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⑦⑤ **Wire dot print head.**

⑦⑦ Print wires for use in a wire dot print head si produced by preparing a powder of high-speed steel with no less than 4.0 weight present of vanadium and no less then 14 equivalents of tungsten, hardening the powder into a mass, and forming a wire from the mass.

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WIRE DOT PRINT HEAD

BACKGROUND OF THE INVENTION

This invention concerns the wire dot print head used in an impact printer, and in particular the print wires used in the print head.

5 Impact printers incorporating a print head that prints by driving print wires have the advantage of very low cost, and are able to print on various media at high speed. As a result, they are used as man-machine interfaces in peripheral terminals of data processing systems and a wide variety of other applications. But in recent years a strong need has emerged for higher printing speeds.

If this kind of printer is to handle large quantities of data without troubles, it is important that the print 10 head should be highly reliable. The print wires, in particular, should not be liable to wear due to repeated impact or damage as a result of fatigue, so that the printer has a stable operation over long periods of time.

In this regard, the operation of a spring-charged wire dot print head will be described as an example.

Fig. 8 is a view in profile of, for example, the wire dot print head shown in Japanese Patent Application 15 Publication No. 56354/1983. In order to reveal the structure, the lower half of the print head is shown in section.

In the figure, 1 is a print wire of which the base is fixed to the tip of armature 2. The base of the armature 2 is supported by the end of biasing leaf spring 3, and the base of spring 3 is fixed to armature supporter 4.

5 5 is a first yoke, 6 is a magnetic spacer, 7 is a second yoke, 8 is a permanent magnet and 9 is a base, these elements being layered in a specified order. Said armature supporter 4 is fixed so that it is in contact with said first yoke 5, magnetic spacer 6 and second yoke 7.

10 10 is a core arranged on base 9 such that it is facing the rear of said armature 2. A demagnetizing coil 11 is fitted to core 10.

The printing operation of this structure is as follows.

25 Firstly, when the demagnetizing coil 11 is not energizing, the flux of permanent 8 permeates second yoke 7, magnetic spacer 6, first yoke 5, armature 2, core 10 and base 9. Because of the magnetic attraction resulting then, the armature 2 is drawn to core 10 as it bends bias string 3.

When the demagnetizing coil 11 is energized, the flux of magnet 8 is cancelled out by the flux of the coil so that the armature is no longer attracted.

30 Bias spring 3 then restores its shape. As a result, printing wire 1 attached to armature 2 is driven in the direction shown by the arrow in the figure, and its tip strikes the recording medium on the platen roll (not shown in the figure) through the ink ribbon, and prints an ink dot as a pixel on the medium.

After said impact has occurred, wire 1 begins to move in the reverse direction to the direction of said arrow, and when the excitation of said demagnetizing coil 11 stops, armature 2 is again pulled towards core 35 10 by the flux magnet 8. This completes one print cycle.

In the print cycle, print wire 1 reciprocates a specified distance once.

In a print head there are several sets of wires 1, armatures 2, bias springs 3, cores 10 and demagnetizing coils 11. Each print wire 1 is driven selectively and by means of a printing action as described above. Characters consisting of dots are thereby recorded on the recording medium.

40 As described above, however, the wire dot print head traverses the specified distance back and forth once on each printing cycle. If the tip of the wire suffers wear and the wire becomes shorter, the distance traversed by the wire will be longer. As a result, the time from when the armature is released by the attractive force when it leaves the core until when the wire strikes the recording medium, and the time from when the print wire strikes the recording medium until when the armature is again attracted by the core, i.e. 45 the return time, are longer, and so the time required by the print wire to travel both directions in order to complete one cycle is longer.

50 As the wire tip wears down, therefore, the distance over which the wire travels lengthens and the time of travel gradually increases. The end result of this process is that printing operations overlap with one another, the wire can no longer follow the print drive interval, and there are missing dots on the recording medium.

For this reason, the resistance of the print wire to wear is extremely important in order to obtain a stable printing action.

In general, the wear of the print wire is a mechanical abrasion due to the ink ribbon. This abrasive wear depends on the wire material, print force, amount of movement while the wire is in contact which depends on print speed, and the fractional coefficient between the contact surfaces of the wire and ink ribbon.

