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(54) DATA REWRITING METHOD FOR BUBBLE MEMORY.

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Description

This invention relates to a method for rewriting data in memories and, more particularly, to a method for rewriting data in a bubble memory which enables the simultaneity of data to be preserved even if a power failure should occur in the course of the rewriting operation.

Wire-cut electric discharge machines are well-known in the art. In such machines a wire is tensioned between an upper guide and a lower guide, and an electric discharge is produced between the wire and a workpiece placed on a table. By moving the workpiece (table) in the X and Y directions along a machining path, the workpiece is cut as instructed. When the wire is tensioned so as to lie perpendicular to the table (workpiece), the upper and lower surfaces of the workpiece can be cut to the same shape. It is also possible to adopt an arrangement in which the upper guide can be displaced in the X and Y directions, such as in a direction at right angles to the direction in which the workpiece is travelling, to incline the wire with respect to the workpiece. This causes the upper and lower surfaces of the workpiece to be cut to different shapes, enabling so-called taper cutting.

A discharge machining operation performed by a wire-cut discharge machine of the aforesaid type can continue for an extremely long period of time, such as 12 hours, 24 hours, and even for as long as one week in some cases. The workpieces which are cut by electric discharge machining generally are mold materials and the like, and some materials can be extremely expensive.

Accordingly, since an interruption in power can occur during machining, such as by inadvertently turning off the power supply or as the result of power failure due to a lightening bolt or some other cause, it is desired that cutting be resumed, as soon as power is restored, from the position formerly occupied by the wire electrode prior to the power interruption. This prevents the workpiece from being wasted. For a long-term discharge machining operation of one day or one week, as mentioned above, machining proceeds continuously day and night. It follows, then, that there is need for a system which, in the event of a power interruption that occurs at night, is capable of resuming machining automatically without operator intervention after power is restored.

When power is interrupted, there results destruction of information indicative of the current and commanded positions of a motor or of a movable element such as the table, and destruction of positional control information relating to backlash direction, pitch error compensation dog number and the like. There is also complete destruction of the internal status of an NC, which includes interpolation control information such as the number of interpolation pulses produced prior to the power interruption as well as the block number, counting from the beginning of the numerical control data. Also, when power is interrupted, the motor or a movable element such as the table moves by a small amount of the order of several microns, by way of example. Accordingly, when power is cut off during a discharge machining operation in the prior-art arrangement, discharge machining cannot be resumed immediately, in automatic fashion without human intervention, from the position occupied before the interruption in power. Instead, it has been conventional practice to adopt a method based upon the following sequence:

(1) The cutting starting point of the discharge machining operation is stored in memory in advance. For example, this may be set on a digital switch or stored in non-volatile memory.

(2) Following the restoration of power the wire is removed and the table or wire is returned to the zero point of the machine. This brings the position of the table, which is the movable element, or of the wire into coincidence with the current position stored in a volatile memory.

(3) Following the return of the zero point, the table or wire is positioned at the cutting starting point by using the cutting starting point information stored in the non-volatile memory or set on the digital switch.

(4) Upon completion of the cutting starting point positioning operation, the wire is rethreaded and a return is effected to the beginning of the numerical control data.

(5) The operator rewinds the command tape to the begining of the data. The table or wire is then moved along the programmed path at a speed greater than the commanded speed, starting from the beginning of the numerical control command data. This causes the table or wire to travel along the previously cut path. By way of example, a well-known dry-run function can be employed to transport the wire or table at the higher speed.

(6) When the table or wire has been moved as far as a position just short of that occupied at the time of the power interruption, the feed speed of the table is restored to that specified by the program, machining power is introduced, and an electric current is passed through the wire to resume the discharge machining operation.

With the conventional method as described above, processing following the re-introduction of power is extremely complicated and a considerable period of time is required to restore the cutting operation. The result is a marked decline in machining efficiency. Since an operator intervenes in order to resume the machining operation, moreover, an interruption in machining caused by a power failure which occurs at night or during a holiday will not be remidied until the next working day. This greatly diminishes machining efficiency.

