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(54) ON-THE-FLY PRINTER

(71) We, KABUSHIKI KAISHA SUWA SEIKOSHA, a Japanese company, of 3 - 4, 4-chome, Ginza, Chuo-ku, Tokyo, Japan, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates generally to an on-the-fly printer utilized in electronic desk calculators and other numerical readout devices.

In the usual line printers, alphabetic and/or numeric characters, such as the numerals 0-9 for example, are provided in columnar fashion on the periphery of a print drum. The drum is disposed so that the desired character in the first column faces the hammer associated with that column, and said hammer is activated to strike the back of the paper to effect the printing of said desired character. The drum is then rotated to position the character desired in the second column and after the hammer associated therewith operates, the process is repeated for each column on said drum. After every column as been printed, the paper is advanced one line and the process is repeated. In this type of printer, the printing speed is relatively slow, as the print drum must stop rotating each time the hammer strikes a character.

In another type of printer, generally referred to as an on-the-fly printer, the hammer strikes a character disposed on a continuously rotating print drum. However, the known arrangements of this type of printer have several substantial drawbacks. Specifically, if the contact time between the hammer and the print drum is too great, smudged printing or ripped paper will result. In order to overcome this defect, the contact time of the hammer with the character must be shortened, thereby increasing the

operating speed of said hammer. In conventional on-the-fly printers, the hammer is directly operated by electromagnets, and an increase in the operating speed of the hammer requires an increase in the size and power of said electromagnets. However, an increase in the size and power of the electromagnets results in an increase in the volume of the printer and requires increased electric power consumption, and is therefore undesirable. By utilizing the electromagnets merely to effect timing of the on-the-fly printer, rather than the actual direct operation of the hammer, the above described defects can be avoided while an extremely compact on-the-fly printer is provided.

Other defects in the known on-the-fly printers sought to be corrected by the present invention are the double striking of a hammer on a single line and the difficulty in adjusting said hammers to ensure clear printing.

According to one aspect of the present invention, there is provided an on-the-fly printer including a trigger lever adapted for rotational and linear displacement, print hammer means for printing in response to the linear displacement of said trigger lever, a ratchet wheel which has at least one tooth extending therefrom for linearly displacing said trigger lever when said trigger lever is disposed in the path thereof and which is in operation rotated continuously, means for selectively rotating said trigger lever into and out of the path of the or a ratchet wheel tooth to effect printing, and a trigger lever stopper disposed in the path of the linear displacement of said trigger lever, said trigger lever having a portion adapted to strike said trigger lever stopper immediately before said print hammer completes striking, via a print carrier, a print drum, said trigger lever being arranged to rebound from said trigger lever stopper to return to its original position.

Preferably said print hammer means includes a hammer lever mounted for rotational displacement about a central region thereof and a hammer mounted on said hammer lever on one side of said central region and spaced therefrom, said trigger lever, upon the linear displacement thereof, engaging said hammer lever at a point disposed at the other side of said central region and spaced therefrom to rotate said hammer lever to effect printing.

Said means for selectively rotating said trigger lever may include an electromagnet and a timing lever mounted for rotational displacement, said timing lever being rotated in response to the energisation of said electromagnet to rotate said trigger lever into the path of the or a said ratchet wheel tooth.

The print drum may be adapted to be continuously rotated at a constant speed, said ratchet wheel being in operation arranged to rotate in synchronism with said print drum.

In a preferred embodiment, the cycle of linear and rotational displacement of said trigger lever commencing with the engagement thereof by the or a said ratchet wheel tooth and ending with the return thereof to its original position out of the path of said ratchet wheel tooth is slightly longer than one pitch time of the said tooth of said ratchet wheel.

Preferably there is a first trigger lever guide pin disposed to position said trigger lever in the path of the or a said ratchet wheel tooth upon the rotational displacement thereof and a second trigger lever guide pin disposed to guide the linear and rotational displacement of said trigger lever out of the path of the or a said ratchet wheel tooth after said trigger lever has acted on said print hammer means to effect printing.

Said print hammer means preferably includes a substantially L-shaped hammer lever rotatably mounted at the junction of its two arms, and a hammer mounted on one of said hammer lever arms for printing, said trigger lever being adapted to strike the other of said hammer lever arms upon the linear displacement thereof by the or a said ratchet wheel tooth rotatably to displace said hammer lever to effect printing.

According to another aspect of the present invention, there is provided a printer having a print drum, a ratchet wheel having at least one tooth, means for continuously rotating said print drum and said ratchet wheel in synchronism with each other, at least one printing column including a trigger lever adapted for rotational and linear displacement, the or a said ratchet wheel tooth in operation linearly displacing said trigger lever when said trigger lever is disposed in the path thereof, a hammer lever adapted for rotational displacement in response to the

linear displacement of said trigger lever, a hammer mounted on said hammer lever to effect printing upon the rotational displacement of said hammer lever, means for selectively rotating said trigger lever into and out of the path of the or a said ratchet wheel tooth to effect printing, and a trigger lever stopper disposed in the path of the linear displacement of said trigger lever, said trigger lever having a portion adapted to strike said trigger lever stopper immediately before said print hammer completes striking, via a print carrier, a print drum, said trigger lever being arranged to rebound from said trigger lever stopper to return to its original position.