Typical frictional coefficients are given in "Transactions of the Institute of Electronics and Communication Engineers of Japan". Sept. 1984, Vol. J67-C, No. 9, p. 643 - p. 650.

The black ink used in the black ink ribbon in an impact printer is usually a composition containing carbon black as disclosed in Japanese Patent Application Publication No. 60956/1982. This composition
5 consists of carbon black and oil-soluble dyes or pigments added to a vegetable or mineral oil vehicle, with a further addition of dispersion and other agents.

Carbon black, as disclosed in the "Kahbon Burakku Binran (Manual of Carbon Black)" (25 May, 1973), published by Tosho, p. 376 - p. 377, is an excellent pigment which has light resistance, heat resistance, alkali resistance, acid resistance and solvent resistance. In addition, as disclosed in the "Manual of Carbon
10 Black", p. 174 - p. 175, carbon black suffers very little structural disintegration under simple compression even up to 5400 kg/cm².

The printing pressure on the print head (the printing pressure is the print force divided by the area of the wire contributing to printing, where the print force is the force applied during printing by the wire on the recording medium), is 1400 kg/cm². It can thus be appreciated that since carbon black can withstand a
15 pressure of 5400 kg/cm², it must be regarded as consisting of very hard particles.

It follows that the carbon black dispersed in the vehicle of the black ink, causes mechanical wear and abrasion of the print surface of the wire in the same way as particles of an abrasive powder. Conventional wire dot printers have print heads with cemented carbide wire, or ferrous metals e.g. high-speed steel (JIS-G-4403), or stainless steel wire (JIS-G-40391), or the like and therefore involve the following problems.

20 There are two essential factors to be considered when driving the wire in a wire dot print head at high speeds.

One of these, as described in detail "Shingaku Giho" EMC, 81 - 1, p. 1 p. 6, is how to fix the wire on the center of percussion of the armature.

Another problem, as described in detail in "Shingaku Gibo" EMC, 84 - 2, p. 9- p. 19, is how to make
25 the print head lighter.

Where print wires consist of cemented carbide alloys, they have excellent wear resistance, but they contain 70 - 85% weight percent of tungsten carbide of density 13.5 - 14.5 g/cm³. It is therefore difficult to make the head lightweight, and to achieve high printing speeds. On the other hand, if the wire consists of ferrous metals such as high-speed steel, its density is then only 8 g/cm³. This makes lightweightness
30 possible, which is favorable to high printing speeds, but as the hardness is much lower than in the case of cemented carbide alloys the wire lacks wear resistance, and there is a consequent shortening of lifetime and reliability.

Further, the wire dot print head is composed of a large number of wires and armatures, so it is important that the print wire should be low cost.

SUMMARY OF THE INVENTION

An object of the invention is to provide a wire dot print head with excellent wear resistance which is also
40 lightweight and low cost.

In order to achieve this objective, this invention offers a print wire made from powder of high-speed steel, to which no less than 4.0 weight percent of vanadium and no less than 14 equivalents of tungsten have been added to confer wear resistance and fatigue resistance.

The print wire composition of this invention described above is based on high-speed steel which is a
45 ferrous metal, and it can therefore be made lightweight. At the same time, it contains no less than 4.0 weight percent of vanadium and 14 equivalents of tungsten which are homogeneously dispersed in the steel in powder form, so that wear resistance and fatigue resistance of the wire are improved.

The wire is therefore able to print at high speed in stable operations over a long period of time, giving improved reliability, and as it can be manufactured fairly easily, its cost is low.

BRIEF DESCRIPTION OF DRAWINGS

Fig. 1 shows the relation between the wear of the print wire and the number of print strikes with
55 reference to the vanadium content.

Fig. 2 shows the relation between the wear of the wire and the vanadium content.

Fig. 3 shows the fatigue strength of the wire with reference to the vanadium content.

Fig. 4 shows the relation between the wear of the wire and the number of print strikes with reference to the equivalent tungsten content.

Fig. 5 shows the relation between the wear of the wire and the equivalent tungsten content.

Fig. 6 shows the fatigue strength of the wire with reference to the equivalent tungsten content.

Fig. 7 is a descriptive drawing showing the progress of wear in the wire.

Fig. 8 is a profile drawing through a spring-charged wire dot print head.