In view of the foregoing, the Applicant has already proposed a status recovery system wherein machining is resumed automatically, and wherein the restarting of a machining operation following the re-introduction of power is accomplished in a short period of time requiring neither a return to a zero point, movement to a cutting starting point nor rethreading of the wire. This previously proposed status restoration system will now be described in brief.

As mentioned above, such information as positional control and interpolation information stored in the memory of a numerical control device is destroyed when power is interrupted, and a table or other movable member traverses a very short distance (several microns) upon the occurrence of the power interruption. Accordingly, when power is interrupted owing to a power failure or the like, machining can be resumed automatically by restoring the main power supply providing that the following conditions are satisfied: (A) power is capable of being applied to the numerical control device automatically by restoring the main power supply; (B) the movable member such as the table is capable of being returned automatically to the position occupied prior to the interruption in power; and (C) the internal status of the numerical control device is capable of being restored automatically to the status which prevailed prior to the interruption in power.

To this end, in accordance with the previously proposed system, a device is provided which, in response to restoration of the main power supply, automatically introduces electric power to the numerical control device and the like. Further, in order to automatically return the movable member such as the table to the position occupied prior to the power interruption, the positional information which prevailed prior to the power interruption is preserved in a non-volatile memory. Also provided is a position sensor capable of sensing the absolute position of the motor or of the movable member such as the table. Following the application of electric power, the movable member such as the table is positioned and returned to the position occupied prior to the power interruption by using the positional control information which prevailed prior to the power interruption, which information is stored in the non-volatile memory, and the absolute position detected by the position sensor.

Furthermore, to automatically restore the internal status of the numerical control device to what it was before the interruption in power, in accordance with the previously proposed system, the location of a block which contains the numerical control data that prevailed prior to the power interruption, as well as such interpolation information as the number of interpolation pulses in said block, are stored in the non-volatile memory, and the numerical control command data from the beginning of the data is retrieved so that numerical control processing can be re-executed starting from said retrieved numerical control data. Then, after power is restored, the motor and the movable element such as the table are locked against movement, numerical control processing is executed sequentially starting from the numerical control command data at the beginning of the program, and processing is halted temporarily when the block location and the number of interpolation pulses, which is based on the numerical control command of said block, coincide with the block location and the number of interpolation pulses, respectively, stored in the non-volatile memory. The internal status of the numerical control device is thus made to coincide with what it was immediately prior to the interruption in power. When the conditions which prevailed just prior to the power interruption are restored, the feed of machining fluid and the introduction of electric current to the wire are carried out, and discharge machining is resumed.

In accordance with the previously disclosed system as described above, therefore, excellent effects are obtained since the discharge machining operation can be resumed automatically without human intervention once power has been applied following the power interruption.

In the previously proposed system, the non-volatile memory stores the positional control information such as the current position prior to the number interruption, the block location containing the numerical control command data which prevailed at such time, as well as the interpolation information such as the interpolation pulses in said block. A bubble memory is employed as the non-volatile memory. The abovementioned positional control information and interpolation information is successively written into the bubble memory periodically at predetermined short time intervals to update the data within the bubble memory, so that the most recent positional control information and interpolation information is stored in the non-volatile memory at all times.

The numerical control information and interpolation information stored in the bubble memory is large in quantity and cannot be written into the memory by a single command. Instead, the information is written into the memory by dividing the information into a number of portions each of which is written at a separate time. If a power failure or the like were to occur during the writing of new data into the bubble memory, therefore, part of the data in the memory would be new, and part would be old. The simultaneity of the data would therefore be destroyed, and it would not be possible to execute the correct processing to cope with the power failure.

