The address register may comprise a plurality of cells each having a bistable trigger circuit such as a conventional flip-flop. The address register **46** is arranged to serially receive and transmit in succession binary coded words indicative of the characters in a line of information to be printed. The binary coded word signals are transmitted by the addressed register by the selective energizing of particular ones of the output leads **50**. The output leads **50** are connected to a plurality of current drivers **52** which, when excited, produce a current signal which is applied to an associated one of a plurality of input leads **54** for the memory **32**. Each one of the input leads is associated with a particular cell for each information group.

To store a character to be printed within a first information group of the memory **32**, a binary coded representation of the first character in a line to be printed is applied to the address register simultaneous with the address counter being in its first count condition. When this occurs, the input lead **44** associated with the first information group within the memory is energized as the binary coded input word excites particular ones of the input leads **54**. The simultaneous exciting of particular leads **54** and the lead **44** selectively stores a binary coded bit in each cell of the first information group indicative of the binary value for a corresponding bit of the coded word representation of the first character in the line to be printed. The process is repeated for each other incoming character in the line to be printed until the entire line of characters is stored within the memory **32**.

As previously described, the memory **32** is adapted to simultaneously compare a coded word representation of the character next to be aligned with the plurality of print positions with each character stored therein to provide for the simultaneous and selective energizing of particular print hammers. To accomplish this, the printing system of the present invention includes word generating means **55** for generating a binary coded word representative of the type character next to be aligned with the plurality of character spaces. The word generating means **55** may take a number of different forms and is illustrated by way of example only, as including a disk **56** having a plurality of holes **58** therein. The holes are spaced equally from each other around the periphery of the disc **56** and are each associated with a different row of type characters on the drum **14**. The disk **56** is coupled by a shaft **60** to the longitudinal axis of the drum **14** for rotation therewith.

Positioned on one side of the disk **56** is a light source **62**, a shield **64** having an opening therein, and a lens **66**. The shield **64** and lens **66** are aligned such that light from the source **62** is focused on a spot along the periphery of the disk **56**. As the disk **56** rotates with the drum **14**, the light from the source **62** is modulated as the openings **58** pass one after another in alignment with the beam of light from the lens **66**.

Positioned on an opposite side of the disk **56** is a photosensitive device **68** for receiving the modulated beam of light. The photosensitive device **68** is coupled to a pulse former **70** which generates a current pulse for each light burst received by the photosensitive device **68**. The openings **58** are spaced relative to each other such that the opening associated with any given row of type characters on the drum **14** passes light to the photosensitive device **68** when the row of type characters is next to be aligned with the plurality of print positions. Thus, for each row of type characters on the drum **14**, a pulse is generated by the pulse former **70** just prior to the actual alignment of the row of type characters with the print positions.

The pulses generated by the pulse former **70** are applied to a character counter **72**. The character counter **72** may be a counter arranged to count in binary code with a different count condition for each different type character on the drum **14**. The pulses generated by the pulse former **70** step the counter **72** to successive count conditions. The counter **72** has a plurality of output leads **74** which are selectively energized in accordance with the count condition of the counter. The output leads **74** are coupled to current drivers **76** which, when excited, produce a current signal for application to an associated one of the plurality of input leads **54** for the memory **32**. In this manner, a binary coded word representation of the type character next to be aligned with the plurality of print positions is applied to the memory **32** by the selective energizing of the particular ones of the input leads **54**.

Since each input lead **54** is associated with a common cell of each information group, the signal representation of the binary coded word indicating the next type character on the drum **14** is simultaneously applied to each information group. The associative memory, as described above, then functions to determine the presence of like coded words by the generation of output signals from each memory cell, wherein a composite output signal for each information group indicates the presence of the coded word by a discrete signal.

The output signals generated by each information group are simultaneously applied by their associated output leads, such as **34** and **36** to the associated hammer drivers, such as **24** and **26**. The hammer drivers are arranged to be responsive to the discrete signals to produce a current signal which actuates the associated print hammer. In this manner, when a particular type character is aligned with each of the print positions, the print hammers associated with the character spaces in which like characters appear are simultaneously energized to print the like type characters in the line of information stored in the memory **32**. After the particular print hammers are actuated the drum **14** rotates to cause another pulse signal to be generated by the pulse former **70** thereby changing the count condition of the binary counter **72**. The simultaneous compare operation then takes place for the next type character to be aligned with the print positions and the simultaneous actuation of particular print hammers again occurs.

The simultaneous comparing of all characters in a line of information to be printed with the next type character

to be aligned with the plurality of print positions occurs for each type character in each group on the drum **14** at which time the complete line of information is printed on the paper **12** within the plurality of print positions. A new line of characters may then be written into the memory **32** and the paper shifted to expose a fresh line to the plurality of print hammers. The associative comparing operation is then repeated for the new line of information to be printed and the over-all operation repeated for each successive line of information.

