Jan. 8, 1963 B. G. MAUDSLEY ETAL 3,072,047

PRINTING APPARATUS

Filed Aug. 18, 1961 5 Sheets-Sheet 1

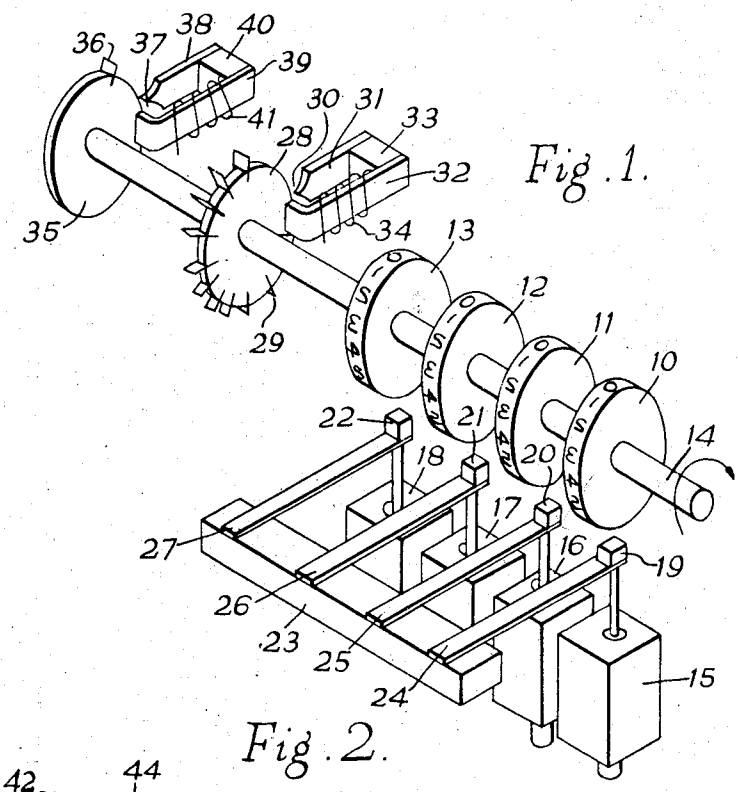
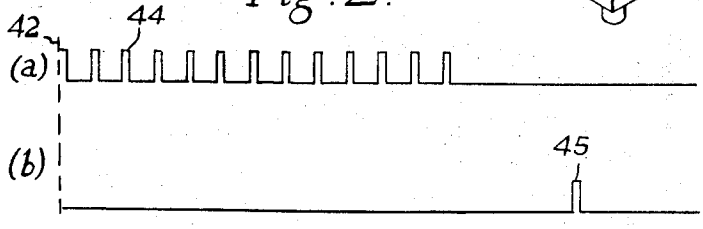


Fig. 1.

Fig. 2.



PRINTING APPARATUS

Filed Aug. 18, 1961 5 Sheets-Sheet 2

Fig. 3.

