United States Patent [19]

Gomi

[11] **3,842,737**

[45] **Oct. 22, 1974**

[54] **PRINTER**

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[73] Assignees: **Kabushiki Kaisha Suwa Seikosha; Shinshy Seiki Kabushiki Kaisha,** Nagano-ken, Japan

[22] Filed: **Feb. 23, 1973**

[21] Appl. No.: **335,198**

[30] **Foreign Application Priority Data**

Feb. 24, 1972 Japan 47-19234
Mar. 30, 1972 Japan 47-32071

[52] **U.S. Cl.** **101/93.34**
[51] **Int. Cl.** **B41j 7/08**
[58] **Field of Search** ..... 101/93 C, 95, 99

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Assistant Examiner—Edward M. Coven
Attorney, Agent, or Firm—Blum, Moscovitz, Friedman & Kaplan

[57] **ABSTRACT**

A printer has control means for print hammers which are arranged in columns and each of which is displaceable between a rest position and a print position, and respective deformable elastic bodies are maintained in a deformed condition by the print hammers in the rest position and bias the print hammers toward the print position. The control means for each hammer comprises a first magnetic circuit including a permanent magnet and a portion of the print hammer, and operable to hold the print hammer in the rest position deforming the associated elastic body, and a second magnetic circuit, including a hammer control coil means, operable to release the print hammer from the rest position responsive to a print command and to return the hammer to the rest position after completing a print action. Each print hammer is released, for movement from the rest position by its associated deformable body, by excitation of the associated control coil means in a direction to decrease the magnetomotive force in the print hammer position and, after completing of the print action, the hammer is returned to the rest position by excitation of the associated control coil means in a direction to increase the magnetomotive force in the print hammer portion.