There may be provided a single motor means alone for driving both said print drum and said ratchet wheel.

Said motor means preferably includes a rotor shaft, a pair of spaced yokes mounted on said shaft for rotation therewith, a plurality of pairs of permanent magnets radially arranged about said shaft between said yokes, one of each of said pairs of permanent magnets being mounted on each of said yokes with a gap therebetween, a plurality of driving coils disposed in the gap between said pairs of permanent magnets, and a detecting means responsive to the position of said rotor shaft and having at least one detecting coil associated with each driving coil for the activation of said driving coil to rotate said rotor shaft.

Preferably, the poles of each pair of permanent magnets defining the gap therebetween are of opposite polarity to produce a magnetic field in said gap.

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

Figure 1 is a schematic representation of one column of a printer according to the present invention,

Figure 2 is a top plan view of a printer according to the present invention, with portions broken away,

Figure 3 is a sectional view taken along line 3-3 of Figure 2 showing one column thereof with the electromagnet associated therewith in the de-energized state,

Figure 4 is a sectional view taken along line 3-3 of Figure 2 with said electromagnet energized and said column disposed in the printing position,

Figure 5 is a side elevational view of the printer of Figure 2,

Figure 6 is perspective view of the trigger lever and trigger lever guide member forming part of the flying printer according to the present invention,

Figure 7 is a top plan view of the trigger lever guide member of Figure 6,

Figure 8 is a sectional view taken across

the rotor of the motor of the printer according to the invention.

Figure 9 is a sectional view taken along line 9-9 of Figure 8.

Figure 10 is a sectional view taken along line 10-10 of Figure 8.

Figure 11 is a circuit diagram of a driving circuit for the motor of Figure 8.

Figures 12A and 12B are respectively wave forms present in the circuit of Figure 11, and

Figures 13A, 13B and 13C are respectively waveforms of the current in the three driving coils of the motor of Figure 8.

Referring to the drawings, Figure 1 is a schematic representation of one column of a printer according to the present invention.

The column includes a print hammer 1 mounted on one arm of an L-shaped hammer lever 2, the upper arm (as viewed) being given the reference number 43 in Figures 3 and 4. Said hammer lever 2 is pivotably mounted at the junction of its arms on a hammer lever shaft 3. Disposed immediately below hammer 1 is print drum 4 having print characters spaced apart on the peripheral surface thereof. The print drum 4 and a print drum gear 5 are mounted for rotation on a print drum shaft 6. The shaft 6, which defines the axis of the print drum 4, is disposed immediately below the position assumed by hammer 1 when it strikes the print drum 4, the hammer 1 being disposed substantially normally to said axis when striking the print drum 4. The print drum gear 5 meshingly engages an intermediate pinion 7 which is adapted to drive an intermediate gear 8 fixed thereto. The intermediate gear 8, in turn, meshingly engages with a ratchet gear 9 fixed to a ratchet wheel 10. The ratchet wheel 10 is shown as being formed with a single tooth 11 but could be formed with a plurality of circumferential teeth if desired. The gear ratio between gears and pinions 5, 7, 8 and 9 is selected so that the pitch time of the tooth 11 equals the circumferential spacing of the characters on the peripheral surface of the print drum 4. Thus, each rotation of the tooth 11 corresponds to the advancing of one character on the print drum 4.

First and second trigger lever guide pins 12 and 13 are provided disposed on either side of a trigger lever 14 which is formed with a tail portion 15 and a projection 16. The trigger lever 14 is adapted for pivotal and linear displacement and a trigger lever guide member 18 is provided to guide the trigger lever 14 during said displacement. A spring 19 is secured between lever 14 and a fixing point 20 for biasing the end 34 of trigger lever 14 out of the path of the tooth 11. The end 21 of the lower arm (as viewed) of hammer lever 2 is engageable by a shoulder 22 of the trigger lever 14 upon linear displacement of the latter, causing the hammer lever 2 to pivot and the hammer 1 to strike print drum 4 via

paper 30 upon which a character is to be imprinted and an inked ribbon 31 which are interposed between the hammer 1 and the print drum 4.

A timing lever 23 is disposed to engage tail 15 of trigger lever 14 and is pivotably mounted on a timing lever shaft 24. Fixed to the timing lever 23 is a magnetic plate 25 movement of which is controlled by an electromagnet 26.

A spring 28 is mounted between the junction of the arms of the hammer lever 2 and a fixing point 29 to bias the hammer lever 2 in the position shown with hammer 1 spaced from the print drum 4.