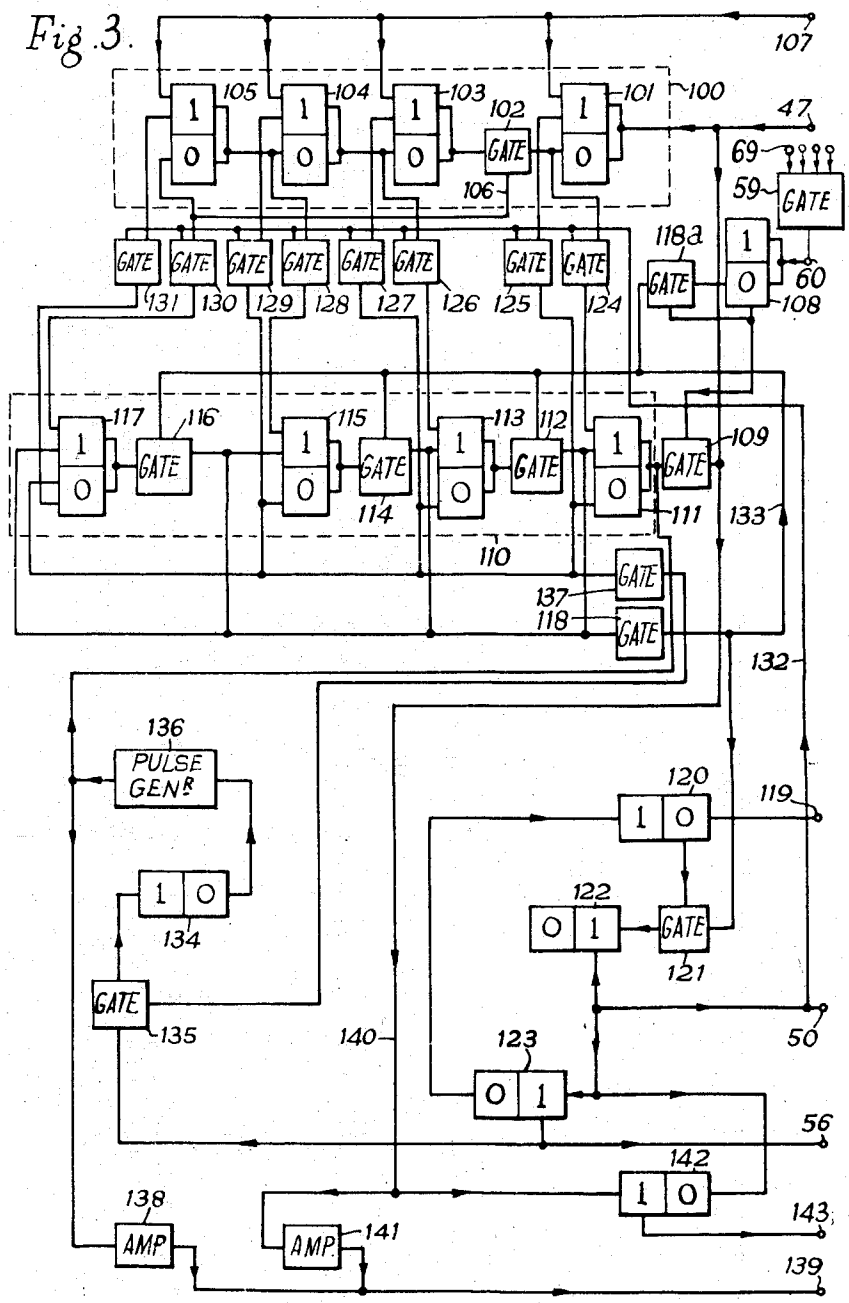
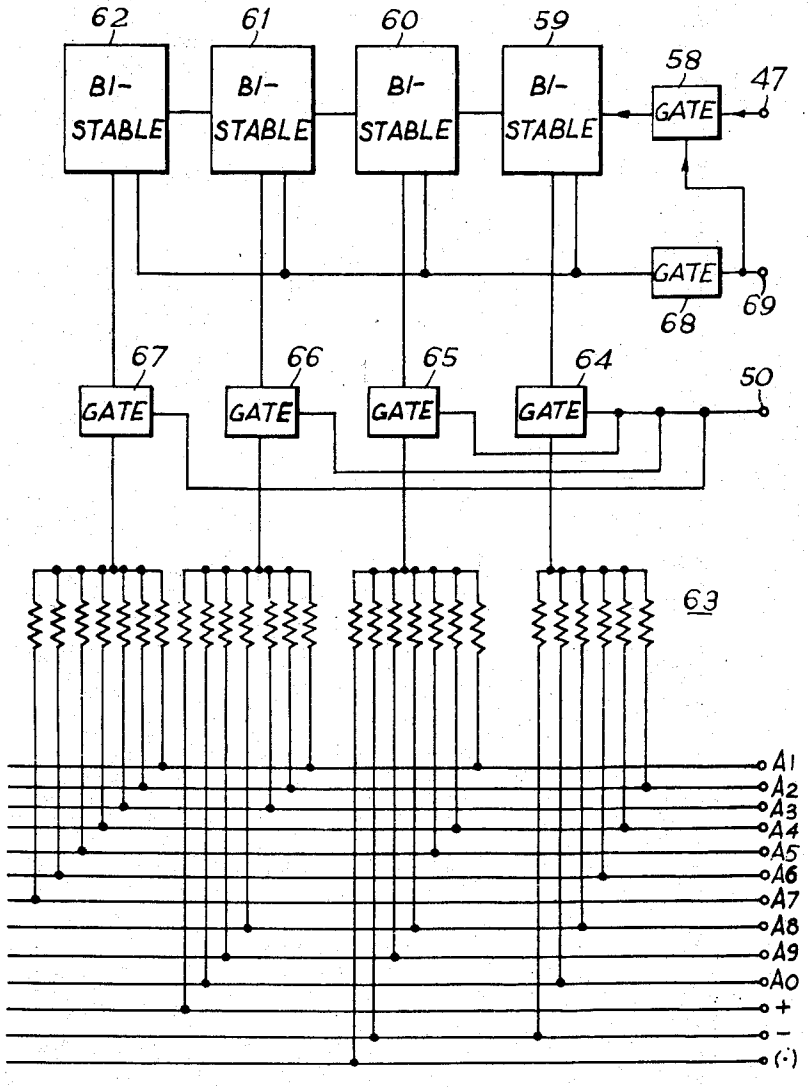


