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PATENT SPECIFICATION

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(54) PRINTING DEVICE FOR OFFICE MACHINES

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Societa per Azioni, a body corporate
organised and existing under the laws of
Italy, of Via G. Jervis 77, 10015 Ivrea
(Turin), Italy, 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:—

The present invention relates to a dot-
matrix printing device for calculating and
accounting machines, typewriters and other
printing office machines, wherein a series of
striking elements in the proximity of the
recording medium are movable transversely
with respect to the medium and are adapted
to be actuated by the armatures of
corresponding electromagnets for
impressing the individual dots of each
character.

A dot-matrix printing device is known
wherein electromagnets actuating striking
elements in the form of flexible wires have
their cores fixed to the frame of the machine
and their armatures have fixed to them the
corresponding flexible wires, which are
guided in the proximity of the recording
medium by corresponding guide tubes fixed
to a slide which is aligned with respect to the
printing line. The slide is moved with a
reciprocating motion parallel to the printing
line so as to allow the ends of the wires to
shift along the rows of the character matrix.
The electromagnets are actuated selectively
for printing the dots disposed in the rows of
the matrix. In order to limit the lateral
stresses exerted on the armatures of the
electromagnets and on the guide tubes and
to permit a sufficient and uniform action at
the printing ends of the wires, the wires
themselves are relatively long and are
arched along a wide radius of curvature in
order to accommodate the movements of
the slide relative to the electromagnets. A
device of this type becomes complex, bulky
and costly because of the further need to
connect the printing wires, which have high
hardness and flexibility characteristics,

individually to the armatures, of which high
magnetic characteristics are required. 50

A dot-matrix printing device is also
known wherein the printing elements are
constituted by styli which are relatively
short and rigid and fixed to cylindrical
armatures of corresponding electromagnets
of the hollow-core, solenoid type. The
guides of the styli and the electromagnets
are fixed to a carriage shifted with a
reciprocating motion parallel to the platen.
This device requires a carriage and a
corresponding guide structure which are
rather heavy and bulky because of the need
to absorb the reaction of all the armatures
when printing takes place. The driving
mechanism of the carriage itself has to be
rather strong and therefore bulky and
costly. 55 60 65

There is likewise known a dot-matrix
printing device wherein the striking
elements are constituted by projections
aligned with the printing line and formed at
the ends of corresponding leaf springs in
such manner as to form a comb. The springs
are fixed on a carriage and are moved with a
reciprocating motion parallel to the line so
that each projection may print all the dots of
a row of the matrix of a corresponding
character. The end of each spring is
adjacent the core of an electromagnet so as
to be selectively attracted by the core itself
and be released to print the corresponding
dot, using the energy stored in the spring. A
device of this type has the disadvantage of
requiring electromagnets of relatively large
dimensions and considerable energy for
activating the electromagnets, which makes
this device costly. 70 75 80 85

The object of the present invention is
therefore to provide a simple and economic
dot printing device of small dimensions
wherein the inertias of the moving parts are
reduced to the maximum degree and which
requires very limited consumption of
energy. 90 95

According to the present invention there
is provided a dot-matrix printing device for
a printing office machine, wherein a series

of striking elements in the proximity of a recording medium are movable transversely of the medium for printing dots in different locations and are adapted to be actuated by the armatures of corresponding electromagnets for impressing individual dots of characters, the striking elements being substantially rigid bars guided in the proximity of the recording medium by a movable guide which effects the transverse movement and each electromagnet having a fixed core and a movable armature engageable with the corresponding bar.

The invention makes it possible to reduce to the minimum the dimensions of the striking elements and the inertias of the masses having a reciprocating motion, which are limited here to the guides of the ends of the bars, and it has been possible to optimise the magnetic circuit, both from the point of view of dimensions and of efficiency and simplicity of construction.

A dot printer operating on telegraph tape is known wherein the dots of a row of the character matrix are printed in parallel by corresponding bars connected by means of springs to a frame moved forward and backward by an actuating eccentric in front of the printing point.

Each bar can be coupled selectively to the armature of an electro-magnet to be left inoperative or to be actuated for printing by the actuating eccentric. A device of this type is very complex and costly and, moreover, cannot be used advantageously in page printers because of the high construction tolerances required by the arrangement of the bars in parallel.

There is also known a serial printing device having seven flexible printing wires, wherein the free ends are vertically aligned by a resin guide. The other ends are each fixed to corresponding armatures arranged in a semi-circle and normally retained on the pole pieces of a magnetic core by the magnetic field generated by a permanent magnet and in opposition to the action of respective printing springs. The device, including the magnetic circuit, the armatures, the wires and the guides, is borne by a carriage movable transversely of the printing line. In the proximity of each armature there is moreover prearranged in the magnetic circuit a winding which, when it is energised, creates a magnetic field opposed to that of the permanent magnet, which allows the striking spring to actuate the wire for printing the dot. In this device, the recovery of the armatures must be effected by the magnetic force of the permanent magnet in opposition to the action of the striking spring. The field of the permanent magnet must be fairly intense, the dimensions of the permanent magnet therefore become considerable and the

energy required for printing the dot, although lower than in printing with positive actuation of the wire, is nevertheless high and requires an electronic control of high power. For these reasons, the device can find application only in those printers in which the problems of cost and size are not important.

There has also been proposed a printing device provided with a series of flexible wires which are also aligned vertically and fixed to corresponding armatures. These armatures, in turn, are retained against the pole pieces of an electromagnet by the magnetic field generated therein by the energising current of the electromagnet themselves and in opposition to the action of striking springs. By de-energising each electromagnet, the striking spring actuates the wire for printing the dot and a common cam brings the armature back into contact with the pole pieces of the electromagnet. In this device, since the electromagnets themselves must create the force necessary for retaining the armatures, with a very limited air gap, a relatively low pulse energy is required, but, since the styli are generally in the inoperative position, the windings of the electromagnets are constantly traversed by the energising current. The dimensions of the electromagnets are therefore large and necessitate a relatively high average energising energy which requires a rather costly supply.

A subsidiary object of the invention, therefore, is to provide a dot printing device having low pulse energy consumption, like those devices which utilise electromagnets subject to control for actuating the printing elements, and with a low average-energy consumption, as in those devices in which the retention of the wires is achieved by the force of a permanent magnetic field.