4 Claims, 9 Drawing Figures

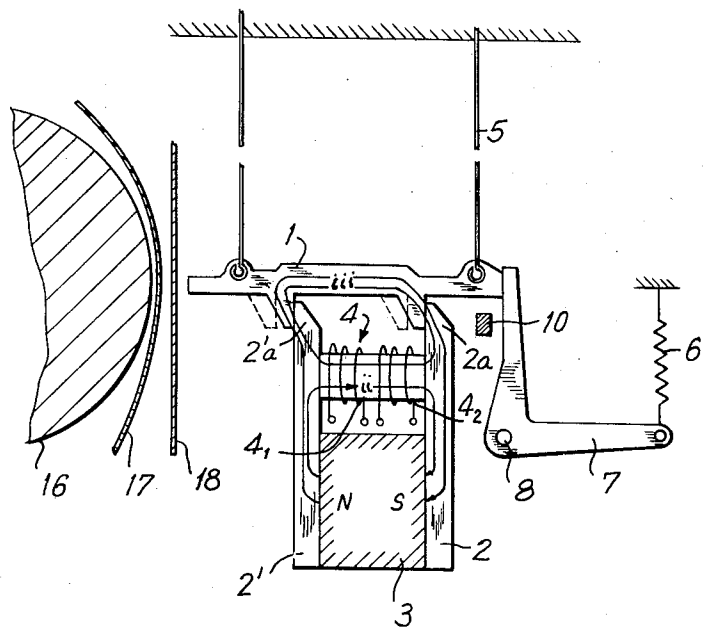


FIG. 1

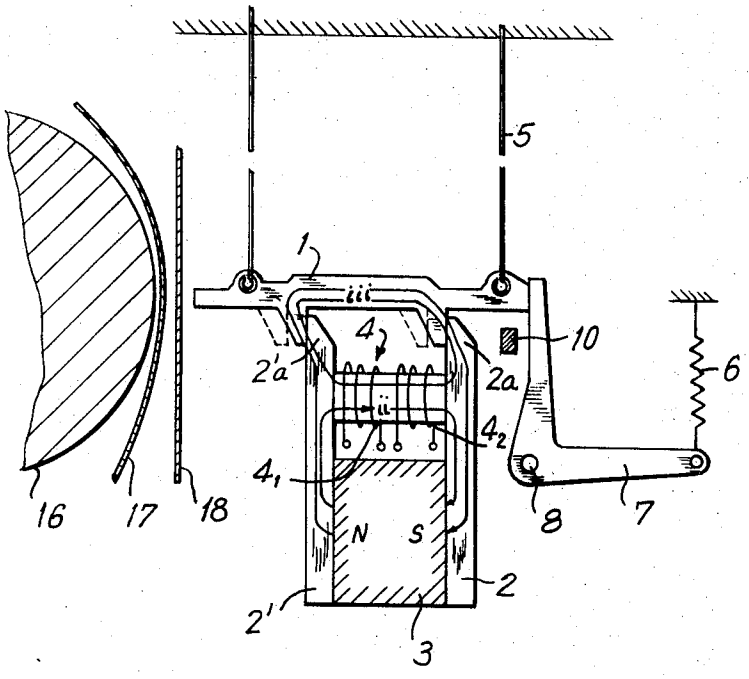


FIG. 2

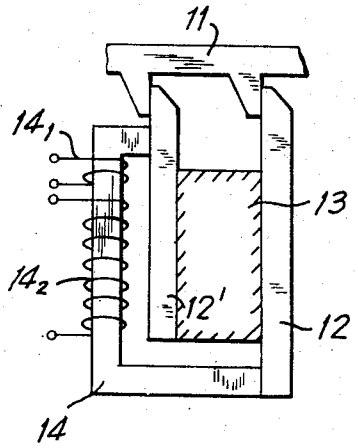


FIG. 3

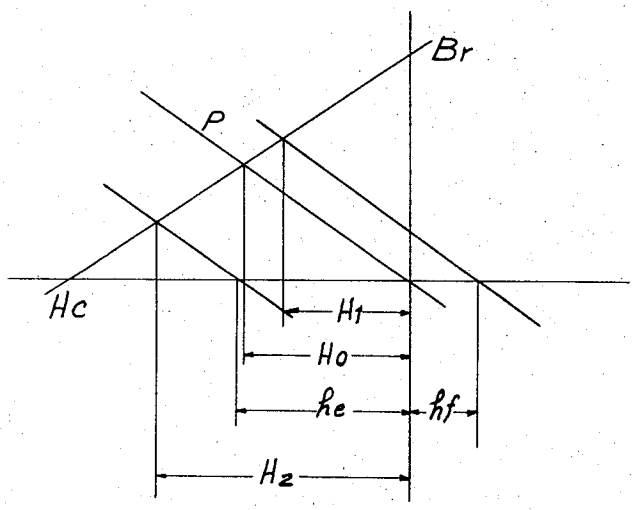


FIG. 4

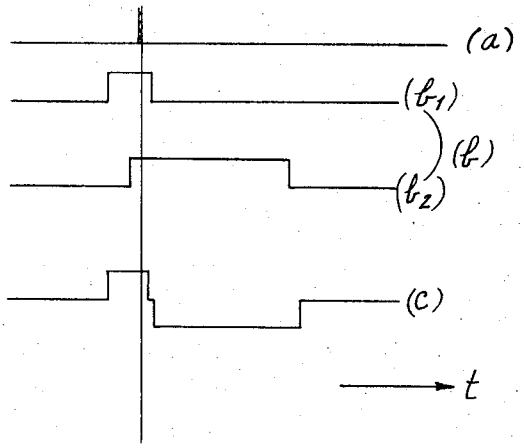
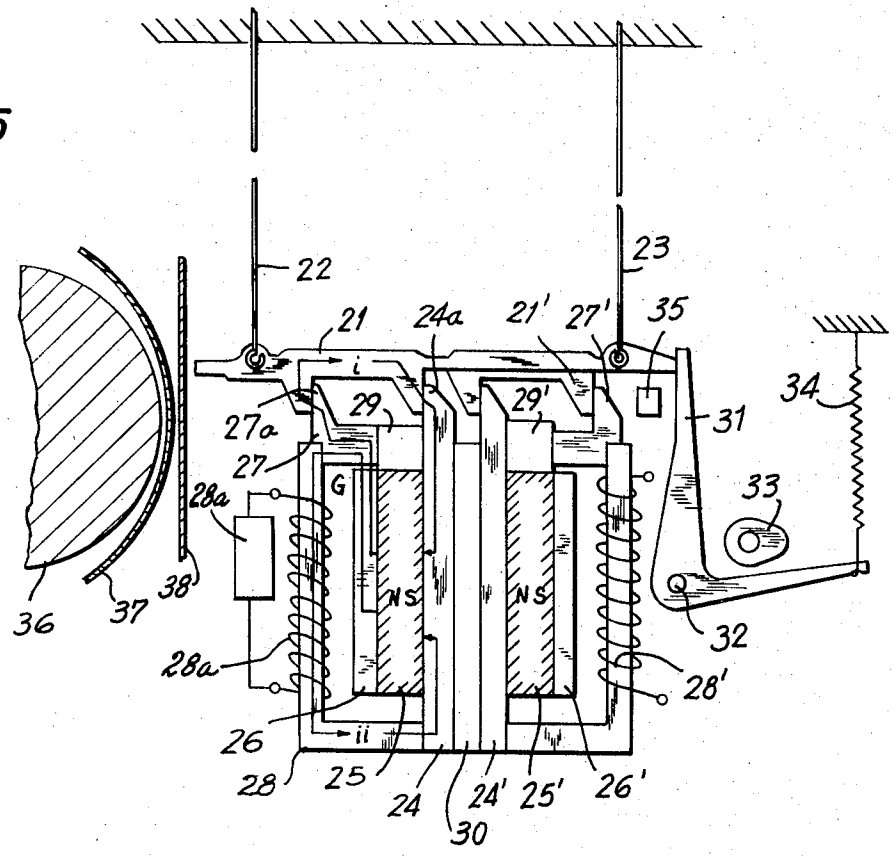