Fig. 4.


62
61
60
59
58
47
BI-STABLE
BI-STABLE
BI-STABLE
BI-STABLE
GATE
GATE
68
69
67
66
65
64
50
GATE
GATE
GATE
GATE
63
A1
A2
A3
A4
A5
A6
A7
A8
A9
A0
+
−
(·)

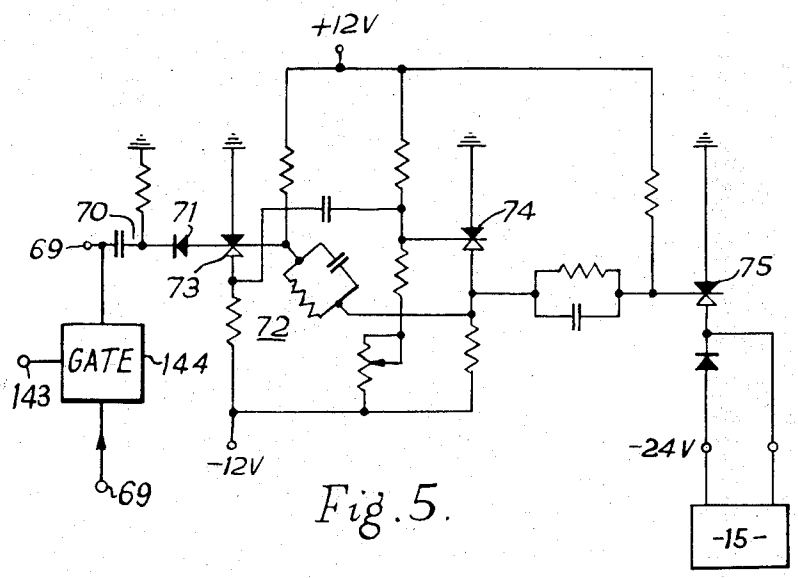
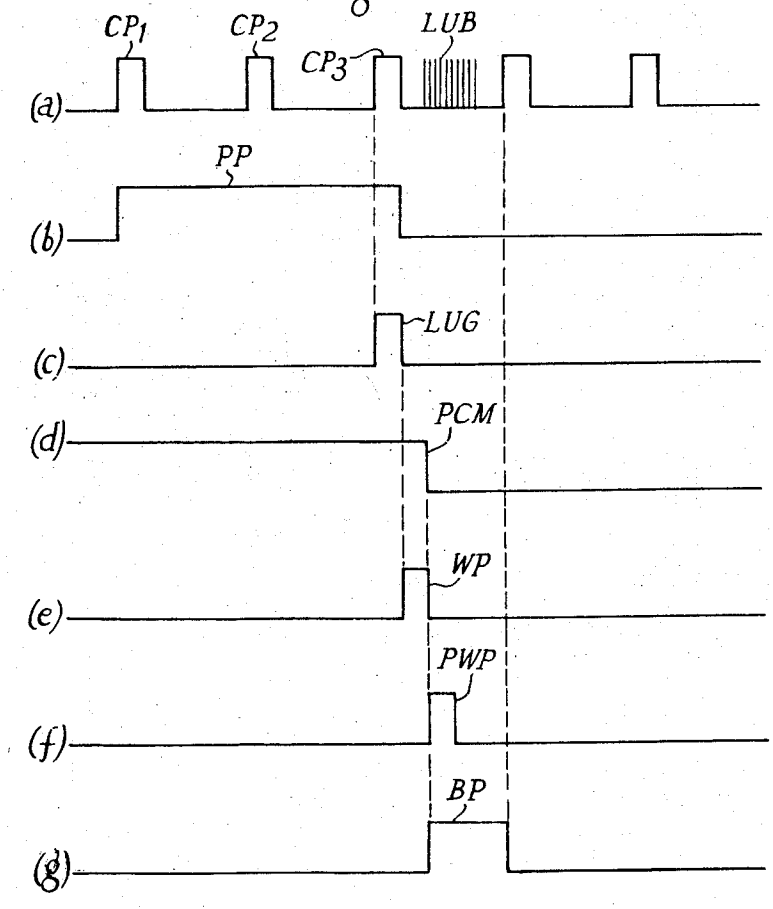