There is therefore provided a device in accordance with the invention, as previously defined, wherein each armature is provided with an actuating spring which tends to move the armature away from the core of the electromagnet, means establishing a bias magnetic flux such as to keep the armature at rest in opposition to the action of the actuating spring and a winding which can be energised selectively to generate a flux opposed to the bias flux so as to allow the actuating spring to move the armature away from the core for impression of a dot, the device including a reloading member which acts on the armatures to bring them back into contact with the cores of the electromagnets.

The combination of a number of structures of the two last-mentioned devices has produced in the present device an unforeseeable cumulative effect in the reduction of the volume and of the

consumption of energy to values completely unknown in existing printing devices.

Features of the embodiments of the invention to be described herein the subject matter of our application No. 7903060 Serial No. 1558279 divided out of the present application.

The invention will be described in more detail, by way of example, with reference to the accompanying drawings, wherein:—

Figure 1 is a plan view, partly in section, of a printing device embodying the invention;

Figure 2 is a section on the line II—II of Figure 1;

Figure 3 is a section on the line III—III of Figure 1;

Figure 4 is a section on the line IV—IV of Figure 3;

Figure 5 is a circuit diagram for the control of the printing device;

Figure 6 is a diagram showing the shape or nature of a number of signals of the circuit of Figure 5;

Figure 7 is a diagram illustrating the printing scheme of the device;

Figure 8 is a plan view of a modified form of the printing device;

Figure 9 is a section on the line IX—IX of Figure 8;

Figure 10 is a side view from the left, partly in section, of the device of Figure 8;

Figure 11 is a section on the line XI—XI of Figure 8;

Figure 12 is a section on the line XII—XII of Figure 11;

Figure 13 is a diagram illustrating a detail of the device of Figure 8 on a larger scale; and

Figure 14 is a diagram showing various operating modes of the printing device.

The printing device includes a frame 11, 411 (Figs. 1 and 8) constituted by a base plate 14, 414 of ferromagnetic material and two vertical sides 12, 412 and 13, 413 in which a platen 15, 415 supporting a sheet of paper 16, 416 is journaled. In front of the platen 15, 415 there is arranged a horizontal slide 18, 418 which can slide in the sides 12, 412 and 13, 413 parallel to the platen 15, 415.

On the slide 18, 418 there is mounted a series of bars 20, 420 which are parallel to one another and slidable individually in guides 19, 419 (Figs. 2 and 10) of the slide 18, 418. Each bar 20, 420 has a thickness of 0.3 mm and has one end 21, 421 tapered in the form of a wedge to define a printing tip of substantially square cross-section.

Interposed between the sheet of paper 16, 416 and the bars 20, 420 there is arranged an inked ribbon 22, 422 of known type. On the slide 18, 418 there is mounted a block 120, 520 of plastics material provided with openings 121, 521 in which the printing ends

21, 421 of the bars 20, 420 are accommodated. This block 120, 520 prevents the inked ribbon 22, 422 touching the bars 20, 420 when the latter are not actuated. Moreover, when the inked ribbon is put on, the length of ribbon interposed between the bars and the platen 15, 415 is prevented from being able to foul the said bars 20, 420.

Each bar 20, 420 is provided with a groove 23, 423 in which there is seated the upper end 24, 424 of an armature 26, 426 of a control electromagnet 27, 427.

Each armature 26, 426 is of ferromagnetic material and has its lower end 29, 429 shaped in the form of a fork which is accommodated in the base plate 14, 414. Moreover, each armature 26, 426 co-operates with a corresponding pole piece 32, 432 of the electromagnet 27, 427.

The pole pieces 32, 432 are formed as tongues of a single plate 30, 430 (Figs. 1 and 8) of ferromagnetic material which is connected to the plate 14, 414 through blocks 33, 433 of non-magnetic material and clamping screws 34, 434 (Figs. 2 and 10).

Between the plate 30, 430 and the plate 14, 414 there is arranged a permanent magnet 35, 435 constituted, for example, by a strip of magnetic rubber. This magnetic rubber is compressed between the said two plates, so that air gaps are avoided, and creates a constant magnetic bias flux between the plate 14, 414 and the pole pieces 32, 432 which keeps the armatures 26, 426 in contact with the pole pieces 32, 432.

Around each pole piece 32, 432 there is arranged a spool 36, 436 of plastics material. Each spool 36 (Fig. 2) is integral with a bracket having a locating peg 37 inserted in a corresponding hole 38 in the base plate 14. On each spool 36, 436 (Figs. 2 and 10) there is wound the turns of an energising coil 40, 440 through which electric current does not normally flow and which can be energised to cancel out the bias flux in the corresponding pole piece 32, 432.

Between the spools 36, 436 and the armatures 26, 426 there is arranged a single support 42, 442 of plastics material which is fixed by means of screws 39 (shown only in Fig. 1) to the base plate 14, 414 and is provided with through holes 43, 443 for housing the ends of the pole pieces 32, 432. A series of springs 45, 445 tend to urge the armatures 26, 426 towards the platen 15, 415 in opposition to the action of the flux created by the permanent magnet 35, 435. More particularly, in the support 42 (Figs. 1 and 2), in correspondence with each armature 26, there is formed a cylindrical recess 44 inside which there is arranged one of the springs 45, which is of spiral type and is compressed between the bottom of the

(11)

(12)

recess 44 and the corresponding armature 26. Except when a winding is energised, the action of the bias flux prevails over the action of the spring.

5 The slide 18, 418 (Figs. 1 and 8) and the bars 20, 420 are caused to move with a reciprocating motion in front of the platen 15, 415 by shifting means which comprise an electric motor 50, 450, a cam 58, 458 set in rotation by the motor 50, 450, and cam followers 59, 459 and 60, 460 which co-operate with the cam 58, 458 and are connected in turn to the slide 18, 418. The motor 50, 450 rotates a worm 55, 455 in mesh with a corresponding gear 56, 456 mounted rotatably on a vertical spindle 57, 457 of the frame 11, 411. The motor 50 is mounted on a third vertical side member 51 of the frame 11 and has its driving shaft 52 connected through an axially sliding flexible coupling 53 to the worm 55.