DETAILED DESCRIPTION OF THE EMBODIMENTS

Some experimental examples of this invention will now be described wherein the print wire consists of high-speed steel with varying amounts of vanadium and equivalents of tungsten.

In general, the wear resistance of metals can be improved by using as hard a material as possible, and increasing the hardness still further by heat treatment. For example as revealed in the article "Metal Wear and Countermeasures" (20 June, 1975), Yokendo, p. 3, of the grades of steel currently available, high-speed steel satisfies these requirements most closely.

It has been shown, for example in "Kinzoku Binran (Manual of Metals)" (20 December, 1982), Maruzen, p. 820 -p. 821, that in comparison to alloy tool steels, high-speed steels contain larger amounts of tungsten, molybdenum and vanadium, and due to their carbides, the wear resistance can be increased.

In the conventional process used to manufacture high speed steels, an ingot is first formed from the molten steel, and the ingot is then forged and rolled into bar stock. It is revealed, for example in "Precision Machinery", Vol. 39, No. 9, published by the Society of Precision Machinery Engineers, p. 888, that in the above process the carbides of said metal elements have very large particles, and this leads to a decrease of anti-wear toughness and fatigue strength properties.

Further, with the melting process, it was previously necessary to limit the content of vanadium, which has the greatest effect on wear resistance, to no more than 5 weight percent from the viewpoint of toughness and fatigue strength. It is revealed however, for example in "Precision Machinery" (Vol. 46, No. 5), p. 529, published by the Society of Precision Engineering, that if the above steel ingot is reduced to a fine powder, it is possible to obtain a fine, homogenous dispersion of vanadium carbide. As a result, toughness is greatly improved, and the content of vanadium can be greatly increased. By forming this powder into a mass or block by means of powder metallurgy, a high vanadium steel that was difficult to produce in the conventional process, can then be obtained easily.

More specifically, in the powder metallurgy, molten mixture of steel, vanadium and tungsten is cooled by atomized water or nitrogen to solidify into minute particles of the size in the order of microns. This process is called atomization. The particles are then sintered in vacuum at a temperature of about 1100 to 1250 °C for about 60 minutes, and then pressed into block in argon (Ar) gas with a pressure of about 40MPa (408 kgf/cm²) at a temperature of about 1200 °C for about 30 minutes. If the molten alloy is cooled gradually, there occurs segregation, and the resultant composition is not uniform. But if the molten alloy is cooled rapidly and solidification into particles as described above, the segregation does not occur and uniform composition is obtained. This is an advantage of using the powder metallurgy.

As is revealed in the above "Guide to Metals", p. 820, tungsten and molybdenum have the same effect on alloys, but as the atomic weight of molybdenum is 1.2 that of tungsten, molybdenum has twice the number of atoms for the same mass. This means that, as disclosed in "Transactions of the Japan Society of Metallurgists" (Vol. 25, No. 6), 1986, published by the Japan Society of Metallurgists, p. 553, it may be written:

Wt. percent of tungsten + 2 x Wt. percent of molybdenum = Equivalent wt. of tungsten.

Brief description on high-speed steel is given below. Until now, there has been no rigorous definition of high-speed steel, but it generally denotes a steel containing approx. 4 weight percent of chromium with an equivalent weight of tungsten of about 10 - 30 and 1 - 5 weight percent of vanadium, and where in addition a high degree of secondary hardness is obtained by heat treatment such as quenching and tempering.

Of the principal elements described above, it is understood that chromium mainly confers hardenability on the high-speed steel while vanadium, as a primary carbide in the steel, forms a vanadium carbide of great hardness (hardness Hv approx. 2500). These thereby confer wear resistance.

Tungsten and molybdenum, as primary carbides in the steel, form tungsten carbide and molybdenum carbide of very great hardness (hardness Hv 1300 - 1800). In particular, by tempering, a fine dispersion of secondary carbides is formed so as to give a tough matrix (secondary hardening), which together with the primary carbides confers high wear resistance on the high-speed steel.

The greater wear resistance of high-speed steel compared to that of other alloys is of course due to the

primary carbide, but there are also secondary carbides in the matrix which contains the primary carbides, and this factor is equally important in conferring high wear resistance.

Some experimental examples on vanadium contents of print wires head from high-speed steel in the form of powder will be described.

