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"ANNULAR ROLLED METAL MEMBER FOR USE IN A PRINT HEAD"

The present invention relates to an annular rolled metal member for use in a print head which may, for example, be employed in an impact printer such as a wire printer.

5 A print head for use in an impact printer such as a wire printer is disclosed in, for example, Japanese Laid-Open Patent Specification No. 11615/1978. In this citation, the print head has a plurality of driving arms whose number is equal to the number of print elements such as wires. The arms have the same length respectively and
10 are arranged radially. The arms are actuated by electromagnetic driver devices having coil cores that are arranged on a circle. Therefore, the number of component parts of the print head is large.

15 In an attempt to reduce the number of component parts, an improved print head has been proposed in Japanese Laid-Open Patent Specification No. 154178/1980, where driving arms are fabricated as one unit. In particular, the arms are formed as parts of a single rolled metal member by press working so that the arms are connected
20 together at their outer ends like a ring. However, all of the arms have the same shape and the same dimensions, and are actuated by electromagnetic driver devices having

coil cores arranged on the same circle similarly to the aforementioned known print head.

However, the Young's Modulus of the rolled metal member may be changed by changing the direction of rolling.

5 For this reason, the arms of the last-mentioned rolled metal member differ in Young's Modulus respectively and so they vary in natural frequency and produce different resilient forces. Therefore, in operation the arms respond at different rates. As a result, the head may form incorrect dots or may print at
10 different pressures. Variations in response do not pose serious problems in printers of the type where the print speed is about 100 characters per second or less. However, the variations in response materially
15 affect the print quality in high-speed printers whose print speed is about 200 characters per second or in ultra-high-speed printers whose print speed is about 400 characters per second.

According, therefore, to the present invention, there
20 is provided an annular rolled metal member for use in a print head, the rolled metal member having a plurality of integral radially extending resilient driving arms which are connected together at their radially outer ends and which are adapted to drive print elements, the length and/or
25 width and/or thickness and/or shape of the driving arms

differing from one another in accordance with the angles that the longitudinal directions of the driving arms make with the direction in which the rolled metal member was rolled so that all the driving arms have substantially the same natural frequency and/or resilient force.

Thus in an annular rolled member according to the present invention, the variations in response to the various driving arms, and the variation in the printing pressure effected by the driving arms may be eliminated.

The driving arms may, for example, differ from each other only in respect of their length or only in respect of their width.

Each of the driving arms may taper radially inwardly.

Each of the driving arms is preferably provided with a hole adapted to receive a part of an armature.

The invention also comprises a print head for use in a printer provided with an annular rolled metal member as set forth above. Thus the print head may have a plurality of armatures a part of each of which is mounted in the hole of the respective driving arm, each armature being provided with a respective printing element which is normally held in an inoperative position by the resilience of the respective driving arm, a plurality of electro-magnetic means being provided each

of which, when energized, causes the respective armature to move its printing element into an operative position.

Preferably, each electro-magnetic means comprises a core whose position with respect to its corresponding armature can be varied.

The invention also comprises, in a print head having resilient driving arms for driving print elements which are formed of a single rolled metal as one unit so as to be connected together at outer ends thereof, the improvement wherein the arms differ in at least one of length, width, thickness or shape, according to the angles that the longitudinal directions of the arms make with the direction in which the metal has been rolled, whereby the arms have the same natural frequency.

Additionally, the invention comprises, in a print head having resilient driving arms for driving print elements which are formed of a single rolled metal as one unit so as to be connected together at outer ends thereof, the improvement wherein the arms differ in at least one of length, width, thickness or shape, according to the angles that the longitudinal directions of the arms make with the direction in which the metal has been rolled, whereby the arms produce the same resilient force.

The invention is illustrated, merely by way of example, in the accompanying drawings, in which:-

Figure 1 is a side elevation view in cross section of a print head provided with an annular rolled metal member according to the present invention;

Figure 2 is a front elevation view of the annular rolled metal member shown in Figure 1; and

Figure 3 is a front elevation view of another embodiment of an annular rolled metal member according to the present invention.