15 On the spindle 57, 457, fast with the gear 56, 456, is mounted the cam 58, 458, with which the cam followers 59, 459 and 60, 460 co-operate. A spiral spring 123, 523 stretched between a point 124, 524 of the cam follower 59, 459 and a point 125, 525 of the cam follower 60, 460 holds the two cam followers 59, 459 and 60, 460 constantly against the edge of the cam 58, 458 in order to take up any possible play due to wear.

20 The cam follower 59 is carried by horizontal slider 62 which is guided in the side members 12 and 13 of the frame 11, and the cam follower 60 is carried by a plate 128 which is connected to the slider 62. This slider is provided with a slot 65 (Figs. 1 and 2) into which a bottom shank 66 of the slide 18 is inserted so as to render the slider 62 and the slide 18 fast with one another.

25 The cam 58, 458 (Figs. 1 and 8) is shaped in such manner as to cause the slide 18, 418 to perform an oscillation the amplitude of which is substantially equal to the width of two print characters along a printing line on the sheet of paper 16, 416. More particularly, each bar 20, 420 is adapted to print two characters (Fig. 7) dot by dot in a 7x5 matrix. The cam 58, 458 which controls the movement of the slide 18, 418 is shaped so that the bars 20, 420 are shifted at substantially constant speed in the spaces in which the characters are to be printed and accelerate and decelerate during the spaces between two characters. Moreover, in order also that the first and last dot of each character row may be equidistant from the other dots, the effective stroke of the bars 20, 420 is greater than the distance between the extreme dots of a row of the matrix.

30 Furthermore, the width of each upper part 24, 424 (Figs. 1 and 8) of each armature 26, 426 is substantially equal to the amplitude of the said oscillation, so that each armature 26, 426 always co-operates

with the same bar 20, 420 during the movements of the latter in front of the sheet of paper 16, 416.

Also fast with the gear 56, 456 (Figs. 3 and 9) is a second worm 68, 468 which has a pitch varying along its circumference and is in mesh with the teeth of a toothed wheel 69, 469 mounted rotatably on a horizontal spindle 70, 470 supported by the side members 13, 413 and 51, 451 (Figs. 1 and 8). The toothed wheel 69, 469 transmits the motion to the platen 15, 415 via a set of gears 72, 472.

To the worm 55, 455 there is keyed a shaft 73, 473 which is journaled in the side members 12, 412 and 13, 413 and rotates a reloading member 74, 474 comprising a cam which co-operates with the armatures 26, 426 to bring them cyclically back into contact with the corresponding pole pieces 32, 432.

A synchronising disc 76, 476 (Figs. 4 and 12) is mounted rotatably on the vertical spindle 57, 457 and is fast with the cam 58, 458. The synchronising disc 76, 476 (Figs. 4 and 12) is constituted by a support of plastics material on one surface of which there is deposited, for example by the printed circuit technique, a layer 79, 479 of a metallic material which is a good electric conductor, such as, for example, gold. The conductive layer defines four circular and concentric tracks 85, 485; 86, 486; 87, 487; 88, 488, with which four sensing tongues or strips 80, 480; 81, 481; 82, 482 and 83, 483, respectively, co-operate. More particularly, the track 85, 485 is entirely metallic, the tracks 86, 486 and 87, 487 have insulating zones 89, 489 and 90, 490, respectively, alternating with conducting zones 91, 491 and 92, 492, respectively, and the track 88, 488 has a single conducting zone 93, 493, while the remaining part is of insulating material. Moreover, the conducting zones 91, 491 and 92, 492 are angularly offset from one another and uniformly distributed around the respective circumferences and are also offset with respect to the conducting zone 93, 493 of the track 88, 488.

The tongue 80, 480 is constantly supplied with an electric reference voltage and the tongues 81, 481; 82, 482 and 83, 483 are adapted to detect the passage of the conducting zones 91, 491; 92, 492 and 93, 493, respectively, to send corresponding electric timing signals SP1, SP2 and SF1 to a sequencing circuit 96 (Fig. 5) of known type, for example of the type described in our British Patent Application No. 51464/74, Serial No. 1473869. More particularly, the signals SP1 and SP2 which are derived from the tongues 81 and 82, because of the rebounds to which the contact portions of the tongues may be subjected, are composed of a sequence of groups of pulses

SP' (Fig. 6) while the signal SF1 output from the tongue 83 is composed of a sequence of groups of pulses SF'; each group of pulses SF' is generated every twenty groups of pulses SP'. In order to limit the sliding distances between the contacts, the conducting zones and the adjacent insulating zones are disposed around the periphery of the disc so that their width is the minimum possible compatible with the possibility of processing the signals by means of relatively simple circuits. Since the pulses SP1' and SP2' have a relatively short average duration, rebound between the contacts can be recognised as the end of the pulse itself and the resumption of contact with respect to the same conducting zone can be recognised as the beginning of a new pulse SP1' and SP2'. For the purpose of preventing erroneous interpretations of the pulses SP' and SF', the signals SP1, SP2 and SF1 are sent to flip-flops 130, 131 and 132, respectively. The flip-flops 130 and 131 are changed over by the leading edge of each group of pulses SP' and their outputs are connected to a shaping circuit 142 from which issues the shaped signal SP which is the actual timing signal of the printing dots.

The flip-flop 132, on the other hand, is changed over by the first leading edge of each group of pulses SF' and has its output connected to a shaping circuit 133 from which issues the shaped signal SF which is the actual timing signal of an elementary printing cycle (20 printing dots to a complete oscillation of the slide 18). The signals SP and SF are sent to a sequencing circuit 96, at which the information relating to the characters which are to be printed arrives on a channel 134 from a calculator 135 to which the printing device may be connected or from a keyboard 136.

The sequencing circuit 96 has outputs 137 connected to the selector electromagnets 27, 427 for selective energisation thereof and comprises a first binary counter 138 and a second binary counter 139 which are adapted to count the timing pulses of the signal SP. More particularly, the counter 138 gives a constant signal as output after five SP' pulses and the counter 139 gives an end-of-cycle signal after eighty SP' pulses, as will be described hereinafter.