In Figure 1, only one column is illustrated by way of example. However, an actual printer would include the desired number of columns, each of which would comprise a hammer 1, a hammer lever 2, a trigger lever 14, a trigger lever spring 19, a timing lever 23, a magnetic plate 25, an electromagnet 26, and a hammer lever spring 28. As more particularly shown in the embodiment of Figure 2, the parallel columns are mounted between a pair of main plates 50 and 51. The printer, as shown in Figures 3 and 4, is preferably provided with single print drum 4, a ratchet wheel 10 having a single tooth 11, first and second guide pins 12 and 13, a trigger lever guide member 18, a trigger lever stopper 17, and a timing lever shaft 24, all of which extend between said main plates. A motor 52 is provided to drive ratchet wheel 10, which in turn drives print wheel 4 through gears and pinions 5, 7, 8 and 9.

While hammer lever 2, trigger lever 14 and timing lever 23 are relatively thin, the electromagnets 26 are relatively bulky. In order to permit the compact mounting of the components of the flying printer according to the invention, said electromagnets are disposed in three banks, as more particularly shown in Figure 3. The electromagnets associated with one of each three adjacent columns forming said flying printer are disposed in a single bank so that space equal to the width of three columns is provided for each electromagnet. The angle defined between magnetic plate 25 and timing lever 23 is selected in each column according to the disposition of the electromagnet associated therewith. Thus, referring to Figure 2, the electromagnets 26 associated with columns *a* and *b* are in one bank, the electromagnets associated with columns *c* and *d* are in a second bank, while the electromagnets associated with columns *g* and *i* are in a third bank.

Also extending between main plates 50 and 51 are a paper feeding roller 53 (Figures 3 and 4) and guide frames 54 and 55 adapted to guide paper 30 (Figure 1) through said flying printer. Said paper feeding roller

advances the paper one line when print drum 4 has completed one cycle of its rotation.

Turning now to the operation of the printer according to the invention, reference is made to Figures 1, 3, and 4. When the printer is activated but no timing signals are applied to the electromagnets or to the paper advance mechanism, motor 52 continuously rotates ratchet wheel 10 in the direction of arrow 32, thereby also rotating print drum 4 in the manner described above and in the same direction as the ratchet wheel 10. The rotation of tooth 11 of said ratchet wheel follows a path defined by dashed line 33. In the absence of any signal energizing electromagnets 26, the column is disposed as shown in Figure 3 with end 34 of trigger lever 14 disposed outside of the path of tooth 11 and maintained in that position by spring 19. When so disposed, trigger lever 14 is positioned by means of second trigger lever pin 13 and trigger lever guide member 18. Magnetic plate 25 is also maintained spaced from electromagnet 26 in the direction of arrow 35 by spring 19 acting through tail 15 of said trigger lever which engages timing lever 23.

In order to print a character, a pulse signal is applied by means to be described to electromagnets 26 immediately before the desired character on the peripheral surface of print drum 4 passes under hammer 1. The energization of one of said electromagnets 26 rotatably displaces its respective magnetic plate 25 in the direction of arrow 36, carrying timing lever 23 therewith which engages the tail 15 of trigger lever 14 to rotate said trigger lever in the counter-clockwise direction about trigger lever guide member 18. When so disposed, as shown in Figure 1, end 34 of said trigger lever lies in the path of tooth 11, and is then adapted to be linearly displaced in the direction of arrow 37 thereby.

The linear displacement of trigger lever 14 is transmitted to arm 21 of hammer lever 2 by means of shoulder 22 of said trigger lever. Said hammer lever is in turn rotated in a counter-clockwise direction causing hammer 1 to strike the print drum through inked ribbon 31 and paper 30 at the moment that the desired character is positioned under said hammer. The column is shown disposed in this position in Figure 4.

At this point in the cycle, it is necessary to rotate hammer lever 14 in the clockwise direction to bring end 34 thereof out of the path 33 of tooth 11 before said tooth completes a single revolution. If this is not done, the trigger lever will be linearly displaced in the direction of arrow 37 a second time during the next revolution of ratchet wheel 10, resulting in the double striking of hammer 1 on a single line. Several features of the printer contribute to the achievement of this desired result. The first

of these is trigger lever stopper 17 which co-operates with projection 16 on trigger lever 14, to operate as follows. At the moment that the end 34 of trigger lever 14 is struck by tooth 11, hammer lever 2 starts its rotation. Specifically, at the moment that the trigger lever 14 is struck by the tooth 11, the trigger lever 14 starts its linear displacement in the direction of arrow 37 at a speed slightly faster than that of the tooth 11. At the same moment, the part 21 of hammer lever 2 starts its displacement at a speed slightly faster than that of trigger lever 14. This results from the fact that the coefficient of restitution at each striking point is not equal to zero. Further, after hammer 1 strikes the desired character, hammer lever 2 returns to its original position at a faster speed than does trigger lever 14. Accordingly, in the absence of trigger lever stopper 17, arm 21 of said hammer lever would tend again to strike shoulder 22 of said trigger lever, causing said hammer lever again to rotate in the clockwise direction causing hammer 1 again to strike a character. The resulting double striking on a single line is of course undesirable. This possibility is avoided by the striking of projection 16 against trigger lever stopper 17 immediately before hammer 1 strikes the character so that trigger lever 14 rebounds in the direction of arrow 38 before the return of hammer lever 2 to its original position. In this manner, the part 21 of said hammer lever 2 will not strike shoulder 22 during its return.