IBM Technical Disclosure Bulletin, Vol. 20, No. 10, March 1978, pages 4071 to 4072, New York, US, M. E. Chamoff et al: "Nonevolatile totals implementation" describes a data rewrite method for rewriting data stored in memory with new data, wherein the memory is provided with first and second data storage areas, the new data is initially written into the first data storage area, and after the writing of the new data into the first data storage area is completed, the new data is then written into the second data storage area, the new data being associated with specific data in the memory to indicate which of the first and second data storage areas contains complete data.

The object of the present invention is to provide a method for rewriting data in a bubble memory which enables the simultaneity of data to be preserved, in an improved more simple manner than in the prior art, and which in a preferred embodiment allows an electric discharge machining operation to be resumed correctly, even if a power failure should occur during the rewriting of the data.

According to the present invention as claimed there is provided

a data rewrite method for rewriting data stored in memory with new data, wherein the memory is provided with first and second data storage areas, the new data is initially written into the first data storage area, and after the writing of the new data into the first data storage area is completed, the new data is then written into the second data storage area, the new data being associated with specific data in the memory to indicate which of the first and second data storage areas contains complete data, characterised in that the memory is a bubble memory and said specific data is written into a predetermined location of the memory before the new data is written into the first data storage area, and is erased when the new data is completely written in the first data storage area, such that said specific data is written into the location of the last record of the first data storage area, and is erased by being rewritten with the new data at the completion of the rewriting of the first data storage area.

In a case where this method is applied to a system for restoring the status of a numerically controlled wire-cut electric discharge machine, the status of the numerically controlled wire-cut electric discharge machine is stored in the bubble memory at predetermined intervals, a check is performed in restoring power following a power interruption to determine whether the specific data is written in the bubble memory, and the status which prevailed just prior to the power interruption is restored on the basis of the data stored in the second data storage area if the specific data is present, or on the basis of the data stored in the first data storage area if the specific data has been erased.

Brief description of the drawings

Fig. 1 is a block diagram of an arrangement to which the present invention can be applied; Fig. 2 is an explanatory view useful in describing the reading and writing of information with respect to a bubble memory; and Fig. 3 is an explanatory view useful in describing a method for rewriting data in a bubble cassette memory in accordance with the present invention.

An embodiment of the present invention will now be described in conjunction with the drawings.

Fig. 1 is a block diagram of an arrangement to which the present invention can be applied. Numeral 101 denotes a numerical control device (referred to hereinafter as a CNC) having a built-in computer. Numeral 101a denotes a numerical control circuit, and 102 a bubble memory for storing numerical control information and interpolation information at predetermined intervals under the control of the CNC. More specifically, the bubble memory 102 has its content updated successively with new data. Numeral 103 denotes a well-known bubble controller including a buffer memory, a read/write control circuit, and the like. Numeral 104 denotes an electric discharge machine.

Fig. 2 is an explanatory view useful in describing the reading and writing of information with respect to a bubble memory.

In Fig. 2, m_1, m_2, m_i. . .m_N denote minor loops which are a total of N in number. Each minor loop is constructed as a closed loop comprising a bubble domain transfer track of 2M bits. Each loop may, for example, be a continuous loop of T-bar patterns. BG represents a bubble generator, BE a bubble erasor, MLR a read-only major line, and MLW a write-only major line. The minor loops m_1, m_2. . .m_N are arranged with one end adjoining the major line MLR and the other end adjoining the major line MLW. When a transfer command is issued by a transfer TFR, those bubble domains (the black circles in the drawing) at bit positions in the minor loops m_1, m_2. . .m_N that are at the locations adjacent the read-only major line MLR at that instant are transferred to the read-only major line MLR. When a transfer command is issued by a transfer TFW, those bubble domains (the black circles in the drawing) which have been written into the write-only major line MLW are transferred to the minor loops m_1, m_2,. . .m_N at the locations where the minor loops are adjacent the major line MLW.

Processing for the reading and rewriting of data will be described next.