5 The wear resistance and fatigue strength have been investigated on printing wires wherein the equivalent tungsten content was fixed at 16, a very standard amount which is found in the compositions SKH-9, SKH-52, SKH-53, SKH-55 and SKH-56 of JIS-G-4403 mentioned above, and 2 - 9 weight percent of vanadium.

10 The detailed chemical composition of the high-speed steel used in this experiment is shown in Table 1 below:

TABLE 1

15 **Detailed Composition (Wt Percent) of the High-Speed Steel
Used in the Experiment**

NAME OF WIRE	C	W	Mo	V	Cr	Co	Fe
M 1	1.0	6.0	5.0	2.0	4.0	8.0	REMAINDER
M 2	1.2	6.0	5.0	3.0	4.1	8.0	REMAINDER
25 M 3	1.4	6.0	5.0	4.0	4.0	8.1	REMAINDER
M 4	1.6	6.0	5.0	5.0	4.1	8.0	REMAINDER
M 5	1.9	6.0	5.0	6.0	4.0	8.1	REMAINDER
30 M 6	2.1	6.0	5.0	7.0	4.1	8.0	REMAINDER
M 7	2.3	6.0	5.0	8.0	4.1	8.0	REMAINDER
35 M 8	2.6	6.0	5.0	9.0	4.0	8.1	REMAINDER

In order to investigate the effects of vanadium over a wide range of composition, we manufactured print wires from high-speed steel using the powder metallurgical methods mentioned above.

40 For a vanadium content of up to 8 weight percent, the wire was manufactured by an elongation process which is economical and has excellent adaptability to mass production techniques. For a content of 9 weight percent, however, the hardness of the high-speed steel is too great and the elongation process could not be used. It was in this case therefore manufactured by an extrusion process similar to that normally used for cemented carbide alloys, followed by sintering. Further, in order to remove decarbonizing and other defective layers on the wire surface, the cylindrical envelope of the wire was ground down.

45 Heat treatment such as quenching and tempering of high speed steel was also carried out under conditions for which the fatigue strength was greatest for each particular grade.

50 Experiments on wear resistance of metals, as disclosed in "Metal Wear and Countermeasures", for example, are usually carried out with an Okoshi Rapid Wear Tester, but our experiments were carried out using an actual impact printer.

In these experiments, high-speed steel printing wires of diameter 0.2 mm were fitted together with a print head onto an impact printer, which was then operated. The printer was operated under a print pressure of 14 kg/mm² and at a print speed of 350 strikes/sec. The ink ribbon was changed after every 10⁷ strikes of each wire so as to maintain a constant ink consumption.

55 The ink ribbon was formed by taking 50 m of polyamide or polyester fiber, and winding it into a Mobius spool of width 13 mm and thickness 0.12 mm. The spool was evenly coated and impregnated with 20 g of ribbon ink containing 5, 10 and 15 weight percent of carbon black respectively.

Firstly, the relation between the number of strikes of the wires and apparent wear was investigated using an ink ribbon wherein the ink contained 15 weight percent of carbon black, these wires consisting of high-speed steel containing 3, 5 or 7 weight percent of vanadium. The results are shown in Fig. 7.

Fig. 7 shows the progress of wear on the print wire, which is characterized by some very specific features. It is seen that for any content of vanadium, the reduction Δh in the length of the wire on its central axis (referred to hereinafter as the amount of wear) is not in direct proportion to the number of print strikes, and until the tip of the wire assumes a definite shape, there is in fact practically no wear Δh on the central axis.

From this figure, the part of the wire that formed the edge before test gradually wears down in the order a, b, c, and so on as the number of print strikes increases, so that the wear contour gradually enlarges. When the contour reaches the position d, however, the wire begins to wear down in the longitudinal direction.

Explaining the situation in further detail, for a wire consisting of high-speed steel containing 3% of vanadium, position a in Fig. 7 corresponding to 30×10^4 strikes, b to 80×10^4 , c to 140×10^4 , d to 230×10^4 and e to 10^7 . For a wire of high-speed steel containing 5% vanadium, position a in Fig. 7 corresponds to 70×10^4 strikes, b to 188×10^4 , c to 329×10^4 , d to 540×10^4 , and e to 2370×10^4 . Further, for a wire of high-speed steel containing 7% vanadium, position a in Fig. 7 corresponds to 113×10^4 strikes, b to 355×10^4 , c to 621×10^4 , d to 1020×10^4 , and e to 2255×10^4 .