The striking of projection 16 against trigger lever stopper 17 also serves to rotate the trigger lever 14 in the direction of arrow 39 about the centre of gravity 40 of said trigger lever during the return thereof to its initial position. This effect, which serves to bring end 34 of said trigger lever out of the path of tooth 11, results from the positioning of the contact point between projection 16 and trigger lever stopper 17 at a position above centre of gravity 40, and preferably on the side adjacent ratchet wheel 10. Also contributing to this rotation is spring 19 which tends to return trigger lever 14 to its original position with the inner surface of shoulder 22 resting against trigger lever guide member 18 and end 34 of trigger lever 14 being out of the path of tooth 11.

Still a further feature of the arrangement according to the invention tending to avoid double striking, is the timing of the arrangement. Each cycle of operation, namely the activation of an electromagnet 26, the linear displacement of trigger lever 14, the striking of hammer 1 and the return of said trigger lever takes an extremely short time, of the order of 7 msec. Despite all of the above described features, it is still possible, in rare cases, that end 34 of said trigger lever might still lie within the path of tooth 11 if said trigger lever returns to its original position

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before tooth 11 has completed one cycle or pitch time. If this were so, undesirable double striking could still result. Accordingly, the arrangement is designed so that the time required for trigger lever 14 to complete one cycle of operating commencing with the linear displacement thereof by tooth 11 and ending with its return to its original position, is slightly longer than the pitch time of the tooth of said ratchet wheel. The timing of the overall arrangement is such that a particular column would never be activated to strike two consecutive characters on the print drum in a single cycle of said print drum.

Referring now to Figures 6 and 7, a detailed view of trigger lever guide member 18 is shown. Said member 18 is cylindrical and is formed with a plurality of grooves 41 defined by walls 42 adapted to receive said trigger levers and to guide same during the rotational and linear displacement thereof.

As shown in Figures 3 and 4, arms 43 of hammer levers 2 upon which hammers 1 are mounted, define the upper level of the printer. In this manner, hammer 1 is disposed immediately above the axis of print drum 4 as defined by shaft 6. This construction permits easy access to hammers 1 to permit the replacement or adjustment thereof. The latter feature is important since in order to print clear characters, the face of the hammer 1 and the surface of the character must lie in the same plane, the striking point and the desired character must exactly coincide, and uniform pressure must be applied to the surface of the character to be printed. Further, of the components of the printer, said hammers 1 are subjected to the greatest wear due to the extremely fast striking speed, and therefore require replacement after an extended period of use. Such replacement may be accomplished without disturbing the other components of the column. Finally, this feature permits the immediate and ready detection of misprints since the operator can see each character immediately after the paper is advanced one line.

The detailed structure of motor 52 is shown in Figures 8-10. Said motor, which is the direct current brushless type, includes a rotor shaft 56 having yokes 57 and 58, formed of a material having high permeability, mounted thereon in spaced relation. Arranged radially about shaft 56 are pairs of permanent magnets 59 and 65, 60 and 66, 61 and 67, 62 and 68, 63 and 69, and 64 and 70. One of each of said pairs of magnets, namely magnets 59, 60, 61, 62, 63 and 64, is fixedly secured to yoke 57, while the other of said permanent magnets is fixedly secured to yoke 58. Each of said permanent magnets is fan-shaped. Each of said pairs of permanent magnets is in spaced relation and disposed with opposite poles in facing relation. Thus, the

south pole of magnet 62 faces the north pole of magnet 68. Further, the six magnets secured to each yoke are disposed so that adjacent magnets have their opposite poles facing the air gap between said pairs of permanent magnets. Thus, permanent magnet 59 has its north pole facing the air gap and its companion permanent magnet 65, while the adjacent permanent magnets 60 and 64 both have their south poles facing said air gap and their respective companion magnets.

Disposed in the air gap between said pairs of permanent magnets are substantially trapezoidal flat driving coils 71, 72 and 73. Said driving coils are radially arranged about rotor shaft 56 but are mounted independently thereof. Said driving coils are spaced substantially 100 degrees apart as measured from the respective centre lines. The sides 74 and 75 of each driving coil are spaced so that one of said sides is disposed in the space between each of two adjacent pairs of permanent magnets in substantially all positions of rotor shaft 56. Thus, in Figure 9, side 74 of driving coil 73 is shown disposed in the space between the pair of permanent magnets 60 and 66 while side 75 of driving coil 73 is disposed between the pair of permanent magnets 61 and 67. In the position shown, driving coil 71 is aligned with the gaps between adjacent pairs of said permanent magnets while the other of said driving coils is aligned as described above.