In reading one access unit of stored information comprising N bits, bubble domains in the N-number of minor loops m_1, m_2. . .m_N are transferred in parallel to the read-only major line MLR in response to the transfer command. In the magnetic bubble memory of Fig. 2, if we let the information of 2M bits stored in each minor loop m_i (i=1, 2. . .N) be expressed by b(i, 1), b(i, 2). . .b(i, 2M−1), b(i, 2M), then one access unit of stored information will be taken to mean N-bit information comprising the bits expressed by {b(i, j), b(2 j). . .b(N, j)}, where j=1, 2. . .2M. This one access unit of stored information is generally referred to as a page or block, and comprises 64 bytes.

The bubble domains which have been transferred to the read-only major line MLR are shifted successively bit-by-bit to provide an output of serial data. Accordingly, if a bubble detector BD such as one which relies upon magnetoresistance is provided at the exit of the read-only major line MLR, the output information may be read by sensing the absence or presence of the bubble domains. It should be noted that, in a read operation, destructive read and non-destructive read operations can be carried out wherein one access unit of the bubble domains in the minor loops $m_1, m_2 \ldots m_N$ is erased in the former but not erased in the latter. In an ordinary read operation, however, information is read non-destructively.

In rewriting information, on the other hand, one desired access unit of information in the minor loops $m_1, m_2 \ldots m_N$ is erased by a destructive read operation as the first step (erase cycle). Since each of the minor loops m_1 through m_N comprises 2M bits, there are N bits arrayed between the read-only major line MLR and the write-only major line MLW, and the bubble domains in each of the minor loops m_1 through m_N will make exactly one revolution in response to $2 \cdot M$ cycles of the applied rotating field. Furthermore, stored information in the minor loops m_1 through m_N that was at the locations adjacent the read-only major line MLR arrives at the transfer area of the write-only major line MLW in response to M cycles of the rotating field.

Accordingly, if N-bit information which has been prepared beforehand at the write-only major line MLW is transferred in parallel to the respective minor loops m_1 through m_N in response to a transfer command from the transfer TFW after M cycles of the rotating field following the destructive read operation, then new information will be written into the bit positions (which will be all "0"s) cleared by the destructive read (write cycle). This completes rewrite processing.

Fig. 3 is an explanatory view useful in describing a data rewriting system in a bubble cassette memory in accordance with the present invention. More specifically, the bubble memory 102 is provided with first and second data storage areas 102a, 102b, into which the same data is written in duplicate. In the Figure, B_1 through B_n and A_1 through A_n represent record areas (referred to hereinafter simply as records) for storing one block of data each.

Positional control information and interpolation information are stored in the bubble memory through a procedure which will now be described.

First, specific data, such as all "1"s which, if discriminated, will indicate the fact that the data in the first data storage area 102a is invalid, is written into the last record B_n of the first data storage area (Fig. 3(b)). Next, items of positional control information and interpolation information are written successively into the first data storage area 102a from the first record B_1 to the last record B_n under the control of the bubble controller (Fig. 1). Completing the writing of the above information into the first storage area 102a therefore rewrites new data into the first storage area and causes normal data to be written into the last record B_n (Fig. 3(c)). After finishing the above-described rewriting of data into the first data storage area 102a, the operation for rewriting data into the bubble memory will be completed when the abovementioned data, written into the first storage area 102a, is again written into the second data storage area 102b from the first record A_1 to the last record A_n (Fig. 3(d)).

If data is thus written into the first and second storage areas 102a, 102b in duplicate form, the data can be restored to its former state, even in the event of a power failure during the rewrite operation, following the restoration of power. The procedure is as follows.