FIG. 5


22
23
21
24a
21'
27'
35
i
29
29'
27a
27
31
34
G
28a
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NS
NS
36
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28a
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FIG. 6

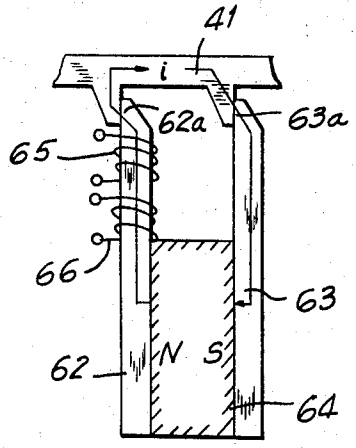

41
i
62a
63a
65
66
63
N
S
62
64

FIG. 7a

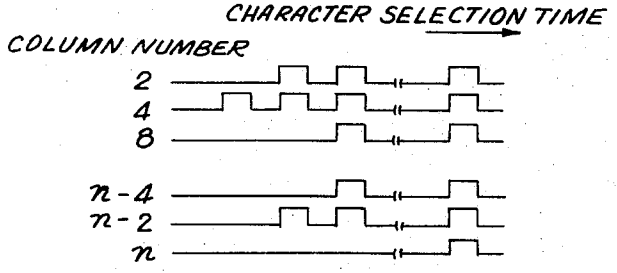


FIG. 7b

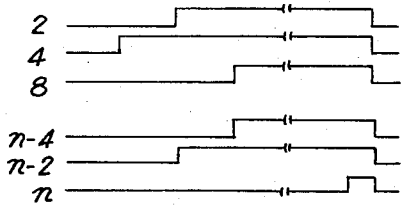
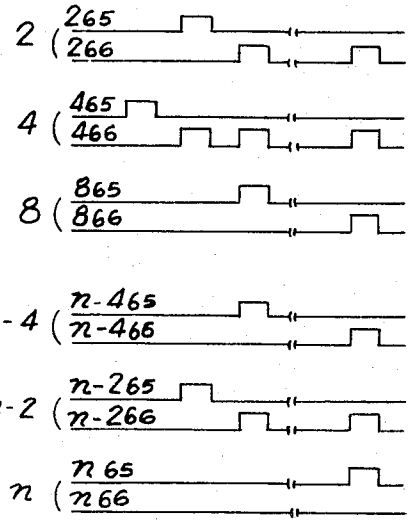


FIG. 7c



PRINTER

FIELD AND BACKGROUND OF THE INVENTION

This invention relates to control means for the print hammers of a high-speed printer and, more particularly, to such a control means in which the print hammers are retained in a rest position by magnetic circuit means and are displaced into the print position by the stored energy of deformable elastic bodies maintained in a deformed condition by each print hammer in its rest position, the release of each print hammer being effected in response to a print command signal.