Referring to Figure 1, there is shown a print head for use in an impact printer such as a wire printer which has a front yoke plate 1 consisting of three layers and a rear yoke plate 2 also consisting of three layers. A doughnut-like permanent magnet 3, whose North and South poles are respectively indicated at N, S, and a yoke frame 4 are mounted between the yoke plates 1 and 2. A non-magnetic auxiliary plate 5 is secured to the rear surface of the rear yoke plate 2. Coils 6 are wound

on cores 7 to actuate eight resilient driving arms 9_{a1} to 9_{a8} (see Figure 2). of an annular rolled metal member 9. The driving arms 9_{a1} to 9_{a8} are formed integrally with and extend radially from the annular rolled metal member 9 and are connected together at their radially outer ends. The driving arms 9_{a1} to 9_{a8} are adapted to drive print elements.

The rear end of each core 7 extends through a hole $2a$ formed in the rear yoke plate 2, and is screwed to the auxiliary plate 5. Thus, each core 7 can be moved back and forth, for adjustment of its position.

The annular rolled metal member 9, which has the eight driving arms 9_{a1} to 9_{a8} , is mounted in front of the front yoke plate 1 and is spaced from the latter by a spacer ring 8, a stopper plate 10 being mounted in front of the annular rolled metal member 9. The driving arms 9_{a1} to 9_{a8} are provided with holes $9b$ at their radially inner ends. Movable yokes (armatures) 11 extend through, and are secured in, the holes $9b$. A print hammer 12, acting as a print element, is rigidly attached to the front end of each movable yoke 11. Each hammer 12 has an impacting projection (print element) $12a$ at its distal end. The rear portion of each movable yoke 11 extends through a hole $1a$ formed in the front yoke plate 1. The rear end surface of each yoke 11 faces the front

end surface of the corresponding core 7. Each movable yoke 11 is magnetically attracted to its respective core 7 against the resilient force of the corresponding driving arms 9_{a1} to 9_{a8} . Indicated by numeral 13 are terminal plates for the coils 6.

Referring to Figure 2, the eight driving arms 9_{a1} to 9_{a8} have been formed integrally with a single rolled metal member 9 by press working. The eight driving arms are connected together at their outer ends, and extend radially inwards. The material of the arms is rolled in the direction indicated by the arrow a. As mentioned previously, it is common practice to design such driving arms so as to have the same general shape and the same dimensions. The present invention, however, is based on the fact that driving arms inclined at different angles to the rolling direction a exhibit different Young's Modulus. Specifically, the arms 9_{a1} to 9_{a8} are designed to have different lengths, depending on the angles that the longitudinal directions of the arms make with the rolling direction a, so that the arms can have the same natural frequency or produce the same resilient force. As an example, the lengths of the arms 9_{a2} , 9_{a3} , 9_{a4} may be made equal to $1.032L$, $1.030L$, $0.997L$, respectively, where L is the length of the arm 9_{a1} . Since the arms 9_{a1} to 9_{a8} are arranged symmetrically with respect

to the centre O in this example, the arms 9_{a5} , 9_{a6} , 9_{a7} , 9_{a8} are identical in length to the arms 9_{a1} , 9_{a2} , 9_{a3} , 9_{a4} respectively. Therefore, the holes 9_b in the arms 9_{a1} to 9_{a8} and the movable yokes or armatures 11 are not located on the same circle and it may be arranged that the cores 7 are similarly not located on the same circle but are aligned with the movable yokes 11.

As will be appreciated, in the arrangement described above, a part of each of the movable yokes or armatures 11 is mounted in the hole 9_b of the respective driving arm so that the respective print hammer 12 is normally held in an inoperative position by the resilience of the respective driving arm, energization of the respective coil 6 causing the print hammer 12 to move into its operative position.

In Figure 3 there is shown another embodiment of an annular rolled metal member for use in a print head. Thus in Figure 3 there is shown an annular rolled metal member 109 having nine resilient driving arms 109_{a1} to 109_{a9} which are formed symmetrically with respect to the X-axis. The arms 109_{a1} to 109_{a9} extend radially and are integrally connected together at their radially outer ends. The arms have the same length, but differ in width according to the angles that the longitudinal directions of the arms make with the rolling direction a. Thus, all of the arms have the same

natural frequency or produce the same resilient force.