What is claimed is:

1. A high speed printing system, comprising:

a print unit for selectively printing in a plurality of print positions on a print medium, said print unit including a plurality of groups of characters, one for each print position, means for moving the groups relative to the print medium to successively align each character of each group with an associated print position such that like characters of the groups are simultaneously aligned with the plurality of print positions, means associated with each print position for transferring any selected character to the print medium when the selected character is opposite the associated print position;

an associative memory having a plurality of input leads and a plurality of output leads, said memory being arranged to store coded words indicative of characters in a line of information to be printed such that each storage location has a different output lead and to simultaneously compare a coded input word applied to the input leads with each stored word to produce a discrete output signal on each output lead for which a match occurs between the stored words associated with the output lead and the coded input word;

means for generating a binary coded signal indicative of the character next to be aligned with the plurality of print positions;

means for applying the generated binary coded signal to the input leads of the memory;

and means for coupling each memory output lead to a different transferring means such that the character associated with each output lead is associated with a corresponding print position on the print medium, each of said means being arranged to excite the associated transferring means in response to a discrete output signal.

2. In a high speed print system, the combination of:

a print unit for selectively printing in a plurality of print positions on a print medium said print unit including means mounting a plurality of groups of characters arranged in rows with one character for each print position, transferring means associated with each print position for transferring any selected character to a print medium when the selected character is opposite the associated print position; means for producing relative movement between the mounting means and the latter means to successively align each character of each group with an associated print position such that like characters in the groups are simultaneously aligned with the plurality of print positions,

position signalling means coupled to said means for producing relative movement for generating a binary coded signal indicative of the character next to be aligned with the plurality of print positions in a timed relationship with the presentation of the character by the print unit,

an associative memory having a plurality of storage locations with each location storing a plurality of binary coded signals and a common output circuit connected to an individual transferring means, the storage location of a binary coded character to be printed in any one line being correlated to the presentation of the character on said mounting means to the transferring means so as to allow all of the same characters to be printed in a line on a print medium to be substantially simultaneously printed and different characters to be printed on the same line to be successively transferred in a timed relationship with the presentation of the characters on said mounting means, and means for applying the binary coded signals from said position signalling means to the associative memory for simultaneous application to each storage location to produce an output signal on the output circuit of the storage location storing a matching character to thereby actuate the connected individual transferring means.

3. In a high speed print system, the combination of:

a print unit for selectively printing in a plurality of print positions on a print medium, said print unit including means mounting a plurality of groups of characters arranged in rows with one character for each print position, transferring means associated with each print position for transferring any selected character to a print medium when the selected character is opposite the associated print position; means for producing relative movement between the mounting means and the latter means to successively align each character of each group in an associated print position such that like characters in the groups are simultaneously aligned with the plurality of print positions,

position signalling means coupled to said means for producing relative movement for generating a binary coded signal indicative of the character next to be aligned with the plurality of print positions in a timed relationship with the presentation of the character by the print unit,

an associative memory having a plurality of storage locations with each location storing a plurality of binary coded signals and having a common output circuit connected to an individual transferring means, the storage location of a binary coded character to be printed in any one line being correlated to the presentation of the character on said mounting means to the transferring means so as to allow all of the same characters to be printed in a line on a print medium to be substantially simultaneously printed and different characters to be printed on the same line to be sucessively transferred in a timed relationship with the presentation of the characters on said mounting means, means for applying the binary coded signals from said position signalling means to the associative memory for application to each storage location to produce an output signal on the output circuit of the storage location storing a matching character to thereby actuate the connected individual transferring means, and means for writing binary coded signals to be printed into said memory for printing same in successive locations on a print medium after all the characters for the immediately preceding location have been presented.

4. A high speed print system, comprising:

a print unit for selectively printing in a plurality of print positions on a print medium, said print unit including a plurality of groups of characters one for each print position, means for moving the groups relative to the print medium to successively align each character of each group with an associated print position such that like characters in the groups are simultaneously aligned with the plurality of print positions, and means associated with each print position for transferring any selected character to the print medium when the selected character is opposite the associated print position;

an associative memory arranged to store coded words such that each storage location has a plurality of input leads and an output lead to simultaneously compare a coded input word simultaneously applied to the input leads with each word stored at each

storage location to produce a discrete output signal on each output lead for which a match occurs between the stored word in the memory and the coded input word;

means for storing coded words indicative of the characters in a line of information to be printed in the memory such that each coded word is stored in a different location and coupled with an individual output lead;

means for generating a coded word indicative of the character next to be aligned with the plurality of print positions;

means for applying the generated coded word to the input leads of the memory;

and means for coupling each output lead to a different and preselected transferring means such that the character associated with each output lead is associated with a corresponding print position on the print medium, each of said means being arranged to excite

the associated transferring means in response to a discrete output signal.

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