In known, high-speed printers of this type, where printing is effected by releasing the energy stored in a deformable elastic body, such as a spring, mechanical means, such as cam mechanisms and the like, have been used to return a print hammer to its rest position.

Also, in high-speed printing mechanisms using a permanent magnet, since the magnetic reluctance or the permanence of the magnetic circuit including a permanent magnet is changed by operating the mechanism, the operating point of the permanent magnet is changed so that the mechanism does not operate uniformly. Also, in a printer wherein a permanent magnet is used in a hammer mechanism portion, there is a disadvantage.

Thus, in a magnetic control means having a first magnetic circuit, including a permanent magnet for holding a print hammer in a hammer rest position storing energy in an elastic body such as a spring, and having a second magnetic circuit including a hammer control coil means for releasing the print hammer from the rest position responsive to a print command, when the print hammer within the first magnetic circuit, including the permanent magnet, is released from the hammer hold portion of the control means within the first magnetic circuit and in the rest position, the entire magnetic reluctance of the magnetic circuit is increased, and the operating point of the permanent magnet is changed. Consequently, since the holding force for the hammers of other columns which have not yet been released from the rest position is increased, it becomes necessary to increase the energization of a release coil in order to release the hammer of the first column, and this involves other disadvantages as well.

SUMMARY OF THE INVENTION

In accordance with the present invention, a print hammer, after finishing the print action, is returned to the rest position by utilizing effectively a magnetic force of the permanent magnet and by exciting only a control coil means, without utilizing the conventional mechanical means, such as cam mechanism and the like. Thus, a printer embodying the invention comprises print hammers formed of magnetic material, a first magnetic circuit including a permanent magnet, for holding the print hammers in the rest position, and a second magnetic circuit, including a hammer control coil means, for providing the action of releasing the print hammer from the hammer rest position responsive to a print command, and further returning the print hammer to the rest position after completion of the print action. The first and second magnetic circuits are connected in parallel with the permanent magnet.

When printing is performed responsive to a print command, the hammer control coil means is excited in a direction such that the magnetic flux, or the magnetomotive force, which flows through a hammer hold portion in the first magnetic circuit for holding the hammer in the rest position, is decreased. After the print action, the print hammer is returned to the rest position by exciting the hammer control coil means in a direction to increase the magnetomotive force in the hammer hold portion of the hammer.

Thus, the conventional complicated mechanisms for returning hammers fo the rest position becomes unnecessary, and a simple and inexpensive hammer mechanism is provided. Furthermore, by utilizing effectively the magnetic force of the permanent magnet, it is possible to provide a hammer mechanism wherein the efficiency in the hammer portion is increased and the power consumption is reduced.

In accordance with a further embodiment of the invention, substantially the same power is required to operate the hammer in each column, as well as there being a reduction in the overall power consumption. More specifically, in a magnetic circuit including a permanent magnet for holding a hammer in the rest position, when the hammer is released from the rest position, and in case there is a column in which a hammer has already been released from the rest position, the control coil means of the latter column is excited so that the operating point of the permanent magnet is restored to its original value before the hammer now to be released has been released from the rest position. Thus, the force required to hold the hammers in the rest position can be maintained constant, and other columns can be released using the same power as required to release the first column.

An object of the invention is to provide a very simple hammer control mechanism designed so that the print hammer, after completing the print action, can be returned to its rest position utilizing only a control coil means in the magnetic circuit for controlling the hammer and without requiring a complicated mechanical means to return the hammer.

Another object of the invention is to provide a very simple hammer mechanism which can be assembled and which requires only a small number of parts.

A further object of the invention is to prevent a disadvantageous influence upon the hammers of other columns resulting from actuating a print hammer of one column.

Another object of the invention is to provide a hammer control mechanism with stable action of the print hammers and a very small power consumption.

Still other objects and advantages of the invention will impart the obvious and, in part, be apparent from the specification and drawings.