Also provided is a detecting means consisting of three pairs of detecting coils 76 and 77, 78 and 79, and 80 and 81, as more particularly shown in Figure 10. Said detecting coils are preferably formed in the shape of small discs with the detecting coils forming each pair being disposed in spaced relation with an air gap therebetween. Said pairs of detecting coils are disposed radially about rotor shaft 56 with an angle of substantially 40 degrees being defined between pairs 76 (77) and 78 (79), and 80 (81), respectively. Said detecting means also includes a shield plate 82 fixedly mounted on rotor shaft 56 and extending into the gap between said pairs of detecting coils. The shield plate is formed with three cut-away regions 83 within the path of said detector coil air gaps. Said cut-away regions 83 are spaced radially about rotor shaft 56, each of said openings defining a 40 degree sector. Shield plate 82 is preferably formed from a material of low electric resistance, such as aluminium.

Referring now to Figure 11, a portion of the electric circuit for driving one driving coil 71 of motor 52 is shown by way of example. The circuit includes an oscillator including transistor 84 and detecting coils 76 and 77. The output of the oscillator passes through a rectifier diode 85 and is applied to an amplification and switching circuit defined

by transistors 86 and 87 adapted to apply driving current to driving coil 71.

Reference is now had to the waveform diagrams of Figures 12 and 13, in connection with which the operation of the brushless direct current motor for use in this invention will be exemplified. Assuming that one of the cut-away regions of shield plate 82 is disposed at the pair of detecting coils 76 and 77, the oscillator circuit associated with said detector coils starts to oscillate to produce the waveform shown in Figure 12A at the collector of said transistor. This oscillating wave has a pulse width of T_1 equal to the period during which the opening 83 in shield plate 82 is positioned opposite detecting coils 76 and 77. The oscillating current is rectified by diode 85 to produce, at connecting point 88 of Figure 11, the driving waveform shown in Figure 12B. During the period T_1 , transistors 86 and 87 are switched on to apply driving current to driving coil 71. The oscillator circuit stops oscillating when shield plate 82 extends into the gap between detecting coils 76 and 77 since said shield plate is formed of a conductor. The driving current in driving coil 71 interlinks with the magnetic flux of the pairs of permanent magnets between which the sides 74 and 75 of said coil extend. Accordingly, a rotational force is produced tending to rotate shaft 56, carrying yokes 57 and 58, the permanent magnets, and shield plate 82 therewith. The time T_2 shown in the waveform of Figure 12A represents the period during which the shield plate extends into the gap between the pair of detecting coils to stop the oscillation thereof. The cycle, as far as detecting coils 76 and 77 and driving coil 71, is repeated after the time T_2 , as represented by the rotation of the rotor by 80 degrees to align the next cut-away region of the shield plate with said detecting coils.

In the embodiment of the arrangement shown in the drawings, three pairs of detecting coils and three corresponding driving coils are provided. Accordingly, the motor according to this invention is provided with three transistorized driving circuits. Each of the three driving circuits drives a driving coil to produce three phases of driving current as shown in the waveforms of Figures 13A, B and C, one of which represents the current in each of said driving coils. Due to the relative position of the detecting coils, driving coils, and shield plates and the alignment of the poles of the permanent magnets, rotor 1 always rotates in the predetermined direction.

The pairs of detecting coils are arranged radially about shaft 1 so that the cut-away region of shield plate 31 is aligned with at least one of said pairs of detecting coils at every position of said rotor shaft. Thus, one of said pairs of coils oscillates at each such

position to drive the driving coil associated therewith. Further, said driving coil associated with the oscillating detecting coils must be disposed so that, during the period of said oscillation, it is not aligned with only one of the pairs of permanent magnets. This arrangement is necessary to ensure that the motor is self-starting since, if a driving coil is aligned with only one pair of permanent magnets at the rest position, no rotating force will be generated in response to the oscillation of the detecting coils to start the motor.

Although the motor in the embodiment shown in the drawings has six pairs of permanent magnets, three driving coils, three pairs of detecting coils and three cut-away regions in the shield plate, this arrangement is shown by way of example and not by way of limitation, and the motor according to the invention may be designed with various combinations of coils and openings. In general, the motor should be constructed such that where n pairs of permanent magnets are provided, n being an even number equal to six or more, $n/2$ driving coils, $n/2$ pairs of detecting coils, and $n/2$ cut-away regions of the shield plate are provided. Further, the detecting coils of the detecting means may consist of only a single oscillating coil the oscillation of which can be stopped by bringing said shield plate into juxtaposition with said coil.