In other words, the number of print strikes until longitudinal wear of the wire begins is closely related to its vanadium content. For a wire containing 3 weight percent of vanadium, this number is 230×10^4 ; for a wire containing 5 weight percent of vanadium, the number is 540×10^4 ; while for a wire containing 7 weight percent of vanadium, the number 1020×10^4 .

The results in the diagrams were obtained for a content of 15 weight percent carbon black in the ink of the ribbon, but similar results were obtained for 5 and 10 weight percent proportions of carbon black.

We next investigated the actual amount of wear of the wire using an ink ribbon containing 15 weight percent of carbon black. For these measurements, we used a high precision wear measuring device which was able to measure the amount of wear Δh in microns compared to the state of the wire before test.

Fig. 1 shows the relation between the amount of wear of the wire as measured by this method and the number of print strikes, the number of strikes being shown on the horizontal axis, and the wear of the wire Δh at a given number of strikes being shown on the horizontal axis.

The number of strikes at which wear Δh begins to be observed depends on the vanadium content, and was found to be as follows.

Weight percent of vanadium	No. of strikes
2	150×10^4
3	230×10^4
4	300×10^4
5	540×10^4
6	780×10^4
7	1020×10^4
8	1250×10^4
9	1500×10^4

After the point where the wear Δh of the print wire is first observed, a linear correlation was found to exist between the amount of wear and the number of print strikes for any vanadium content.

Comparison is now made between the wears using the Okoshi Wear Tester and the wears obtained in the above experiments.

It is well known that, in wear tests carried out with the Okoshi Wear Tester, there is a linear correlation between the slide distance or slide time and the amount of wear from the time when the test is begun.

In this experiment, however, a linear correlation does not appear immediately at the beginning of the print test between the number of print strikes and the wear of the wire. Instead, depending on the vanadium content, the wear is extremely characteristic in that no wear is observed up to a certain number of print strikes.

5 Next, we investigated the amount of wear of the print wires when they were subjected to 100 million (10^8) printing actions.

Fig. 2 shows the correlation between the wear of the print wire at this time, and the vanadium content. The vanadium content of the high-speed steel is on the horizontal axis, while the wear of the wire after 10^8 print strikes is shown on the vertical axis.

10 As seen from this figure, the wear decreases for increasing vanadium content in every case. Up to a vanadium content of 4 weight percent, however, wear increases very sharply in comparison to other vanadium contents.

It was thus realized that the vanadium content should be not less than 4 weight percent to improve the wear resistance of the print wire.

15 We then investigated the fatigue strength of high-speed steel containing 2 - 9 weight percent of vanadium.

The experiment was carried out by, for example, a Hay Robertson Wire Rotation and Bending Fatigue Tester of the type shown in "Kinzoku Zairyo Kyodo Shiken Binran (Manual of Fatigue Testing of Metals)". 20 July, 1982, Yokendo, p, 256.

20 Fig. 3 shows the fatigue strength of the print wire in this experiment. The horizontal axis is the amount of vanadium in the high-speed steel, while the vertical axis represents the average number of print strikes until a rupture occurred due to fatigue. At each measurement point, 10 samples were used. In the key to this figure, the symbols correspond to pressures of 120 kg/mm², 130 kg/mm² and 140 kg/mm², respectively. In every case, the fatigue strength tends to decrease depending on the vanadium content although the
25 decrease is not very great.

From the above, it is clear that the vanadium content should be no less than 4 weight percent in order to improve the wear resistance of the print wire without considerable loss of fatigue strength.

We shall now consider the equivalent weight of tungsten of the print wire.

30 From the above tests, it was found that the vanadium content of the print wire should be no less than 4 weight percent in order to increase its wear resistance. We therefore here investigated the wear resistance and fatigue strength of a print wire with an equivalent tungsten content in the range of 10 - 32 when the vanadium content was 4%. Up to an equivalent tungsten content of 28, the wire was manufactured by the above elongation process. As wires with higher tungsten equivalents were very hard, however, they could not be manufactured by elongation. Instead, therefore, these latter wires were formed by extrusion as
35 described above, followed by sintering and grinding.

Table 2 shows the detailed chemical composition of the wires used in this experiment.