Fig. 5.

Fig. 6.



United States Patent Office 3,072,047
Patented Jan. 8, 1963

3,072,047

PRINTING APPARATUS

Brian G. Maudsley and Geoffrey David Maskens, Farnborough, and Raymond J. D. Reeves, Bracknell, England, assignors to The Solartron Electronic Group Limited, Farnborough, England, a British company

Filed Aug. 18, 1961, Ser. No. 133,016
3 Claims. (Cl. 101—93)

The present invention relates to printing apparatus of the type comprising a print-wheel adapted for continuous rotation, and an associated hammer adapted to be operated to effect printing as selected print characters on the wheel pass the hammer.

It is an object of the invention to provide improved apparatus of the type specified wherein the time taken to print a given sequence of characters is minimised. In known apparatus working on a fixed cycle basis time is wasted because the selected character often passes the hammer once with no printing being effected, printing only being effected the second time the hammer is reached.

According to the present invention, printing apparatus of the type specified includes a control-pulse generator coupled to the print-wheel and adapted to generate a control pulse each time each type face on the print-wheel passes through a datum position, and a circuit for operating the hammer connected to the pulse generator, the hammer-operating circuit including a pulse counter adjustable from a datum setting by information to be printed to any one of a plurality of different settings representative of different characters on the print-wheel, the counter being responsive to control pulses from the pulse generator to be restored progressively to the datum setting, means being provided responsive to restoration of the counter to its datum setting to operate the hammer, and the apparatus is characterised by means operable before the application of the first control pulse to the pulse counter for modifying the setting of the pulse counter to compensate for a deviation in the angular position of the print-wheel from a datum position corresponding to the datum setting of the pulse counter.

The invention will now be described, by way of example, with reference to the accompanying drawings, in which:

FIG. 1 shows, somewhat diagrammatically, an assembly of four print-wheels, four print-hammers associated with the four wheels respectively, and a pulse generator,

FIG. 2 is an explanatory diagram,

FIG. 3 is a schematic circuit diagram of a common control circuit of the apparatus,

FIG. 4 is a schematic circuit diagram of part of an operating circuit including a buffer store for one hammer shown in FIG. 1,

FIG. 5 is a circuit diagram of a feed circuit for a single hammer shown in FIG. 1, and

FIG. 6 is another explanatory diagram.

In FIG. 1 a print-wheel assembly comprises any desired number of print-wheels of which four are shown at **10**, **11**, **12** and **13** mounted on a common shaft **14** driven continuously by an electric motor (not shown). Each print-wheel carries type faces of the digits 0 and 1 to 9, a plus (+) sign, a minus (—) sign and a decimal point (.), that is thirteen characters in all, on its periphery. Part of the periphery bears no type faces. The character positions on all print wheels correspond.