As best shown in Figure 2, driving coils 71, 72 and 73 are fixedly mounted on a circuit board 89. In like manner, detecting coils 76, 78 and 80 are mounted on a circuit board 90, while detecting coils 77, 79 and 81 are mounted on a circuit board 91. The foregoing construction produces an extremely compact motor capable of producing sufficient force to operate the printer.

Returning now to Figures 2 and 5, the overall operation of the printer will be described. Rotor shaft 56 of motor 52, upon which ratchet wheel 10 is mounted, carries at one end thereof a position detector 100 having a magnet 101 mounted on the peripheral surface thereof which generates timing signals with every rotation, said timing signals being detected by a magnetic pickup head 102. The rotation of rotor shaft 56 and ratchet wheel 10 is transmitted to print drum 4 for the rotation thereof and synchronization with said ratchet wheel 10. As discussed earlier, one rotation of ratchet wheel 10 equals the advancing of print drum 4 by one character. Thus, if there are sixteen characters circumferentially spaced about print drum 4, ratchet wheel 10 will rotate sixteen times for every rotation of print drum 4. Mounted on one end of shaft 6 which carries said print drum is a position detector 103, also provided with a magnet in the peripheral surface thereof to provide timing

signals for detection by a magnetic pickup head 104. The timing signals detected by magnetic head 102 are preferably counted by a suitable pulse counter which operates in conjunction with a coincidence circuit adapted to compare the input signals from the circuitry of the desk calculator or other device to which the printer is connected with the detected signal. When coincidence is detected, the electromagnet associated with said circuit is energized to effect printing.

The timing signals detected by magnetic head 104 are used for resetting the flying printer to permit printing of the next line. Said reset signal provides clock pulses to suitable controlling circuitry which permits both the resetting of the character counter and the energization of a paper feeding electromagnet 105 which displaces a hooked lever 106 to rotate a ratchet 107 and the paper feeding roller 53 to shift said paper by one line.

It will be seen that when the trigger lever 14 is struck by the ratchet wheel 10, it undergoes linear displacement. Then the trigger lever stopper 17 is struck by the projection 16 of the trigger lever and the trigger lever rebounds. During this rebound, the centre of gravity 40 of the trigger lever moves along a curved path.

(a) Since the contact point between the trigger lever stopper and the projection is in the preferred embodiment disposed above the extension line of the path of the motion of the centre of gravity, the centre of gravity 40 of the trigger lever must on its rebound descend relative to its path when the trigger lever undergoes linear displacement.

(b) Since the ratchet wheel 10 is above the path of the centre of gravity, the trigger lever end 34 which performs rotational displacement about its centre of gravity 40 does not re-enter the locus of the tooth of the ratchet wheel. Gravity is therefore assisting the spring 19 whereby to assist prevention of double printing.

The above conditions (a) and (b) assist in realising high speed on the on-the-fly printer according to the illustrated preferred embodiment.

It has been found that a printer constructed in accordance with the illustrated preferred embodiments of this invention offers advantages over the prior art. Thus, although printing is performed during the continuous rotation of the print drum, the period of dwell of the hammer is shortened and clearly-printed characters are obtained. The arrangement minimises the wear on the trigger lever utilised to transmit energy to the hammer, giving such trigger lever an extremely long life. Since said trigger lever is preferably formed from a material of great stiffness, the operation of the arrangement results in a relatively low energy loss during

high speed operation. Further, the arrangement avoids the defect of double striking, and provides an arrangement which is readily serviced.

Further, the preferred embodiments according to this invention provide a device which consumes relatively little electric power, while utilising a single motor to drive the entire mechanism including both the ratchet wheel and print drum. The preferred embodiments according to this invention in effect convert the rotational kinetic energy stored in the ratchet wheel to linear energy by the action of the trigger levers which are positively actuated by the rotating tooth to provide a large amount of mechanical energy to the print hammers without requiring large electromagnets.

WHAT WE CLAIM IS:—

1. An on-the-fly printer including a trigger lever adapted for rotational and linear displacement, print hammer means for printing in response to the linear displacement of said trigger lever, a ratchet wheel which has at least one tooth extending therefrom for linearly displacing said trigger lever when said trigger lever is disposed in the path thereof and which is in operation rotated continuously, means for selectively rotating said trigger lever into and out of the path of the or a ratchet wheel tooth to effect printing, and a trigger lever stopper disposed in the path of the linear displacement of said trigger lever, said trigger lever having a portion adapted to strike said trigger lever stopper immediately before said print hammer completes striking, via a print carrier, a print drum, said trigger lever being arranged to rebound from said trigger lever stopper to return to its original position.

2. A printer as claimed in claim 1 wherein said print hammer means includes a hammer lever mounted for rotational displacement about a central region thereof and a hammer mounted on said hammer lever on one side of said central region and spaced therefrom, said trigger lever, upon the linear displacement thereof, engaging with said hammer lever at a point disposed at the other side of said central region and spaced therefrom to rotate said hammer lever to effect printing.