The invention, accordingly, comprises the features of construction, combination of elements, and arrangement of parts which will be exemplified in the constructions hereinafter set forth and the scope of the invention will be indicated in the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

For a fuller understanding of the invention, reference is had to the following description taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a side elevation view, partly in section, of the operative portion of one column of a high-speed

printer in accordance with one embodiment of the invention;

FIG. 2 is a partial side elevation view of one column of a printer, and illustrating a modification;

FIG. 3 is a graphical illustration of the change in the operating point of a permanent magnet in the arrangement of the invention;

FIG. 4 is a set of curves illustrating the method of operation of the invention;

FIG. 5 is a partially sectioned side elevation view of the operative portion of two columns of a printer in accordance with a further embodiment of the invention:

FIG. 6 is a partial side elevation view illustrating a modification; and

FIGS. 7*a*, 7*b* and 7*c* are curves illustrating the operating of the embodiment of the invention shown in FIGS. 5 and 6.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring first to the embodiment of the invention shown in FIGS. 1 – 4, one column of a high-speed printer embodying the invention is illustrated as including a print hammer 1 suspended by parallel flexible springs 5. The column further includes magnetic material yokes 2 and 2′ extending in spaced, substantially parallel relation from the opposite polarity pole faces of a permanent magnet 3 and having respective attractive faces 2*a* and 2′*a* forming a hammer-hold arrangement. A hammer control coil means 4, including a hammer release coil 4_1 and a reset coil 4_2, for returning hammer 1 to the rest position, is wound on a member interconnecting yokes 2 and 2′.

A lever 7, swingable about a pivot 8, is provided for transmitting the force of a spring 6, for driving hammer 1, to hammer 1, and a stop 10 is provided to limit movement of transmitting lever 7 in the hammer driving direction. A print drum, on which characters are disposed, is indicated at 16 in association with an ink ribbon 17, whereby printing may be recorded on paper or the like 18 by operation of hammer 1.

In its rest position, as illustrated in FIG. 1, hammer 1 is attracted to the attractive faces 2*a* and 2′*a* of the hammer-hold portion, and is biased toward drum 16 by the spring force of spring 6 acting through lever 7 and constituting a deformable elastic body maintained in a deformed condition by hammer 1 in its rest position. The permeance *P*(Bd-Hd) of permanent magnet 3, at this time, is shown in FIG. 3.

To effect a print action of hammer 1 responsive to a print command, hammer control coil 4 is excited in a direction such that the magnetic flux of the magnetic flux loop *ii* flowing through hammer release coil 4_1 is increased when the selected character on drum 16 approaches the front or active end of hammer 1. At this time, as shown in FIG. 3, a magnetic field having the intensity *hf* is applied to permanent magnet 3 along the characteristic curve of magnet 3, so that the intensity of the magnetic field is decreased from H_0 to H_1 and the effective magnetic flux in the hammer-hold portion is decreased. When the hammer-hold force is lowered, hammer 1 starts to be actuated toward the character under the force of spring 6. Hammer 1 continues to be supplied with print energy until transmitting lever 7 strikes against stop 10. Then the kinetic energy of hammer 1 causes it to strike against the character, and the print action is performed.

After completion of the print action, hammer reset coil 4_2 is excited in a direction such that the magnetic flux flows in the direction opposite to that indicated in the magnetic flux loop *ii* shown in FIG. 1. The operating point, on the characteristic curve of permanent magnet 3, at this time, is shown in FIG. 2. A magnetic field of an intensity *he* in the opposite direction is applied to permanent magnet 3, so that the intensity of the magnetic field is increased from H_0 to H_2, and the magnetomotive force in the hammer-hold portion is increased. This results in attraction of hammer 1 to the rest position responsive to this increased magnetomotive force.

It has been explained that the timing of the return of hammer 1 is such that the hammer control coil 4 is excited after the hammer strikes against the character. However, it is also possible to excite the hammer control coil when the hammer is in a position such that its reactionary energy, after striking against the character, can be utilized to a maximum. For example, the restoring magnetomotive force can be applied slightly before the hammer strikes against the character.

FIG. 4 illustrates one example of the timing of the exciting state of the hammer control coil, in which curve *a* illustrates the point at which the hammer stikes against the character. Curve *b* illustrate the exciting state of the release coil 4_1 shown in curve b_1, and of the reset coil 4_2, shown in curve b_2.