The sensing tongues 80, 480; 81, 481; 82, 482 and 83, 483 are supported by a block 95, 495 (Figs. 4 and 12) of plastics material which is pivoted on the spindle 57, 457 of the fixed frame 11, 411. The block 95 (Figs. 1 and 4) is constantly pulled towards the side member 51 of the frame 11 by a spring 99 and has a lug 103 bearing against an adjusting screw 104 which can be screwed into, or out of, the side member 51. In this way, by screwing the screw 104 in or out, a turning action of the block 95 with respect

to the side member 51 is produced, which advances or retards the picking-up of the synchronising signals by the tongues 81, 82 and 83.

The use of a sliding synchronising disc enables a transducer to be obtained which is economic and reliable and which, in contrast to optical or magnetic transducers, does not require high current inputs to be provided for the power supply of the printing device, which is therefore also of limited dimensions for this reason.

In order to bring the reloading member 74, 474, which brings the armatures 26, 426 back cyclically against the corresponding pole pieces 32, 432, into phase with the synchronising disc 76, 476, a leaf spring 106 (shown only in Fig. 1) is fixed to the vertical side member 12, 412. This spring 106 has one end 108 disposed between two flanges 109 and 110 of the shaft 74, 473 and is provided with a through hole 111 through which there extends an adjusting screw 112 screwed into the side member 12, 412. The spring 106 constantly tends to shift the shaft 73, 473 to the left.

By screwing the adjusting screw 112 in or out, axial movements of the shaft 73, 473 (Figs. 1 and 8) and the worm 55, 455 with respect to the driving shaft 52 are produced. The axial movements of the shaft 73 are possible because of the presence of the coupling 53. These axial movements cause the gear 56, 456 and the synchronising disc 76, 476 to rotate, while the cam 74, 474 is only shifted axially. Moreover, this adjustment can be made with the machine in operation in order if necessary to correct the phase of energisation of the electromagnets 27, 427 and improve the printing cycle, as will be described hereinafter.

The printing device hereinbefore described operates in the following manner. In the inoperative position, the motor 50, 450 is stationary and the slide 18, 418 is stationary at any point of its travel in front of the platen 15, 415. On the switching on of the machine, the counters 138 and 139 of the circuit 96 (Fig. 5) are zeroised in any known manner. By supplying the motor 50, 450 (Figs. 1 and 8), the worm 55, 455 is set in rotation and consequently causes the cam 58, 458, the worm 68, 468 of varying pitch and the synchronising disc 76, 476 to rotate.

The slide 18, 418 and the bars 20, 420 thus begin to oscillate in front of the sheet of paper 16, 416. After each rotation of the worm 68 through 180°, the platen 15, 415 carries out a small rotation so as to cause the sheet 16, 416 to advance by one elementary step (i.e. the pitch between dots in the matrix) which, in accordance with current standards, is about 0.38 mm.

(14)

The sensing tongues 81, 481; 82, 482 and 83, 483 detect the passage of the conducting zones 91, 491; 92, 492 and 93, 493 respectively, sending corresponding electric timing signals SP and SF to the sequencing circuit 96 (Fig. 5) which controls the energisation of the electromagnets 27, 427.

After counting five timing pulses SP', the counter 138 generates a signal enabling printing true and proper. The first pulse SF' which arrives at the sequencing circuit 96 after the enabling signal of the counter 138 gives the start for the printing cycle.

It is to be noted that the synchronising disc 76, 476 (Figs. 3 and 11), the worm 68, 468 of varying pitch and the cam 58, 458 are offset from one another so that the pulses SF' are generated in coincidence with the advance of the platen 15, 415 and when the slide 18, 418 is located shifted completely to the right (Figs. 1 and 8). The first row of dots is therefore printed from right to left.

As has been seen, each bar 20, 420 is adapted to print two print characters for each printing line and, therefore, all the seventy dots of the two 7x5 matrices must be covered in successive passes, the inked ribbon 22, 422 being impressed only when a predetermined dot is to be printed on the basis of a predetermined code.

Thus, for example, if a bar 20, 420 is to print the numerals one and two (Fig. 7), during the first pass from right to left it imprints the 2nd, 3rd, 4th, and 8th dots, while during the second pass, from left to right, it imprints the 12th, 13th, 16th, and 20th dots after the paper has been advanced by one elementary step.

Referring only to the device of Figs. 1 to 7, after the second pass and before the third a second phasing pulse SF' is generated.

After seven passes the bar 20 completes the printing to two characters, but the slide continues to oscillate at least until the completion of the eighth pass. After eighty pulses SP', in fact, the counter 139 generates an end-of-cycle signal which arrests the motor 50, unless an order to print a following line of characters arrives at the sequencing circuit 96 from the calculator 135 or from the keyboard 136.

On sending the end-of-cycle signal after the eightieth pulse SP' from the commencement of the printing, before the motor stops it carries out, owing to inertia, a further small rotation which causes another pulse SF' to be generated and the slide 18 to stop at any point between the ninth and tenth passes. As a rule, the slide 18 stops at least five positions before the completion of the tenth pass. In this way, when the order for another printing cycle is given, a fresh pulse SF' is generated after the counter 138 has generated the enabling signal, having

already counted five pulses SP'. By this expedient, while the slide 18 performs three idle passes, line-spacing equal to three elementary advances of the paper 16 is obtained between two successive lines of characters.

The cam 58 is shaped so as to cause the slide 18 to shift at constant speed when the bars 20 are located in correspondence with the printing points and to cause it to accelerate and decelerate during its movement between one character and the other, so that the time taken by the bars 20 to bring themselves from the 5th to the 8th column of the matrices may be equal to the unit time which is taken for the movement between two adjacent columns. Moreover, in this way, the conducting zones 91 and 92 of the synchronising disc 76 are also uniformly distributed along the tracks 86 and 87.

The printing of a dot takes place in the following manner. Referring to the device according to the two embodiments, the armatures 26, 426 are held when inoperative or at rest with a force of about 100 g. against the corresponding pole pieces 32, 432 by the effect of the bias magnetic field created by the strip 35, 435 of magnetic rubber and in opposition to the force of the springs 45, 445 which is equal to about 70 g.

The corresponding selector magnet 27, 427 is now energised by means of a current pulse of about 100 mA for 1 msec. at 18 v. in the coil 40, 440. This creates in the corresponding pole piece 32, 432 a magnetic flux which is opposed to that of the previously existing field, in such manner as to reduce the net magnetic force below the force of the springs 45, 445. The spring 45, 445 can thus urge the armature 26, 426 towards the platen 15, 415, causing it to rotate with respect to its pivoting seat 31, 431. As soon as the armature 26, 426 separates from the pole piece 32, 432, an air gap is formed which further reduces the residual magnetic force and enables the spring 45, 445 to accelerate the armature 26, 426 strongly towards the platen 15, 415.