3. A printer as claimed in claim 1 or claim 2 wherein said means for selectively rotating said trigger lever includes an electromagnet and a timing lever mounted for rotational displacement, said timing lever being rotated in response to the energisation of said electromagnet to rotate said trigger lever into the path of the or a said ratchet wheel tooth.

4. A printer as claimed in any preceding claim wherein the print drum is adapted to be continuously rotated at a constant speed, said

signals for detection by a magnetic pickup head 104. The timing signals detected by magnetic head 102 are preferably counted by a suitable pulse counter which operates in conjunction with a coincidence circuit adapted to compare the input signals from the circuitry of the desk calculator or other device to which the printer is connected with the detected signal. When coincidence is detected, the electromagnet associated with said circuit is energized to effect printing.

The timing signals detected by magnetic head 104 are used for resetting the flying printer to permit printing of the next line. Said reset signal provides clock pulses to suitable controlling circuitry which permits both the resetting of the character counter and the energization of a paper feeding electromagnet 105 which displaces a hooked lever 106 to rotate a ratchet 107 and the paper feeding roller 53 to shift said paper by one line.

It will be seen that when the trigger lever 14 is struck by the ratchet wheel 10, it undergoes linear displacement. Then the trigger lever stopper 17 is struck by the projection 16 of the trigger lever and the trigger lever rebounds. During this rebound, the centre of gravity 40 of the trigger lever moves along a curved path.

(a) Since the contact point between the trigger lever stopper and the projection is in the preferred embodiment disposed above the extension line of the path of the motion of the centre of gravity, the centre of gravity 40 of the trigger lever must on its rebound descend relative to its path when the trigger lever undergoes linear displacement.

(b) Since the ratchet wheel 10 is above the path of the centre of gravity, the trigger lever end 34 which performs rotational displacement about its centre of gravity 40 does not re-enter the locus of the tooth of the ratchet wheel. Gravity is therefore assisting the spring 19 whereby to assist prevention of double printing.

The above conditions (a) and (b) assist in realising high speed on the on-the-fly printer according to the illustrated preferred embodiment.

It has been found that a printer constructed in accordance with the illustrated preferred embodiments of this invention offers advantages over the prior art. Thus, although printing is performed during the continuous rotation of the print drum, the period of dwell of the hammer is shortened and clearly-printed characters are obtained. The arrangement minimises the wear on the trigger lever utilised to transmit energy to the hammer, giving such trigger lever an extremely long life. Since said trigger lever is preferably formed from a material of great stiffness, the operation of the arrangement results in a relatively low energy loss during

high speed operation. Further, the arrangement avoids the defect of double striking, and provides an arrangement which is readily serviced.

Further, the preferred embodiments according to this invention provide a device which consumes relatively little electric power, while utilising a single motor to drive the entire mechanism including both the ratchet wheel and print drum. The preferred embodiments according to this invention in effect convert the rotational kinetic energy stored in the ratchet wheel to linear energy by the action of the trigger levers which are positively actuated by the rotating tooth to provide a large amount of mechanical energy to the print hammers without requiring large electromagnets.

WHAT WE CLAIM IS:—

1. An on-the-fly printer including a trigger lever adapted for rotational and linear displacement, print hammer means for printing in response to the linear displacement of said trigger lever, a ratchet wheel which has at least one tooth extending therefrom for linearly displacing said trigger lever when said trigger lever is disposed in the path thereof and which is in operation rotated continuously, means for selectively rotating said trigger lever into and out of the path of the or a ratchet wheel tooth to effect printing, and a trigger lever stopper disposed in the path of the linear displacement of said trigger lever, said trigger lever having a portion adapted to strike said trigger lever stopper immediately before said print hammer completes striking, via a print carrier, a print drum, said trigger lever being arranged to rebound from said trigger lever stopper to return to its original position.

2. A printer as claimed in claim 1 wherein said print hammer means includes a hammer lever mounted for rotational displacement about a central region thereof and a hammer mounted on said hammer lever on one side of said central region and spaced therefrom, said trigger lever, upon the linear displacement thereof, engaging with said hammer lever at a point disposed at the other side of said central region and spaced therefrom to rotate said hammer lever to effect printing.

3. A printer as claimed in claim 1 or claim 2 wherein said means for selectively rotating said trigger lever includes an electromagnet and a timing lever mounted for rotational displacement, said timing lever being rotated in response to the energisation of said electromagnet to rotate said trigger lever into the path of the or a said ratchet wheel tooth.

4. A printer as claimed in any preceding claim wherein the print drum is adapted to be continuously rotated at a constant speed, said



ratchet wheel being in operation arranged to rotate in synchronism with said print drum.

5. A printer as claimed in any preceding claim, wherein the contact point between said trigger lever portion and said trigger lever stopper is disposed above the centre of gravity of said trigger lever.

6. A printer as claimed in claim 5, wherein the contact point between said portion of said trigger lever and said trigger lever stopper is disposed on the side of said centre of gravity adjacent said ratchet wheel.