While FIG. 1 shows an example of the invention wherein release coil 4_1 and reset coil 4_2 are used separately as a control coil means 4, FIG. 2 illustrates an arrangement in which the release coil 14_1 and the reset coil 14_2 are provided in a single control coil means. In the embodiment of FIG. 2, yokes 12 and 12′ extend from respective opposite polarity surfaces of a permanent magnet 13, and the control coil means 14_1, 14_2 is wound on a magnetic yoke member 14. The yokes 12 and 12′ have attractive faces cooperating with a hammer 11.

The control as shown in the curve *c* of FIG. 4 can also be used, particularly if the release signal for hammer 1 or 11 is positive, an opposite polarity signal being applied to the control coil means to return the hammer. However, in the case of using the arrangement in a high-speed printer, it is satisfactory if the release coil and the reset coil are provided separately as mentioned, so that a coil having a small L and a fast response is used as a release coil, and a coil having a large L and consuming little power, is used as a reset coil.

As stated, when the hammer is reset, the reaction energy of the hammer, after striking the character, can be utilized to a maximum. Thus, it is unnecessary to provide a complicated device, such as a device for absorbing the energy of the hammer, in order to prevent disadvantageous influences caused by the reactionary energy of the hammer, as would be the case in which the hammer were returned to its rest position mechanically as in a conventional printer. Clearly, there is no disadvantageous influence caused by the above-mentioned reactionary energy of the hammer, in the present invention.

Additionally, it is not necessary to provide a complicated mechanical reset mechanism for the hammers as, in accordance with the invention, it is possible to attain a simple and inexpensive hammer control mechanism,

whereby the embodiment of the invention shown in FIGS. 1 – 4 is very advantageous.

Referring now to FIGS. 5 – 8, in the embodiment of the invention illustrated therein, a hammer 21 is suspended by parallel flexible springs 22 and 23. Yokes 24 and 27 have respective attractive faces 24*a* and 27*a* forming a hammer-hold portion. Yoke 27 is fixed to yoke 24 through the medium of a member 29 of non-magnetic material, and a permanent magnet is indicated at 25. Yoke 24 engages one face of magnet 25 and the yoke 26 engages the opposite polarity face of magnet 25 and is connected magnetically with yoke 27 through a gap *G*. A stand 30 of a non-magnetic material mounts yoke 24.

A magnetic circuit is thus provided consisting of a hammer-hold portion and a control portion 28 having coil 28*a* wound thereabout, said hammer-hold and control portions being disposed in parallel with permanent magnet 25. A transmitting lever 31, pivoted at 32, is provided for transmitting, to the hammer 21, the bias of a spring 34 constituting a deformable elastic body maintained in a deformed condition by hammer 21 in the rest position. Hammer 21 is attracted and held at the hammer-hold portion constituted by the attractive faces 27*a* and 24*a*, and is biased toward a character by lever 31. A stop 35 limits motion of lever 31, and a reset cam 33 is provided to return hammer 21 to the rest position after finishing the print action. Hammer 21 is cooperable with characters on a print drum 36, representing a character carrier, and associated, through an ink ribbon 37, with a recording paper 38.

The operation of the hammer mechanism will now be explained. When the selected character on print drum 36 draws near the front or active end of hammer 21, coil 28*a* is excited by excitation circuit 28*a'* in a direction such that the magnetic flux flowing through the control portion is increased, so that the magnetomotive force of the hammer-hold portion is decreased, and the amount of the magnetic flux, of magnetic flux loop *i*, flowing through the hammer-hold portion, is reduced. When the attractive force is thus lowered, hammer 21 is released from the hammer-hold portion and, under the influence of transmitting lever 31 biased by spring 34, begins to be actuated toward print drum 36. The hammer continues to be supplied with the energy of spring 34 until transmitting lever 31 strikes against stop 15. Then hammer 21 strikes against the character on drum 36, and paper 38 and inked ribbon 37, by virtue of its kinetic energy, and the print action is performed.