Under the four print-wheels are mounted four solenoids **15**, **16**, **17** and **18** for actuating corresponding hammers **19**, **20**, **21** and **22**, the hammers being mounted on a support **23** through leaf springs **24**, **25**, **26** and **27** respectively.

Coupled to the shaft **14** there is a pulse generator for generating two trains of pulses. One train is generated by means of a wheel **28** of non-ferrous material with thirteen equally-spaced teeth **29** of ferro-magnetic material along an arc of the periphery of the wheel **28**. The remainder of the periphery of the wheel **28** carries no teeth.

Rotation of the wheel **28** by rotation of the shaft **14** brings the teeth **29** successively into a gap **30** between two pole-pieces **31** and **32** of a permanent magnet **33**. The pole-piece **32** carries a winding **34** and hence rotation of the wheel **28** causes a pulse train in the form of a recurring sequence of 13 pulses to be generated in the winding **34**. Another pulse train is generated by means of a further wheel **35** also carried by the shaft **14**, the further wheel being of non-ferrous material and carrying a single tooth **36** of ferro-magnetic material.

Rotation of the wheel **35** by the shaft **14** carries the tooth **36** repeatedly through a gap **37** between two pole-pieces **38** and **39** of a permanent magnet **40**. The pole-piece **39** has a winding **41** and hence each rotation of the wheel **35** carrying the tooth **36** through the gap **37** causes a pulse to be generated in the winding **41**.

In FIG. 1 the thirteen teeth **29** are aligned with the thirteen type-faces respectively on the print-wheels and the tooth **36** lies in the arc of the periphery of the print-wheels which carries no type-faces.

Referring now to FIG. 2(*a*) a broken vertical line **42** indicates the beginning of one revolution of the shaft **14** with its associate print-wheels and pulse generator wheels. Thirteen pulses shown at **44** represent the thirteen pulses generated in the winding **34** (FIG. 1). These will be referred to as character pulses. The complete cycle takes 100 milli-seconds and the thirteen character pulses **44** occupy the first 60 milli-seconds.

The single pulse generated in the winding **41** (FIG. 1) during the same revolution of the shaft **14** is shown at **45** in FIG. 2(*b*) occurring in the interval between the last of the thirteen pulses **44** and the beginning of the next revolution. This will be referred to as a "zeroing" pulse.

The character and zeroing pulses are preferably shaped in known manner.

FIG. 3 shows a control circuit common to all the print wheels. The character pulses are applied to a terminal **47** in FIG. 3 and are thus applied continuously to a four stage binary counter shown within a broken line **100**. The binary counter **100** has a first stage **101** connected through a gate **102** to a second stage **103**. This stage is connected through a further stage **104** to a final stage **105**. The gate **102** is normally held open by potential applied over a wire **106** from the final stage **105**. The zeroing pulses are applied to terminal **107** and the pulses appearing on the terminal **107** are applied to all stages of the counter **100** to return it to its zero condition. Thus the count in the counter **100** at any instant is representative of the angular position of the print-wheel at that instant.

Turning now to FIG. 4, there is shown an information buffer store for one print wheel. An identical store is provided for each wheel to hold the information supplied from whatever is the source of information until printing has occurred. Each store is in the form of a counter set to the state indicating the character to be printed by its associated print wheel on the occurrence of a pulse which will be called the "write" pulse. The write pulse is applied to a terminal **50** in FIG. 4 and its manner of generation will be described later.

For the purpose of setting the counter it is assumed that digital information to be printed is supplied in non-coded form. Thus the information is arranged to appear in the form of a voltage on one terminal out of thirteen marked A1 to A9 and A0, + to indicate addition, — to indicate subtraction, and (.) to indicate a decimal point. There is,

of course, a different set of terminals for each print wheel.