For instance, the widths of the arms 109_{a2} , 109_{a3} , 109_{a4} , 109_{a5} , may be $1.039w$, $1.122w$, $1.083w$, $1.015w$, respectively,

where w is the width of the arms 109_{a1} . The arms 109_{a6} to 109_{a9} have widths which are the same as that of the arms 109_{a2} to 109_{a5} , respectively, which are on the opposite side of the X-axis. The movable yokes or armatures (not shown) rigidly fixed to the arms 109_{a1} to 109_{a9} are located on the same circle. Also, the cores (not shown) are situated on the same circle.

In the above embodiments, the driving arms have different lengths or widths so that they can have the same natural frequency or produce the same resilient force. It is also possible to make the driving arms different in thickness, by making use of milling or grinding steps. Although the arms 9_{a1} to 9_{a8} shown in Figure 2 take a substantially trapezoidal form and taper off, the form or shape of the various arms may be varied by changing the degree to which they taper off. Thus, the arms may be made to differ from each other in length and/or width, and/or thickness and/or shape in such a way that all of the arms have the same natural frequency or produce the same resilient force.

The resilient driving arms may thus have the same natural frequency in spite of the fact that they are formed

of a single rolled metal as one unit. Hence, the arms do not vary in response characteristics. Therefore, when moved at a high speed, they do not malfunction. Further, they may be brought into operation without delay.

5 Consequently, improved reliability and print quality can be provided. Also, the arms can produce the same resilient force, even though they are formed of a rolled metal as one unit. Thus, the arms may exert the same driving force on the print elements, and may bend to the same
10 extent. As a result, the dots to be formed do not differ in print darkness. In this way, print quality can be improved.

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C L A I M S

1. An annular rolled metal member for use in a print head, the rolled metal member having a plurality of integral radially extending resilient driving arms which are connected together at their radially outer ends and which are adapted to drive print elements, the length and/or width and/or thickness and/or shape of the driving arms differing from one another in accordance with the angles that the longitudinal directions of the driving arms make with the direction in which the rolled metal member was rolled so that all the driving arms have substantially the same natural frequency and/or resilient force.
2. A member as claimed in claim 1 in which the driving arms differ from each other only in respect of their length.
3. A member as claimed in claim 1 in which the driving arms differ from each other only in respect of their width.
4. A member as claimed in any preceding claim in which each of the driving arms tapers radially inwardly.



5. A member as claimed in any preceding claim in which each of the driving arms is provided with a hole adapted to receive a part of an armature.

5 6. An annular rolled metal member substantially as hereinbefore described with reference to and as shown in Figure 2 or Figure 3 of the accompanying drawings.

7. A print head for use in a printer provided with an annular rolled metal member as claimed in any
10 preceding claim.

8. A print head for use in a printer provided with an annular rolled metal member as claimed in claim 5, the print head having a plurality of armatures a part of each of which is mounted in the
15 hole of the respective driving arm, each armature being provided with a respective printing element which is normally held in an inoperative position by the resilience of the respective driving arm, a plurality of electro-magnetic means being provided each of
20 which, when energized, causes the respective armature to move its printing element into an operative position.

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13



9. A print head as claimed in claim 8 in which each electro-magnetic means comprises a core whose position with respect to its corresponding armature can be varied.
- 5 10. A print head for use in a printer substantially as hereinbefore described with reference to and as shown in the accompanying drawings.
- 10 11. In a print head having resilient driving arms for driving print elements which are formed of a single rolled metal as one unit so as to be connected together at outer ends thereof, the improvement wherein the arms differ in at least one of length, width, thickness or shape, according to the angles that the longitudinal directions of the arms make with the direction in which the metal has been rolled, whereby the arms have the same natural frequency.
- 15 12. In a print head having resilient driving arms for driving print elements which are formed of a single rolled metal as one unit so as to be conencted together at outer ends thereof, the improvement wherein the arms differ in at least one of length, width, thickness or shape, according to the angles that the longitudinal directions of the arms make with the direction in which the metal has been rolled, whereby
- 20 the arms produce the same resilient force.
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