In this way, the bar 20, 420 is also moved at high speed towards the platen 15, 415 and a dot of substantially square section is imprinted on the sheet of paper 16, 416. Once the printing of the dot has been effected, the cam 74, 474 brings the armature 26, 426 back cyclically into contact with the pole piece 32, 432.

In this cyclic system with mechanical recovery of the armatures, the energisation of the electromagnet 27, 427 which begins substantially at the same instant when the timing pulses are picked up on the synchronising disc 76, 476 must be in phase with the rotation of the cam 74, 474. In order to optimise the printing cycle, this is

effected with the machine in operation by screwing the screw 112 into or out of the side member 12, as has been seen hereinbefore.

More precisely, referring to Figure 14, on a space-time graph v of the cam 74, 474 and between the instant when the command of energisation is given to the electromagnets 27, 427 and the instant when the armatures 26, 426 are close to the platen 15, 415, a fixed time tr of about 2.3 msec. elapses due to the inductances of the magnetic circuit, the mechanical characteristics of the springs 45, 445 and the inertia of the armatures 26, 426. The command of energisation is therefore given at an instant t_0 which is a time tr in advance with respect to the instant t_1 when the cam 74, 474 is beyond the path of the armatures 26, 426 towards the platen 15, 415. Moreover, to enable the bars 20, 420 to imprint a dot correctly on the sheet of paper 16, 416, the recovery of the armatures 26, 426 (instant t_2) must begin at least after a time ta of the order of about 1.5 msec. With times tr and ts close to the values already given, the nominal printing cycle T becomes about 6.25 msec., which corresponds to a printing speed of two lines per second for the printing system used.

During the operation of the device, the supply conditions of the electric motor 50, 450 may vary and, consequently, the speed of rotation of the shaft 52, 452 may also vary, and therefore that of the cam 74, 474.

The variations in speed of the motor 50, 450, acting on the cycle T and not on the times tr and ta , alter the conditions of release and recovery of the armatures 26, 426. More particularly, for a lower limit value, corresponding to a curve v' , the instant at which the bar 20, 420 touches the platen coincides with the instant t_1'' at which the cam 74, 474 would tend to arrest the bar. Below this value, the armature 26, 426 would beat against the cam 74, 474 before this has brought itself beyond the path of the armatures 26, 426, thereby preventing the printing of the dot. On the other hand, the speed cannot rise above a value (curve v'') such that the instant t_2' arrives before the time $(tr+ta)$ has elapsed from the command of energisation of the electromagnets 27, 427, because in this case the armatures 26, 426 would be brought back towards the corresponding pole pieces before the printing of the dot on the sheet of paper 16, 416 has been completed.

In the programming of the nominal speed v , account is therefore taken of a safety margin in order to define the range v' and v'' within which the speed will always be satisfactory for obtaining a good printing quality.

On the other hand, the times (tr and ta), which are optimized for a prototype, may

assume values different from one to another in mass production units. Above all, it is desired to have a wide margin of tolerances in mass production. Accurate phasing is, therefore, advisable on each individual unit to take account of the specific characteristics of the unit itself. This can easily be done, with the device in operation, by varying the speed of the motor and thereafter controlling the regularity of the printing in the following manner.

First, the motor 50, 450 is brought to the lower limit speed which, for example, may be 10% lower than the nominal speed, and the screw 112 is operated on so that, with good operation, the picking-up of the timing pulses is advanced to the maximum with respect to the phase of the cam 74, 474, so that the striking occurs at the instant t_1'' , precisely at a time tr after the energisation of the selector electromagnets 27, 427. Then the motor 50, 450 is brought to the highest speed, which may be, for example, 10% higher than the nominal speed, and it is checked that the instant t_2' occurs after the time $(tr+ta)$ has elapsed. It is, therefore, clear that because of this adjustment or setting-up neither further gradual adjustments in the stationary state on the same unit nor the use of special test equipment are necessary.

In addition to the phasing already described, the device enables phasing to be effected easily of the instant of energisation of the electromagnets 27, 427 with respect to the position of the slide 18, 418 along the printing line, for obtaining a good printing quality with the zig-zag method of printing already described. In fact, if the command to the bars 20, 420 is given when they have not yet reached the nominal printing position or have already gone beyond it, the dots of the rows printed in the passes from right to left will be disposed to the right or to the left, respectively, of the theoretical position, and, conversely, the dots of the rows printed in the passes from left to right will be disposed to the left or to the right, respectively, of the theoretical position, thus giving rise to staggering of the dots in the same column of the matrix.

For this phasing, the adjusting screw 104 is operated on to shift the tongues 80, 480; 81, 481; 82, 482 and 83, 483 with respect to the synchronising disc 76, 476, thus advancing or retarding in this way the picking-up of the timing signals until such time as the dots in the same column are visibly aligned. This adjustment can therefore also be made with the machine in operation, thus permitting an immediate check by the operator on the result of the printing.

The printing device illustrated in Figures 8 to 13 has the following modifications with

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respect to the printing device illustrated in Figures 1 to 7.

5 Each bar 420 (Figs. 8 and 13) has a front end 550 (remote from the platen) guided in a corresponding slot 551 in the support 442, so that the bars 420, instead of shifting in parallel together with the slide 418, oscillate about their pivoting point constituted by the slot 551, thus describing a circular arc with their printing ends 421. This modification with respect to the device of Figure 1 enables the dimensions of the upper ends 424 of the armatures 426 which co-operate with the grooves 423 of the bars 420 to be reduced.