By means of a matrix **63** of resistors the non-coded applied information is translated into the binary code and the voltages in the binary code are applied to open a corresponding pattern of gates in a group of gates **64, 65, 66, 67** corresponding to the first four binary digits.

The next succeeding write pulse occurring after the gates in the pattern have been opened passes from the terminal **59** through the open gates and sets four bistables **59** to **62** forming the buffer store accordingly.

Once the buffer stores have been set to counts indicating the characters to be printed, the said counts are all modified by the same number, provided as will subsequently be described in connection with FIG. 3, to take account of the existing angular positions of the print wheels as indicated by the counter **100**. The modification is effected by an appropriate number of pulses forming what is hereinafter referred to as a "line up burst" and which occurs wholly between two consecutive character pulses.

Once the counts have been modified character pulses are applied from the terminal **47** (FIG. 3) to a terminal **109** (FIG. 4) as subsequently described, and thence through a gate **58** to cause the buffer store to count down from its modified count to zero 1111 assumed for convenience to be the datum state of the store. When this state is reached and all bistables **59** to **62** store zero, a gate **68** opens and a voltage is applied to the gate **58** to close the same and prevent further counting down. The same voltage, applied by way of a terminal **69** to the circuit shown in FIG. 5 causes printing to occur immediately.

In this way the printer is brought rapidly by the line up burst to a condition of preparedness for printing the specified characters the next time each reaches the datum position aligned with the print hammer. The printer does not have to await a datum position in the cycle of the continuously rotating print wheels before counting down to 1111, when printing is effected.

Assume for example that the characters on all wheels run in the order character 1, character 2 and so on up to character 13, this being the order in which they pass the hammers. Assume further that, the buffer stores for two print wheels have fed to them (in binary code) the counts 10 and 7 indicating that characters 10 and 7 respectively are to be printed, just as characters 2 are passing the hammers. This latter fact is indicated by the counter **100** and as a result a line up burst of two pulses is generated, reducing the counts in the buffer stores to 8 and 5 respectively. These buffer stores are then caused to count down by the ensuing character pulses and clearly when each is cleared to zero the correct character (10 in the first instance and 7 in the second), is at the hammer for printing under the control of the circuit of FIG. 5. There is of course one such circuit for each print wheel.

Referring now to FIG. 5 the terminal **69** corresponds to the terminal **69** of FIG. 4 and the voltage appearing on this terminal is applied through an input differentiating circuit **70** and a rectifier **71** to a mono-stable circuit **72** comprising two PNP transistors **73** and **74** and providing an output pulse of short duration. This pulse is applied through a further PNP transistor **75** functioning as a power amplifier and serving to operate the hammer-solenoid **15** (FIG. 1).

Each of the other solenoids **16, 17** and **18** has, as previously mentioned, an individual control circuit as shown in FIGS. 4 and 5 whereby all hammers can be operated in one complete revolution of the print-wheels.

Returning to FIG. 3 the terminals **69** correspond to the terminal **69** of each of the four circuits as shown in FIG. 4 and each time the four buffer stores are all restored to zero a voltage appears on a terminal **60**, to which the terminals **69** are connected through a gate **59**. This triggers a bistable circuit **103** (hereinafter referred to as the paralysis bistable). This bistable when so triggered applies a gating voltage to a gate **109** which opens and allows character pulses to pass from the terminal **47** into a further four-stage binary counter shown within a broken line **110**, hereinafter referred to as a line-up counter. This counter has a first stage **111** connected through a gate **112** to a second stage **113**. This is connected through a gate **114** to a further stage **115** which is connected through a further gate **116** to a final stage **117**.

The line-up counter serves two entirely different functions. That to be described in the immediately following paragraphs is the control of the production of a "paralysis pulse." The second is the control of the production of the line-up burst.

It is arranged that when a predetermined count (in this embodiment a count of three) has been made in the counter **110** a gate **118** detects this and provides an output voltage which is applied through a gate **118***a* to reset the paralysis bistable.

Thus the gate **109** is closed to arrest the line-up counter at a count of three.