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TABLE 2

Detailed Composition (Wt Percent) of the High-Speed Steel
Used in Experiments

NAME OF WIRE	C	W	MO	V	Cr	Co	Fe
M 1	1.3	4.0	3.0	4.0	4.1	8.0	REMAINDER
M 2	1.4	4.0	4.0	4.0	4.0	8.0	REMAINDER
M 3	1.4	4.0	5.0	4.0	4.0	8.0	REMAINDER
M 4	1.4	6.0	5.0	4.0	4.0	8.1	REMAINDER
M 5	1.4	6.0	6.0	4.0	4.0	8.0	REMAINDER
M 6	1.5	6.0	7.0	4.0	4.1	8.0	REMAINDER
M 7	1.5	6.0	8.0	4.0	4.0	8.0	REMAINDER
M 8	1.6	8.0	8.0	4.0	4.0	8.1	REMAINDER
M 9	1.6	8.0	9.0	4.0	4.0	8.0	REMAINDER
M10	1.6	8.0	10.0	4.0	4.1	8.0	REMAINDER
M11	1.7	10.0	10.0	4.0	4.0	8.0	REMAINDER
M12	1.7	10.0	11.0	4.0	4.0	8.0	REMAINDER

The wires were formed by the same powder metallurgical techniques as in the previous experiments, and heat treatment was also carried out as previously under those conditions for which fatigue strength was greatest for the various grades of steel. In addition, all wear tests and fatigue tests performed on the wires were carried out under exactly the same conditions as in the previous experiments.

Firstly, the amount of wear of the wire was investigated as a function of the number of print strikes using an ink ribbon wherein the ink contained 15 weight percent of carbon black.

Fig. 4 shows the relation between the amount of wear of the print wire and the number of print strikes at this time. The horizontal axis in the figure is the number of print strikes mentioned above, and the vertical axis is the amount of wear of the wire for various numbers of print strikes.

In the previous experiment, there was no wear Δh of the wire up to a certain number of print strikes depending on the vanadium content, but after a certain number of strikes had occurred, there was linear relation between the amount of wear and the number of strikes. In the same way, here also, there was no wear Δh of the wire up to a certain number of print strikes depending on the equivalent tungsten content.

Further, after a certain number of strikes depending on the tungsten equivalent, the amount of wear Δh increased in proportion to the number of strikes as in the previous experiment.

The amount of wear for 10^8 strikes of the print wire was then obtained.

Fig. 5 shows the relation between the wear of the wire and the equivalent tungsten content. The horizontal axis is the equivalent tungsten content of the high-speed steel, while the vertical axis is the wear of the wire after 10^8 print strikes. In every case, the amount of wear decreased with increasing equivalent tungsten content. Up to a tungsten content of 14, however, the wear increased sharply in comparison to other tungsten contents.

It was therefore clear that the equivalent tungsten content of the wire should be no less than 14 in order to improve the wear resistance.

We next investigated the fatigue strength of the high speed steel for an equivalent tungsten content in the range 10 - 32. This experiment also was carried out with a Hay Robertson Wire Rotation and Bending Fatigue Tester as in the previous experiment.

Fig. 6 shows the fatigue strength of the print wire in this experiment. The horizontal axis is the equivalent tungsten content of the high-speed steel, while the vertical axis is the average number of print strikes until the wire ruptures due to fatigue. For each measurement point, 10 samples were used. The symbols correspond to pressures of 120 kg/mm², 130 kg/mm² and 140 kg/mm² respectively. In every case, the fatigue strength of the wire tended to decrease with increasing equivalent tungsten content, although the decrease was not very great.

From the above, it was clear that the equivalent tungsten content should be no less than 14 in order to improve the wear resistance of the wire without any appreciable loss of fatigue strength.

The print wire in this invention consists of high speed steel containing no less than 4.0 weight percent of vanadium and having an equivalent tungsten content of no less than 14. As a result, the wire is lightweight but also has sufficient mechanical strength and wear resistance. It can therefore be used for high speed print over long periods giving stable operation and improved reliability. At the same time, this wire based on high-speed steel can be manufactured more easily and at lower cost than in the case of a cemented carbide alloy.

This invention can of course not only be used in a spring-charged wire dot print head, but also offers the same advantages in a plunger or clapper type head.