10 In the device of Figure 1, in fact, the printing tip 21 of each bar 20 is at a distance of 5.1 mm from the adjacent printing tip, since in accordance with current standards with a step equal to 10 characters per inch a print character has a width of about 1.757 mm and the distance between one character and another is about 0.793 mm. The pitch between two adjacent armatures 26 is 5.1 mm. Moreover, since each printing point is at a distance of 0.364 mm from the adjacent point, the useful stroke of each printing tip 21 of the bars 20, and therefore also of the slide 18 in front of the platen 15, is about 4.004 mm and the actual stroke which, for reasons already described, is greater than the distance between the extreme dots of a row of the dot matrix, is about 4.3 mm. Consequently, in order to be able to co-operate always with the same bar 20, each armature 26 must have its upper end 24 at least 4.6 mm wide. It is moreover expedient that this end 24 of the armatures 26 be wider than the length of the actual stroke of the bars 20. In fact, their width is 4.8 mm. In this way, the nominal clearance between one armature 26 and the adjacent one comes out at 0.3 mm. Consequently, the tolerances, both at the pivoting seats 31 and at the armatures 26, have to be rather fine.

35 In the device of Figure 8, on the other hand, while the excursion which the printing tip 421 must perform in front of the platen 415 is still 4.004 mm, it is sufficient that the upper end 424 of each armature 426 be 3.5 mm wide. In this way, the armatures 426 being still pitched at intervals of 5.1 mm, the ends 424 have a clearance of 1.6 mm between them and therefore the tolerances may be relaxed.

40 It is obvious that, in order to reduce the dimensions of the armatures 426 further, they could be placed closer to the pivoting point 551, but, since the rise of the circular arc described by the printing end 421 decreases with the approach of the armature 426 to the end 421, the armatures 426 are disposed at an intermediate point so that the rise may be contained within acceptable and practically negligible levels

if these are related to the distance at rest between the printing end 421 and the platen 415. It is obvious that this rise could also be completely nullified by shaping the armature 426 so that it is curved and has a central valley or hollow corresponding to the value of the rise which it is desired to take up.

In order to permit the bars 420 to oscillate, the guides 419 of the slide 418 are slightly wider than the bars 420 themselves. The play which is created between the guide 419 and the bar 420 is, however, negligible when the bars are inclined, whereas it would be excessive when the bars are in the intermediate positions. Since, however, with the printing system adopted, the points intermediate between two characters are never printed on, there is no disadvantage because of this play.

In the modified construction of Figure 8, instead of the springs 445 being of spiral type, they are constituted by a plurality of leaf springs formed from a single metal plate 560 fixed at the bottom to the support 442 by means of a clamping element 561 of plastics material (Figs. 8 and 10).

The armatures 426 are also modified with respect to the armatures 26. More particularly, on each of these there is formed a horizontal front projection 570 and a projecting element 572, which is also at the front. The horizontal projection 570 has an end 571 in the form of a spherical cap which normally co-operates with the corresponding pole piece 432. On the projecting elements 572, in turn, there bear the terminal portions of the springs 445.

The use of a spherical surface which contacts the pole piece 432 enables an air gap which is very limited (of the order of 0.02 mm) and constant to be obtained even if the armature 426 is not perfectly aligned, because of the clearance with which it is pivoted, with a negligible air gap, in its seat 431. Moreover, the area of contact being limited, the specific force between the cap 571 and the pole piece 432 becomes very high. This causes any possible foreign particles or traces of lubricant to remain outside the air gap and not affect the reluctance of the magnetic circuit.

The support 442 is also modified with respect to the corresponding support 42. More particularly, in order to receive the ends 571 of the individual armatures 426, a recess 580 is formed in correspondence with each of these. The aim of this recess 580 is to prevent contaminants such as oil, dust or paper fibres, interposing themselves between the armature and the pole piece and thus cause deterioration of the working conditions.

Inside the support 442 and over the entire length thereof there is arranged a non-

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magnetic metal plate 581 provided with slots 582 in which hooked shanks 583 of each spool 436 are engaged.

5 As has been seen hereinbefore, an elementary printing cycle T (printing of a dot) has a duration of about 6.25 msec, which corresponds to a frequency of 160 Hz. Therefore, the shaft 73 and the cam 74 rotate under normal conditions at 9,600 revolutions per minute. In order to deaden the noise due to the impact between the cam 74 and the armatures 26 during the recovery of the latter, the cam 74 is constituted by an eccentric and, in correspondence with each armature 26, there is arranged slidably in a groove a ring 190 (Figs. 1 and 2) of plastics material or sufficiently hard rubber. These rings balance the forces on the various armatures 26 and, by rotating in their respective grooves, act so that throughout the period during which the eccentrics 74 maintain the armatures 26 in contact they limit the wear between the parts in reciprocal movement.

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As a modification, for the purpose of reducing the speed of rotation of the armature reloading member, in particular on account of the problems of balancing that this requires, the cam 474 (Figs. 8 and 10) has a profile comprising three lobes offset by 120° from one another. Both the speed of rotation of the shaft 473 and that of the motor 450 are thus reduced in the ratio of 3 to 1. Moreover, in order to reduce the overall dimensions of the device, the motor 450 is fixed to the side member 412 below the platen 415. In this case, in order to reduce the noise due to the reloading of the armatures, between the cam 474 and the armatures 426 there are interposed leaf springs 575 formed from a single metal plate 576 which is fixed to a bent lower portion 577 of the frame 411 by means of a clamping element 578 of plastics material. Each upper end 574 of the leaf springs 575 acts on a spherical cap 573 which is formed on the armature 426 opposite the horizontal projection 570, at the rear of the armature.

50 For the purpose of reducing the time taken to carry out line-spacing between two lines of characters and the wear between the worm and the corresponding pin, the worm 468 (Figs. 9 and 11) is formed on the periphery of a drum 580 of plastics material and inside which there is formed the profile of the cam 458. Pins 581 of the wheel 469 co-operate with the grooved profile of the worm 468. This profile 468 is formed so that after each 180° of rotation of the drum 580, simultaneously with the reversal of the movement of the slide 418, the platen 415 advances by one elementary step, equal to 0.38 mm, during the first seven passes, and advances by three elementary steps, equal to 1.14 mm, when

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the slide 418 has completed the seventh pass and is about to perform the eighth (see also Fig. 7). In this way, the sliding for each character between the surface of the worm 468 and the pin 581 is reduced in the ratio of 5 to 1 with respect to the corresponding sliding between the surface of the worm 68 and the teeth of the gear 69. Moreover, the time taken to carry out the line-spacing is substantially equal to that taken for printing a line of dots. To do this, the system for detecting the timing signals is partly modified. More particularly, instead of the pulses SF' being generated every twenty printing dots, they are generated only at the beginning of a line of characters. In fact, the tongue 483 is normally kept spaced from the synchronising disc 476 by a block 590 arranged on the block 495. The tongue 483 is urged cyclically towards the disc 476 by a slider 591 slidable inside the block 495 and controlled in turn by a bail lever 592. The lever 592 is pivoted on a fixed pin 594 (see also Fig. 12) and has an arm 593 in contact with the slider 591 and an arm 595 in contact with the outer profile 596 of the wheel 469. A spring 597 ensures contact between the lever 592 and the wheel 469.