Referring now to FIG. 6(*a*) the three pulses passed into the line-up counter are as shown at CP_1, CP_2 and CP_3. The corresponding pulse (paralysis pulse) appearing at the output of the paralysis bistable is shown in FIG. 6(*b*) at PP and will be seen to begin at the beginning of the pulse P_1 and to end at the end of the pulse P_3.

During the paralysis pulse PP the paper on which printing is being effected is fed forward, ready for printing of the new row of characters.

When to be printed information is available, a print command pulse is applied to a terminal **119** and triggers a bistable circuit **120** hereinafter referred to as the print command bistable.

This is employed to open a gate **121** and allow the pulse which appears at the output of the gate **118** to be fed to a bistable circuit **122** (hereinafter referred to as the write bistable). This circuit when triggered in this way provides a write pulse at the terminal **50** which corresponds to the terminal **50** of FIG. 4.

Thus the information to be printed is stored in the information store as previously described.

It will be understood therefore that a print command pulse can be applied at any time. Immediately all characters still being dealt with have been printed the gate **59** opens and the paralysis pulse is generated, allowing paper feed to be effected. The write pulse initiating the next printing cycle follows automatically and immediately, whereby printing time is minimised.

The write pulse is also applied to trigger a bistable circuit **123** which thereby generates a post-write pulse. This is applied to an output terminal **56** and indicates that the source of information can be cleared, as the information has now been transferred to the buffer stores.

The next line of character information can be set up in the information source and the next print command pulse can be applied. (The post-write bistable **123** resets the print command bistable.)

The four stages of the character counter **100** are linked with the four stages of the line-up counter **110** by eight gates as shown at **124** and **131** respectively. These gates are normally closed and are opened momentarily by the write pulse applied thereto over a connection **132**. These gates when open set the line-up counter to the same count as the character counter, internal carries in the line-up counter being inhibited by the gates **112, 114** and **116** which are closed by the pulse appearing on the connection **133** from the output of the gate **118**.

The post-write pulse furthermore triggers a bistable circuit **134** through a gate **135** held open.

The bistable circuit **134** will be referred to as the line-up bistable and serves, when triggered, to switch on a free-running multivibrator pulse generator **136** which will be referred to as the line-up pulse generator and which operates at a frequency which is high compared with the frequency of the character pulses.

Pulses from the line-up pulse generator are applied to the line-up counter 110 and rapidly reduce its setting to zero. The zero setting is detected by a gate 137 which provides output voltage to reset the line-up bistable and hence to switch off the line-up pulse generator.

This burst of pulses forms the above-mentioned line-up burst and is applied through an amplifier or emitter follower transistor circuit 138 to an output terminal 139. This is connected to each terminal 47 (FIG. 4) and hence the line-up burst is applied to the counter in the buffer information store.

This burst modifies the setting of the information store to take account of the deviation of the print-wheel from a datum angular position which in this embodiment corresponds to zero.

The counter in the information store can now be counted out by character pulses to effect printing when zero is reached.

The character pulses appearing on a connection 140 (FIG. 3) are applied through an amplifier or emitter-follower transistor circuit 141 to the terminal 139.

Referring to FIG. 6 the line-up burst is shown at LUB in FIG. 6(*a*) and it will be seen that the whole of the line-up burst occurs before the first character pulse CP_4 to be applied to count out the counters in the buffer information stores.

In FIG. 6(*c*) the voltage pulse LUG is the pulse which appears at the output of the gate 118. The output from the print command bistable is shown at PCM in FIG. 6(*d*). The write pulse is shown at WP in FIG. 6(*e*) and the past-write pulse in FIG. 6(*f*).

Referring again to FIG. 3 the write pulse is additionally applied to a bistable circuit 142 to be referred to as the blanking bistable. The blanking bistable is set by the write pulse and is re-set by the next succeeding character pulse appearing over lead 140. Thus a pulse is applied from the blanking bistable to an output terminal 143. This pulse will be referred to as the blanking pulse and is shown at BP in FIG. 6(*g*). The blanking pulse is applied to paralyse the hammer amplifier or to close a gate 144 (FIG. 5) in series with each hammer amplifier during the line-up burst and hence prevents operation of the hammers should the line-up burst cause the counter in any buffer information store to pass through zero when modying the setting of the counter.