7. A printer as claimed in any preceding claim, wherein the cycle of linear and rotational displacement of said trigger lever commencing with the engagement thereof by the or a said ratchet wheel tooth and ending with the return thereof to its original position out of the path of said ratchet wheel tooth is slightly longer than one pitch time of the said tooth of said ratchet wheel.

8. A printer as claimed in any preceding claim including a trigger lever guide member formed with at least one groove therein, said trigger lever being positioned in the or a said guide groove and rotating about the bottom surface thereof.

9. A printer as claimed in any preceding claim including a first trigger lever guide pin disposed to position said trigger lever in the path of the or a said ratchet wheel tooth upon the rotational displacement thereof and a second trigger lever guide pin disposed to guide the linear and rotational displacement of said trigger lever out of the path of the or a said ratchet wheel tooth after said trigger lever has acted on said print hammer means to effect printing.

10. A printer as claimed in any preceding claim wherein said means for selectively rotating said trigger lever includes spring means secured to said trigger lever and biased rotatably and linearly to displace said trigger lever back to its original position out of the path of the or a said ratchet wheel tooth after said trigger lever has acted on said print hammer means to effect printing.

11. A printer as claimed in any preceding claim wherein said print hammer means includes a substantially L-shaped hammer lever rotatably mounted at the junction of its two arms, and a hammer mounted on one of said hammer lever arms for printing, said trigger lever being adapted to strike the other of said hammer lever arms upon the linear displacement thereof by the or a said ratchet wheel tooth rotatably to displace said hammer lever to effect printing.

12. A printer having a print drum, a ratchet wheel having at least one tooth, means for continuously rotating said print drum and said ratchet wheel in synchronism with each other, at least one printing column including a trigger lever adapted for rotational and linear displacement, the or a

said ratchet wheel tooth in operation linearly displacing said said trigger lever when said trigger lever is disposed in the path thereof, a hammer lever adapted for rotational displacement in response to the linear displacement of said trigger lever, a hammer mounted on said hammer lever to effect printing upon the rotational displacement of said hammer lever, means for selectively rotating said trigger lever into and out of the path of the or a said ratchet wheel tooth to effect printing, and a trigger lever stopper disposed in the path of the linear displacement of said trigger lever, said trigger lever having a portion adapted to strike said trigger lever stopper immediately before said print hammer completes striking, via a print carrier, a print drum, said trigger lever being arranged to rebound from said trigger lever stopper to return to its original position.

13. A printer as claimed in claim 12 wherein said hammer lever is substantially L-shaped and pivotably mounted about the junction of its two arms, said hammer being mounted on one arm of said hammer lever, said arm being disposed above said trigger lever, ratchet wheel and print drum, said hammer being positioned to strike said print drum via a print carrier to effect printing at a point above the longitudinal axis of said print drum.

14. A printer as claimed in any preceding claim wherein said printer includes a plurality of printing columns disposed in side-by-side relation along said print drum and ratchet wheel.

15. A printer as claimed in claim 13 or 14 wherein the portion of the or each hammer lever upon which said hammer is mounted defines the top of the or each said column.

16. A printer as claimed in any preceding claim wherein the contact point between said trigger lever portion and said trigger lever stopper is disposed above the extension line of the path of the motion of the centre of gravity of said trigger lever.

17. A printer as claimed in claim 16 wherein the contact point between said portion of said trigger and said trigger lever stopper is disposed on the ratchet wheel side of the extension line of the path of the motion of the centre of gravity of said trigger lever.

18. A printer as claimed in any preceding claim including a single motor means alone provided for driving both said print drum and said ratchet wheel.

19. A printer as claimed in claim 18 including a gear train interconnecting said ratchet wheel and said print drum for transmitting the output force of said motor means from one to the other.

20. A printer as claimed in claim 18 or 19 wherein said motor means includes a rotor shaft, a pair of spaced yokes mounted on said



5 shaft for rotation therewith, a plurality of
pairs of permanent magnets radially arranged
about said shaft between said yokes, one of
each of said pairs of permanent magnets be-
ing mounted on each of said yokes with a gap
therebetween, a plurality of driving coils
disposed in the gap between said pairs of
permanent magnets, and a detecting means
10 responsive to the position of said rotor
shaft and having at least one detecting
coil associated with each driving coil for the
activation of said driving coil to rotate said
rotor shaft.

15 21. A printer as claimed in claim 20
wherein the poles of each pair of permanent
magnets defining the gap therebetween are of
opposite polarity to produce a magnetic field
in said gap.

22. A printer as claimed in claim 20 or 21
wherein, at each position of said rotor shaft,
the driving coils activated at said position
have portions disposed in the gap defined by
selected pairs of permanent magnets, all of
said pairs of permanent magnets being
25 selected to produce a force on said rotor
shaft in a predetermined direction.

22. A printer substantially as hereinbefore
described with reference to and as shown in
the accompanying drawings.

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