The outer profile 596 of the wheel 469 is shaped in such a manner as to shift the lever 592 cyclically clockwise (Fig. 11) to bring the slider 591 upward and thus bring the tongue 483 against the corresponding track 488 of the disc 476 only at the beginning of each line of characters. As has already been described, the synchronising disc 76 for picking up the twenty timing pulses SP', which produce the printing of the twenty dots of an elementary printing cycle, has on its tracks 86 and 87 ten conducting zones 91 and 92, respectively, for each track and contact of each of these conducting zones with the corresponding tongues 81 and 82 causes the generation of a timing pulse SP'. Apart from the advantages of easy processing of shaped signals, this also entails reducing to the minimum the dimensions of the disc 76 and the unit sliding effects between the individual tongues and the conducting zones 91 and 92.

The separation of the picking-up of the timing signals on two different numbers (tongues 81 and 82), however, requires careful precision in the arrangement of the tongues 81 and 82 with respect to the synchronising disc 76. Mutual misalignment thereof, in fact, would lead to a phase difference between the picking-up of the pulses of the track 86 and those of the track 87, and a consequent inequality between the distances between the dots of the matrix. Moreover, this could limit the tolerance in the phasing between the synchronising disc 76 and the recovery member 74 for the armatures 26.

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In order to obviate this possible drawback, the synchronising disc 476 presents the following modifications. In each of the tracks 486 and 487 there are twenty conducting zones 491 and 492, so that at each revolution of the disc 476 twenty pulses SP1' and twenty pulses SP2' are generated. The signals SP1 and SP2 are sent in one case to the set input and in the other case to the reset input of a single flip-flop which has an output connected directly to the sequencing circuit 96. The pulses SP1' act in this way as actual timing pulses, while the pulses SP2', which are out of phase with respect to the pulses SP1' serve only to reset the pulses SP1'. In this way, the timing pulses SP', which correspond to the pulses SP1', are picked up by a single element (tongue 482) and are all equidistant. Moreover, this enables a second flip-flop and a shaping circuit to be saved, compared with the device of Figures 1 to 7.

Moreover, as another modification, the block 495 is fixed to the frame 411 by means of a clamping screw 495a which engages a slot 598 in the block itself to clamp it removably with respect to the frame 411. By slackening the screw 597, the block 495 can be rotated manually with respect to the frame 411 to advance or retard the picking-up of the timing signals by the tongues 481, 482 and 483 for the purposes seen hereinbefore.

Finally, as a last modification, the profile of the cam 458 is modified with respect to that of the cam 58. In fact, as has been seen, the cam 58 is shaped in such a manner as to cause the slide 18 to move at constant speed when the bars 20 are in correspondence with the printing points and cause it to accelerate and decelerate during the movement between one character and the other. In practice, this causes each dot to be printed on the fly, while the slide 18 advances with a continuous motion in front of the sheet of paper 16. According to the modification, on the other hand, the cam 458 is shaped in such manner as to cause the slide 418 to move step by step in front of the platen 415, so that the slide 418 itself is stationary when the bars 420 are actuated.

For the protection of all the bars 420, a cover 599 (Fig. 10) of plastics material is provided, this being arranged above the support 442.

It is moreover to be noted that in order to reduce the cost of the device the armatures 26, 426 are produced by sintering powders of ferromagnetic materials, for example by the method described in the Applicants' British Patent No. 903519.

It is obvious that other modifications or additions of parts may be made in the printing devices hereinbefore described without departing from the scope of the

claims. For example, both the synchronising disc and the cam which controls the movement of the slide 18, 418 may be keyed directly on the shaft 73, 473 which carries the recovery member for the armatures 26, 426 thus eliminating the coupling between the worm 55, 455 and the gear 56, 456.

WHAT WE CLAIM IS:

1. A dot-matrix printing device for a printing office machine, wherein a series of striking elements in the proximity of a recording medium are movable transversely of the medium for printing dots in different locations and are adapted to be actuated by the armatures of corresponding electromagnets for impressing individual dots of characters, the striking elements being substantially rigid bars guided in the proximity of the recording medium by a movable guide which effects the transverse movement and each electromagnet having a fixed core and a movable armature engageable with the corresponding bar.

2. A printing device according to claim 1, wherein each electromagnet has substantially U-shaped core with a pair of pole pieces parallel to each other and the armature is kept bearing against the pole pieces by a corresponding magnetic field in opposition to the action of an actuating spring, the armature having a first end pressing against a first pole piece by way of engaging surfaces of which one is flat and the other is spherical, and a forked second end engaging in the second pole piece to form a hinge for the armature.

3. A printing device according to claim 2, wherein each armature is formed of sintered powders of ferromagnetic material and is provided at the first end with a projection having a substantially spherical surface facing a corresponding plane surface of the first pole piece.

4. A printing device according to claim 2 or 3, comprising a support of non-magnetic material provided with recesses for protecting the couplings between the armatures and pole pieces.

5. A printing device according to any one of the preceding claims, wherein the electromagnets have a common pole piece constituted by base of the device.

6. A printing device according to both claim 2 and claim 5, wherein the base represents the second pole piece of each core and the second ends of the armatures are constituted by forks the arms of which are inserted with a clearance in corresponding holes in the base.

7. A printing device according to any one of the preceding claims, wherein individual pole pieces of the electromagnets are formed by the tongues of a single comb-shaped plate.



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20 For the protection of all the bars 420, a cover 599 (Fig. 10) of plastics material is provided, this being arranged above the support 442.

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claims. For example, both the synchronising disc and the cam which controls the movement of the slide 18, 418 may be keyed directly on the shaft 73, 473 which carries the recovery member for the armatures 26, 426 thus eliminating the coupling between the worm 55, 455 and the gear 56, 456.