It will be appreciated that the line-up store is left in its zero setting ready for use in printing the next character. The first operation of the line-up counter is in the generation of the paralysis pulse PP during which the paper on which printing is effected is fed forward.

In the embodiment described 52 wires are necessary between the information source and the control circuits of the printer. It will be appreciated that the number of wires can be reduced to four (to the four solenoids) by locating the control circuits at the source. Only two further wires need then be provided from the pulse generator windings 34 and 41 to the location of the source.

Furthermore although the digital information is provided in the form of a one-out-of-*n* code in the embodiment described it can of course be provided in other codes to reduce the number of wires. For example if the information is provided in the binary code only four wires are needed to each buffer store and the resistor matrix 63 can be dispensed with.

Although the invention has been described with reference to four print-wheels only it will be understood that any desired number of print-wheels can be added, each with its associated information store (FIG. 4), hammer amplifier (FIG. 5) and hammer. The main control circuit as shown in FIG. 3 is common to all wheels.

Furthermore although the invention has been described with reference to the printing of the thirteen characters 0, 1 to 9, +, —, and (.) it will be understood that any desired characters and other numbers of characters can be printed by suitably modying the apparatus. For example it may be required to print all 26 letters of the alphabet in which case all counters will require an extra stage.

The invention enables a high printing rate to be effected. Rates in excess of ten lines per second can readily be achieved. The quality of the print is higher than that obtained with mosaic printing in which characters are printed by selections of marks from a mosaic of marks. Furthermore the control apparatus described can be substantially simpler than is used in mosaic printing.

It will be appreciated that the control apparatus can be in the form of standard units employing transistors whereby the cost of manufacture can be low, and the control logic can readily be modified to use a printer with different sources of information to be printed. The use of the buffer information store enables the source to be released rapidly to acquire further data. Thus the invention enables a printer of considerable flexibility to be provided.

It will also be understood that analogue stores may be used in place of the digital stores described.

We claim:

1. Printing apparatus comprising a print wheel having type faces thereon, means to rotate said print wheel continuously, a hammer aligned with said print wheel, a hammer actuator coupled to said hammer, a control-pulse generator to generate a control pulse each time each type face on the print wheel passes through a datum position, and an operating circuit connected between said pulse generator and said actuator, said operating circuit including a pulse counter electrically adjustable from a datum setting by signal information to be printed to any one of a plurality of different settings representative of different characters on the print wheel, a circuit to apply control pulses from said pulse generator to said counter to restore said counter progressively to its datum setting, a sensing device to sense restoration of the counter to its datum setting and apply an operating pulse to said actuator, and a setting circuit operable before said progressive restoration of the counter to modify the setting thereof to compensate for a deviation in the angular position of the print wheel from a datum position corresponding to the datum setting of the pulse counter.

2. Printing apparatus as claimed in claim 1, wherein said setting circuit comprises a second counter, means to set said second counter to a count representative of said deviation, a second pulse generator to generate pulses at a recurrence frequency high compared with the frequency of the first said pulse generator, a circuit connecting said second counter and said second pulse generator to cause a burst of pulses to be applied from said second pulse generator to the first said counter to modify the setting thereof, the number of pulses in said burst being determined by the count in said second counter.

3. Printing apparatus as claimed in claim 2, wherein said setting circuit further includes a third counter, a circuit connecting the first said pulse generator to said third counter to provide a count therein at all times indicative of said deviation, gating means coupling said second and third counters, means connecting said gating means to the first said counter to open said gating means when the first said counter is set by information to be printed to set the second counter into correspondence with said third counter for determining the number of pulses in said burst.

References Cited in the file of this patent

UNITED STATES PATENTS

2,574,283	Potter	Nov. 6, 1951
2,776,618	Hartley	Jan. 8, 1957
2,915,967	Gehring	Dec. 8, 1959
2,945,183	Hartke et al.	July 12, 1960