First, the data in the last record Bn of the first storage area 102a is read following the restoration of power. Next, the data which has been read is discriminated to determine whether it is the specific data (all "1"s). If it is, this indicates that the power failure occurred during the rewriting of data into the first storage area 102a. Accordingly, if the data which has been stored in the second stage area 102b is read and fed into the CNC, it becomes possible for the CNC to use this data to correctly restore the conditions which prevailed just prior to the power failure. If the discriminated data read out of the last record B_n is found not to be the specific data, on the other hand, this signifies that the data stored in the first storage area 102a is the latest data. If the data stored in the first storage area 102a is read out and fed into the CNC, therefore, the CNC will employ this data to correctly restore the conditions which prevailed prior to the power failure.

In accordance with the present invention as described above, data is written into a bubble memory in duplicate form. In the event of an interruption in power during a rewrite operation, therefore, the simultaneity of data can be preserved and the conditions which prevailed prior to the power interruption can be restored correctly, enabling machining to be resumed.

While a case has been described where the present invention is applied for restoring conditions which prevailed prior to a power interruption in an electric discharge machine, it is obvious that the invention has other applications and is not limited to the foregoing arrangement.

Claims

1. A data rewite method for rewriting data stored in memory (102) with new data, wherein the memory (102) is provided with first and second data storage areas (102a, 102b), the new data is initially written into the first data storage area (102a), and after the writing of the new data into the first data storage area (102a) is completed, the new data is then written into the second data storage area (102b), the new data being associated with specific data in the memory (102) to indicate which of the first and second data storage areas (102a, 102b) contains complete data, characterised in that the memory (102) is a bubble memory and said specific data is written into a predetermined location (Bn) of the memory (102) before the new data is written into the first data storage area (102a), and is erased when the new data is completely written in the first data storage area (102a), such that said specific data is written into the location (Bn) of the last record of the first data storage area (102a), and is erased by being rewritten with the new data at the completion of the rewriting of the first data storage area (102a).

2. A data rewrite method according to claim 1 characterised in that the status of a numerically controlled machine (104) is stored in the bubble memory (102) at predetermined intervals, a check is performed in restoring power following a power interruption to determine whether said specific data is written in the bubble memory (102), and the status which prevailed just prior to the power interruption is restored on the basis of the data stored in said second data storage area (102b) if the specific data is present, or on the basis of the data stored in said first data storage area (102a) if the specific data has been erased.

3. A data rewrite method according to claim 2, wherein the numerically controlled machine (104) is a wire cut electric discharge machine.

Patentansprüche

1. Datenumschreibungsverfahren zum Umschreiben von Daten, die in einem Speicher (102) gespeichert sind, mit Hilfe neuer Daten, wobei der Speicher (102) mit einem ersten und einem zweiten Datenspeicherbereich (102a, 102b) versehen ist, wobei die neuen Daten anfänglich in den ersten Datenspeicherbereich (102a) eingeschrieben werden und wobei, nachdem das Einschreiben der neuen Daten in den ersten Datenspeicherbereich (102a) beendet ist, die neuen Daten anschließend in den zweiten Datenspeicherbereich (102b) eingeschrieben werden, welche neuen Daten spezifischen Daten in dem Speicher (102) zugeordnet sind, um zu kennzeichnen, welcher der ersten und zweiten Datenspeicherbereiche (102a, 102b) vollständige Daten enthält, dadurch gekennzeichnet, daß der Speicher (102) ein Magnetblasenspeicher ist und die spezifischen Daten an einer vorbestimmten Stelle (Bn) des Speichers (102) in diesen eingeschrieben werden, bevor die neuen Daten in den ersten Datenspeicherbereich (102a) eingeschrieben werden, und gelöscht werden, wenn die neuen Daten vollständig in den ersten Datenspeicherbereich (102a) eingeschrieben sind, so daß die spezifischen Daten an der Stelle (Bn) des letzten Speicherungsvorgangs in dem ersten Datenspeicherbereichs (102a) eingeschrieben werden und durch Umschreiben mit den neuen Daten beim Vervollständigen des Umschreibens des ersten Datenspeicherbereichs (102a) gelöscht werden.