Hammer 21 is restored to the rest position by operating rest cam 33, and by retracting transmitting lever 31, and further by attracting and holding hammer 21 in the rest position. However, it is not necessary to provide the gap G, although, in FIG. 5, two magnetic circuits, namely a first hammer-hold magnetic circuit including a portion of hammer 21 for holding hammer 21 in the position at which driving spring 34 is deformed, and a second control magnetic circuit including coil 28*a* for releasing hammer 21 from the rest position responsive to a print command, are connected in parallel with permanent magnet 25 through gap *G*.

However, the printer would have a plurality of parallel columns each including a separate hammer, set of yokes, coil, transmitting lever and spring but with odd and even columns each sharing a common permanent magnet. This arrangement is shown in FIG. 5 by a second magnetic circuit associated with hammer 21', each component of the second magnetic circuit being identical with the corresponding component in the above-described circuit, the reference numerals of the second circuit being primed. While the second magnetic circuit associated with hammer 21' is shown provided with a separate permanent magnet 25', a completely independent magnetic circuit cannot be considered on account of leakage of the magnetic flux and the like. For the purpose of this discussion, the first magnetic circuit will be considered representative of odd columns while the second magnetic circuit (primed reference numerals) will be considered representative of even columns.

Considering only the case of even columns, when a hammer of one even column is released from the hammer-hold portion, the entire magnetic reluctance of the magnetic circuits, as seen from the permanent magnet 25, is increased, and the operating point of the permanent magnet is changed in a direction such that the permeance coefficient is decreased. Furthermore, as the amount of the magnetic flux flowing through the hammer-hold portion of other columns within the even columns is increased, the holding force for the respective hammers is increased. Accordingly, in such a condition, in order to release a hammer which has not yet been releaed from the hammer-hold position, it is necessary to use a power, to excite the coil, greater than the power required to excite the coil in order to release the first column. Even if there is a slight surplus of power from the first coil, it is very inconvenient, because it takes a long time after the command signal is sent to the control coil means until the hammer is released from the hammer-hold portion, and so on. When the hammer is released from the hold position, if the hammers in a small number of columns already have been released, other columns can be released with a small increase in power but, if the hammers in most columns have already been released, the hammers in the remaining columns cannot be released with a small excess power supplied to the release coil means, but rather a very great excess power is required.

The procedure for controlling the hammer, in accordance with the invention and eliminating the above disadvantages, will be described with reference to FIGS. 7a – 7c. In the procedure of printing one character, when the hammer in a second column is released from its hammer-hold position, the hammer control coil means of an already-released hammer is excited so that the operating point of the permanent magnet is returned to the original operating point at the time when the initially released hammer is being attracted to the hammer rest position. Namely, even if the operating point of the permanent magnet is changed by releasing a hammer from the rest position, when the hammer in the next column is released from its rest position, the permanent magnet is applied with a magnetic field such that the operating point of the permanent magnet is returned to its original operating point. Thus, as the hammer in each column can be controlled with the same power, there is a very substantial advantage in that, for example, useless consumption of power is avoided and each hammer can be controlled with a very small power, among others.

FIGS. 7*a*, 7*b* and 7*c* graphically illustrate the method of operation of the embodiment of the invention shown

in FIGS. 5 and 6. FIG. 7*a* illustrates the procedure for improving the operating point of the permanent magnet.

After one hammer is released from its rest position, the control coil means thereof is not excited until the hammer in a succeeding column is released from its hold position. By applying the signal at the same time as the release signal for releasing a hammer of the next column, the operating point of the permanent magnet is improved. Waste of power can be reduced a great deal by this procedure.

A simple control procedure shown in FIG. 7*b* also can be applied. In this latter case, the operating point of the permanent magnet is improved by continuing to excite the control coil means of the column having a hammer which has already been released from the hold position until the printing cycle is finished. Additional control procedures may readily be used, based upon the arrangement shown in FIGS. 7*a* and 7*b*.

In the arrangement of the invention shown in FIG. **5,** the hammer-hold portion and the control portion **28** are disposed in parallel with the permanent magnet **25.** However, in the embodiment shown in FIG. **6,** only a part of the magnetic circuit is illustrated. In the same manner as in FIG. **5,** even columns are constructed separately from the odd columns. A print hammer is illustrated at **41,** and yokes **62** and **63,** having respective attractive faces **62***a* and **63***a*, form the hammer-hold portion, the yokes being associated with respective opposite polarity faces of a permanent magnet **64.** The release coil, for releasing hammer **41** from the rest position, is shown at **65,** and a coil **66** is provided for changing the operating point of the permanent magnet.