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2. A printing device according to claim 1, wherein each electromagnet has substantially U-shaped core with a pair of pole pieces parallel to each other and the armature is kept bearing against the pole pieces by a corresponding magnetic field in opposition to the action of an actuating spring, the armature having a first end pressing against a first pole piece by way of engaging surfaces of which one is flat and the other is spherical, and a forked second end engaging in the second pole piece to form a hinge for the armature.

3. A printing device according to claim 2; wherein each armature is formed of sintered powders of ferromagnetic material and is provided at the first end with a projection having a substantially spherical surface facing a corresponding plane surface of the first pole piece.

4. A printing device according to claim 2 or 3, comprising a support of non-magnetic material provided with recesses for protecting the couplings between the armatures and pole pieces.

5. A printing device according to any one of the preceding claims, wherein the electromagnets have a common pole piece constituted by base of the device.

6. A printing device according to both claim 2 and claim 5, wherein the base represents the second pole piece of each core and the second ends of the armatures are constituted by forks the arms of which are inserted with a clearance in corresponding holes in the base.

7. A printing device according to any one of the preceding claims, wherein individual pole pieces of the electromagnets are formed by the tongues of a single comb-shaped plate.



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8. A printing device according to both claim 5 and claim 7, comprising a strip of a magnetic elastomer interposed between the base and the comb-shaped plate for generating a substantially constant magnetic flux in each core, and clamping means keeping the magnetic rubber in contact with the comb-shaped plate and the base.

9. A printing device according to any of the preceding claims, wherein each armature is provided with an actuating spring which tends to move the armature away from the core of the electromagnet, means establishing a bias magnetic flux such as to keep the armature at rest in opposition to the action of the actuating spring and a winding which can be energised selectively to generate a flux opposed to the bias flux so as to allow the actuating spring to move the armature away from the core for impression of a dot, the device including a reloading member which acts on the armatures to bring them back into contact with the cores of the electromagnets.

10. A printing device according to claim 9, wherein the armatures are aligned in a row parallel to the printing line on the recording medium and the reloading member comprises cam elements which act on the armatures and are mounted on a shaft disposed parallel to the printing line.

11. A printing device according to both claim 4 and claim 9, wherein the actuating springs comprise metal tongues formed on a single plate supported by the said support of non-magnetic material.

12. A printing device according to claim 9, wherein yielding means are arranged between the reloading member and the armatures, which yielding means deaden the noise due to the cyclic recovery of the armatures by the reloading member and which adjust the armatures individually to the corresponding cores.

13. A printing device according to both claims 10 and claim 12, wherein the cam elements are constituted by eccentrics and the yielding means are constituted by rings of resilient material carried circumferentially slidably by corresponding guides of the eccentrics.

14. A printing device according to both claim 10 and claim 12, wherein the yielding means comprise a plurality of leaf springs which co-operate at different points with the cam elements and the armatures.

15. A printing device according to any one of claims 9 to 14, wherein the electromagnets are actuated in response to synchronising signals associated with mutual feed movement between the bars and the recording medium, and wherein the recovery of the armatures by the reloading member is effected after a substantially fixed time delay, from the instant when each

of the timing signals is picked up, the device comprising means which vary phase of movement of the reloading member with respect to the picking-up of the synchronising signals for immediate control of the result of the printing due to the phasing between the timing signals and the recovery of the armatures of the electromagnets.

16. A printing device according to any one of claims 1 to 15, wherein each armature is in articulated engagement with the corresponding bar.

17. A printing device according to claim 16, wherein for the striking movement, the bars are individually slidably mounted at at least one point of the movable guide and the articulated engagement comprises a slot coupling which permits transverse movement of the bars with respect to the armatures, the width of each armature being substantially equal to the amplitude of the excursion of the corresponding bar in front of the recording medium.

18. A printing device according to claim 17, wherein each bar has a printing end in engagement with the movable guide to follow the movements thereof in front of the recording medium, and an end opposite the printing end pivoted slidably in a corresponding fixed guide, and wherein the slot coupling is in a part of the bar intermediate between the two ends.

19. A printing device according to any of claims 1 to 17, wherein the dots are imprinted in a matrix of rows and columns and the striking elements are moved in both directions to print the rows of the matrix in successive passes from right to left and from left to right, and wherein the medium is caused to advance by one elementary step with respect to the striking elements after the completion of each pass, comprising a series of synchronising elements associated with each column of the matrix carried by a synchronising disc which rotates in synchronism with the feed member, and sensing elements which detect the passage of the synchronising elements to actuate the striking elements selectively, means being provided for varying the position of the sensing elements so as to adjust the timing of the synchronisation for visible control of the alignment of the columns of printed dots of each matrix.

20. A printing device according to claim 19, wherein the synchronising elements comprise a plurality of insulating zones alternating with electrically conductive zones disposed round two concentric tracks and the sensing elements comprise two metal tongues which contact the conductive zones to send the signals coming from one and the other of the tracks alternately to corresponding bistable storage devices to

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change their states only in response to the initial pulses of each contact of one or the other tongue with the conductive zones.

- 5 21. A printing device according to claim 19 or 20, wherein each printing element prints at least two consecutive characters of a line of print, and the feed member comprises parts which accelerate and decelerate each printing element in the
10 space separating two adjacent characters so that the time for passing through the space is substantially equal to the time taken by the printing element to shift between two adjacent columns of the matrix, for which
15 reason the synchronising elements are equidistant from each other.

22. A printing device according to any one of claims 1 to 21, wherein the striking elements are moved reciprocatingly in front
20 of the recording medium to print the characters in a predetermined number of pairs of passes from right to left and from left to right, and wherein the recording medium is movable with respect to the

striking elements by a line-spacing mechanism, comprising phasing elements operating synchronously with the line-spacing mechanism for generating a phase signal at each pair of passes, means being provided for enabling the printing elements
30 for printing a line of characters only in response to the first phase signal of the predetermined number of pairs.

23. A dot-matrix printing device for a printing office machine, substantially as described with reference to, and as illustrated in, Figs. 1 to 5 of the accompanying drawings.

24. A dot-matrix printing device for a printing office machine, substantially as described with reference to, and as illustrated in, Figs. 8 to 13 of the accompanying drawings.

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