2. Datenumschreibungsverfahren nach Anspruch 1, dadurch gekennzeichnet, daß der Zustand einer numerisch gesteuerten Maschine (104) in dem Magnetblasenspeicher (102) in vorbestimmten Intervallen gespeichert wird, daß eine Prüfung bei einem Wiedereinschalten der Stromversorgung auf eine Stromversorgungsunterbrechung hin durchgeführt wird, um festzustellen, ob die spezifischen Daten in den Magnetblasenspeicher (102) eingeschrieben sind, und der Zustand, der gerade vor der Stromversorgungsunterbrechung geherrscht hat, auf der Grundlage der Daten, die in dem zweiten Datenspeicherbereich (102b) gespeichert sind, wenn die spezifischen Daten vorliegen, oder auf der Grundlage der Daten, die in dem ersten Datenspeicherbereich (102a) gespeichert sind, wenn die spezifischen Daten gelöscht werden sind, wiederhergestellt wird.

3. Datenumschreibungsverfahren nach Anspruch 2, bei dem vorgesehen ist, daß die numerisch gesteuerte Maschine (104) eine Drahtschneide-Elektroerosionsmaschine ist.

Revendications

1. Un procédé de réécriture de données pour réécrire de nouvelles données sur des données stockées en mémoire (102), dans lequel la mémoire (102) est dotée d'une première et d'une seconde zone de stockage des données (102a, 102b), les nouvelles données sont écrites initialement dans la première zone de stockage des données (102a), et après que l'écriture des nouvelles données dans la première zone de stockage des données (102a) est terminée, les nouvelles données sont alors écrites dans la seconde zone de stockage des données (102b), les nouvelles données étant associées à des données particulières dans la mémoire (102) pour indiquer celles de la première et de la deuxième zones de stockage des données (102a, 102b) qui contient des données complètes, caractérisé en ce que la mémoire (102) est une mémoire à bulles et en ce que lesdites données particulières sont écrites dans un emplacement prédéterminé (B_n) de la mémoire (102), avant que les nouvelles données ne soient écrites dans la première zone de stockage des données (102a), et sont effacées lorsque les nouvelles données sont complètement écrites dans la première zone de stockage des données (102a), de telle façon que lesdites données particulières soient écrites à l'emplacement (B_n) du dernier enregistrement de la première zone de stockage des données (102a), et soient effacées en étant surchargées par les nouvelles données à la fin de la réécriture de la première zone de stockage des données (102a).

2. Un procédé de réécriture de données selon la revendication 1, caractérisé en ce que le statut d'une machine à commande numérique (104) est stocké dans la mémoire à bulles (102) à intervalles prédéterminés, une vérification est effectuée au rétablissement de l'alimentation après une coupure de l'alimentation pour déterminer si lesdites données particulières sont écrites dans la mémoire à bulles (102) et le statut qui existait immédaitement avant la coupure de l'alimentation est rétabli sur la base des données stockées dans ladite seconde zone de stockage des données (102b) si les données particulières sont présents, ou sur la base des données stockées dans ladite première zone de stockage (102a) si les données particulières ont été effacées.

3. Un procédé de réécriture de données selon la revendication 2, dans lequel la machine à commande numérique (104) est une machine à décharges électriques à électrode filiforme.