Hammer **41** is released by exciting release coil **65** so that the magnetic flux of magnetic flux loop *i* flowing through the hammer-hold portion is decreased. By releasing hammer **41** from its rest position, the operating point of permanent magnet **64** is changed as well as in the magnetic circuit shown in FIG. **5.** The influence of other columns can be prevented by exciting coil **66** so that the operating point of permanent magnet **64** is returned to its original operating point before the hammer has been released from the hammer rest position, which is also the case with the magnetic circuit shown in FIG. **5.**

FIG. 7*c* illustrates one embodiment of this particular control procedure. The subscript **65** of the column number indicates the signal for releasing the hammer from the hammer hold position, and the subscript **66** illustrates the signal applied to the column which has been already released in order to improve the operating point of the permanent magnet when another column, which has not yet been released, is activated to release its hammer from the rest position.

Curve 7c corresponds to the control procedure shown in FIG. 7*a*, but other control procedures, for example the control procedure shown in FIG. 7*b* or an improvement on the procedure shown in FIG. 7*a* and 7*b*, are possible.

In accordance with the invention shown in FIGS. **5,** 6 and 7*a* – 7*c*, in a printer using a permanent magnet and a hammer mechanism, even if the operating point of the permanent magnet is changed by releasing one column with the magnetic circuit including the permanent magnet for holding the hammer, from the hammer hold portion, any influence upon other columns can be prevented by applying the magnetic field to the permanent magnet so that the operating point thereof is returned to its original point before the hammer has been released from the hammer hold portion. Furthermore, it is possible to equalize the power for releasing the hammer for each column from the hold portion, so that the same power is required for each of the columns. Thus, the hammers of all columns can be controlled with a very small power, and the overall power consumption is reduced. In addition, since the hammer of each column can be controlled with same small power, irrespective of the state of other columns, stable actions of the hammer can be obtained. This is an important advantage of the present invention.

It will thus be seen that the objects set forth above, and those made apparent from the preceding description, are efficiently attained and, since certain changes may be made in the above constructions without departing from the spirit and scope of the invention, it is intended that all matter contained in the above description, as shown in the accompanying drawings, shall be interpreted as illustrative and not in a limiting sense.

It is also to be understood that the following claims are intended to cover all of the generic and specific features of the invention herein described, and all statements of the scope of the invention which, as a matter of language, might be set to fall therebetween.

What is claimed is:

1. In a printer having respective control means for print hammers which are arranged in a plurality of columns and each of which is displaceable between a rest position and a print position, and having respective deformable elastic bodies maintained in deformed condition by the associated print hammers in the rest position, improved magnetic circuit control means associated with each of said columns for holding each said print hammer at said rest position and selectively releasing said print hammers for displacement to said print position, a permanent magnet common to each of the columns, a first hammer hold magnetic circuit portion associated with each hammer including a portion of the associated print hammer and a second release magnetic circuit portion associated with each hammer including release coil means, said release coil means including means for applying signals thereto, said first and second magnetic circuit portions being connected in parallel with said permanent magnet, each of said magnetic circuit control means being adapted to hold said respective hammer at said rest position and to release said respective hammer upon application of a signal to its release coil means by said signal applying means in a direction so as to decrease the magnetomotive force applied to said hammer, the energy stored in the respective deformed body displacing said respective hammer from said rest position to said print position upon said decrease in said magnetomotive force, said release coil having applied thereto a further signal by said signal applying means when said associated hammer is displaced from its rest position and at least one other hammer associated with said common permanent magnet is to be released from its respective rest position so that the operating point of said common permanent magnet is substantially returned to the original operating point before said at least one other print hammer is released from a rest position.

2. In a printer as claimed in claim **1** including means for returning each of said print hammers at the end of a print cycle to its rest position at which the associated

deformable elastic bodies are maintained in deformed condition.

3. In a printer as claimed in claim 1, wherein both said parallel connected magnetic circuit portions include an air gap therein.

4. In a printer as claimed in claim 1, wherein a single air gap is in series with said permanent magnet and said first and second magnetic circuit portions.

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