Fig. 1

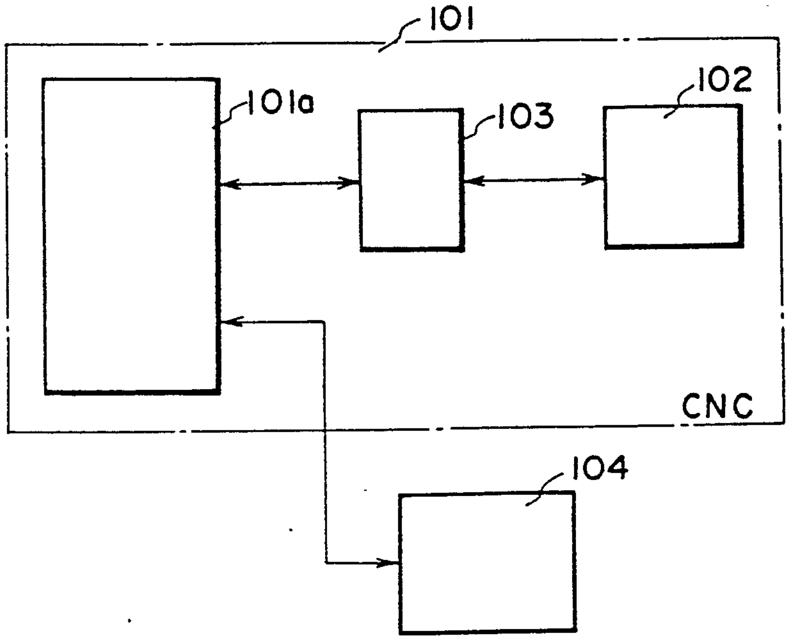
101
101a
103
102
CNC
104

Fig. 3

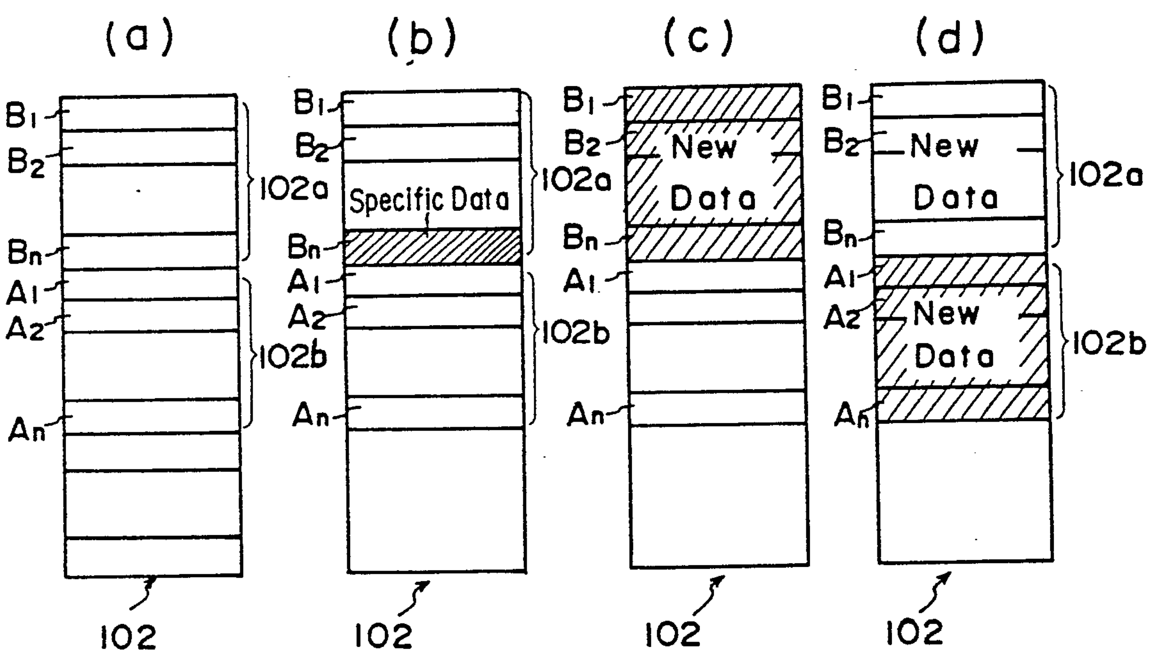
(a)
(b)
(c)
(d)
B1
B2
Bn
A1
A2
An
102a
102b
Specific Data
New Data
102

Fig. 2