Claims

1. A wire dot print head comprising print wires which can be driven selectively to print by means of dots onto a recording medium, wherein the raw material of said wires is powder of a high-speed steel containing no less than 4.0 weight percent of vanadium and no less than 14 equivalents of tungsten.

2. A print wire for use in a wire dot print head, the print wire being made from powder of a high-speed steel containing no less than 4.0 weight percent of vanadium and no less than 14 equivalents of tungsten.

3. A process for producing a print wire for use in a wire dot print head, said process comprising the steps of:

preparing a powder of high-speed steel with no less than 4.0 weight percent of vanadium and no less than 14 equivalents of tungsten,

hardening the powder into a mass, and

forming a wire from said mass.

FIG. 1

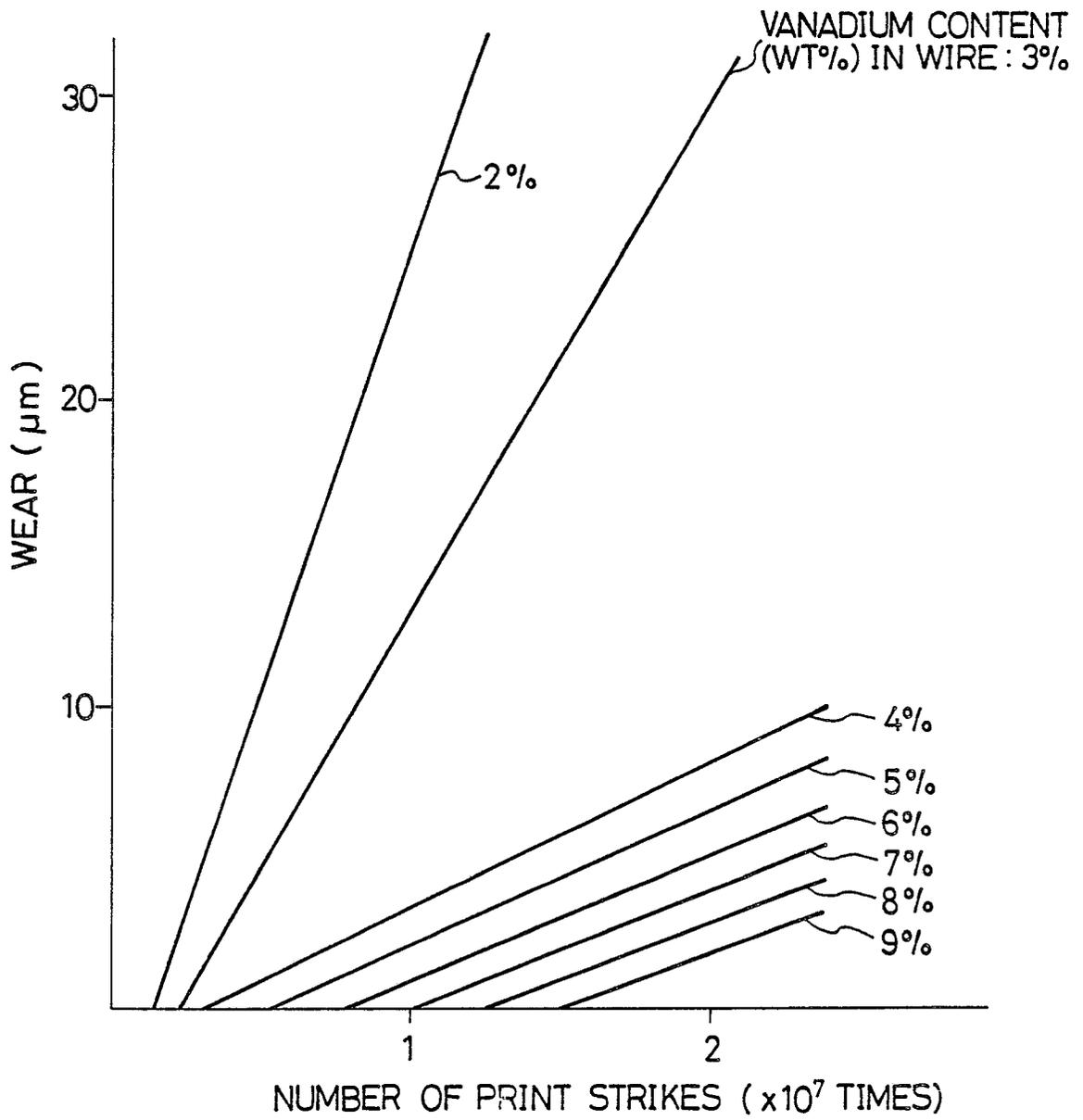


FIG. 2

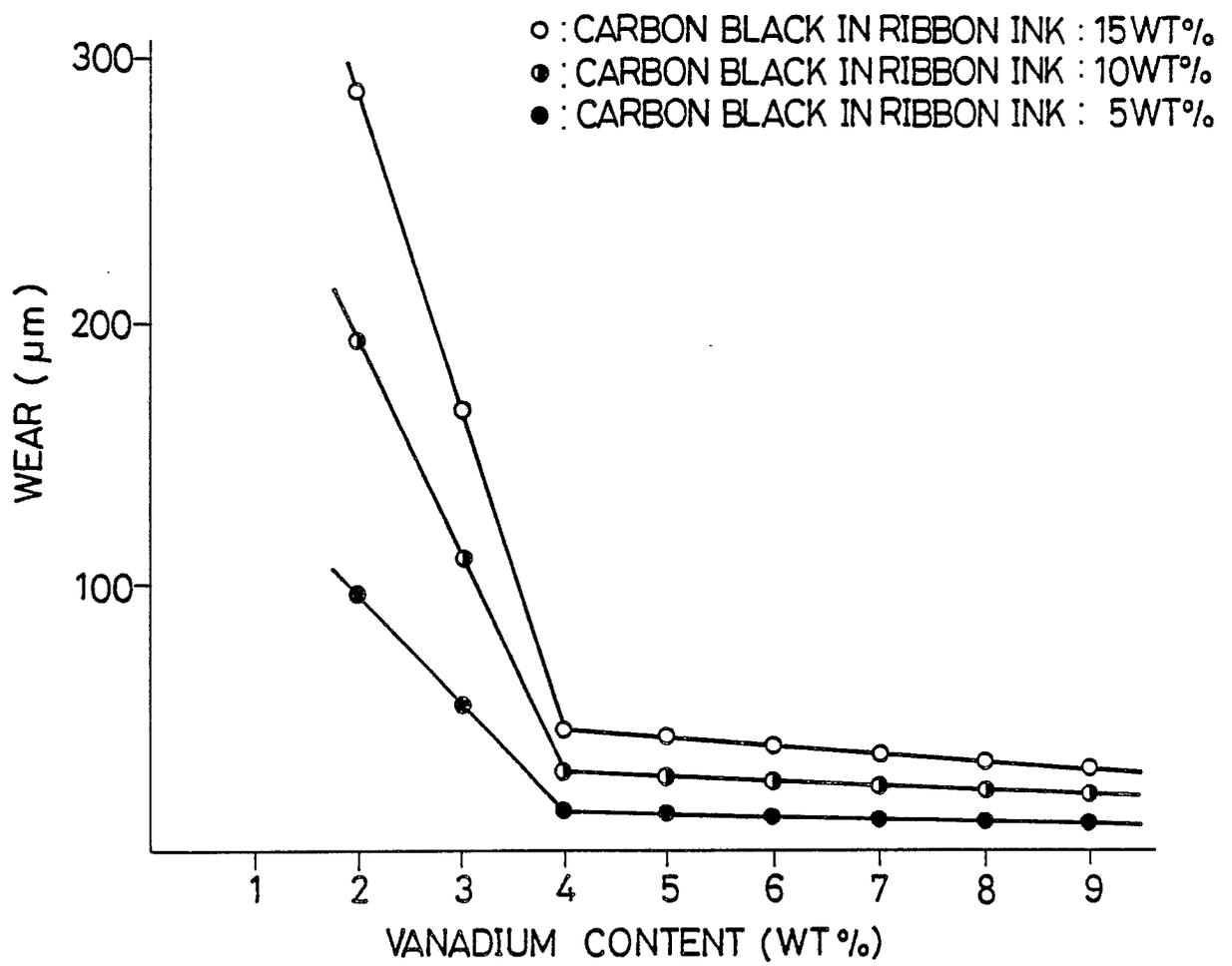


FIG.3

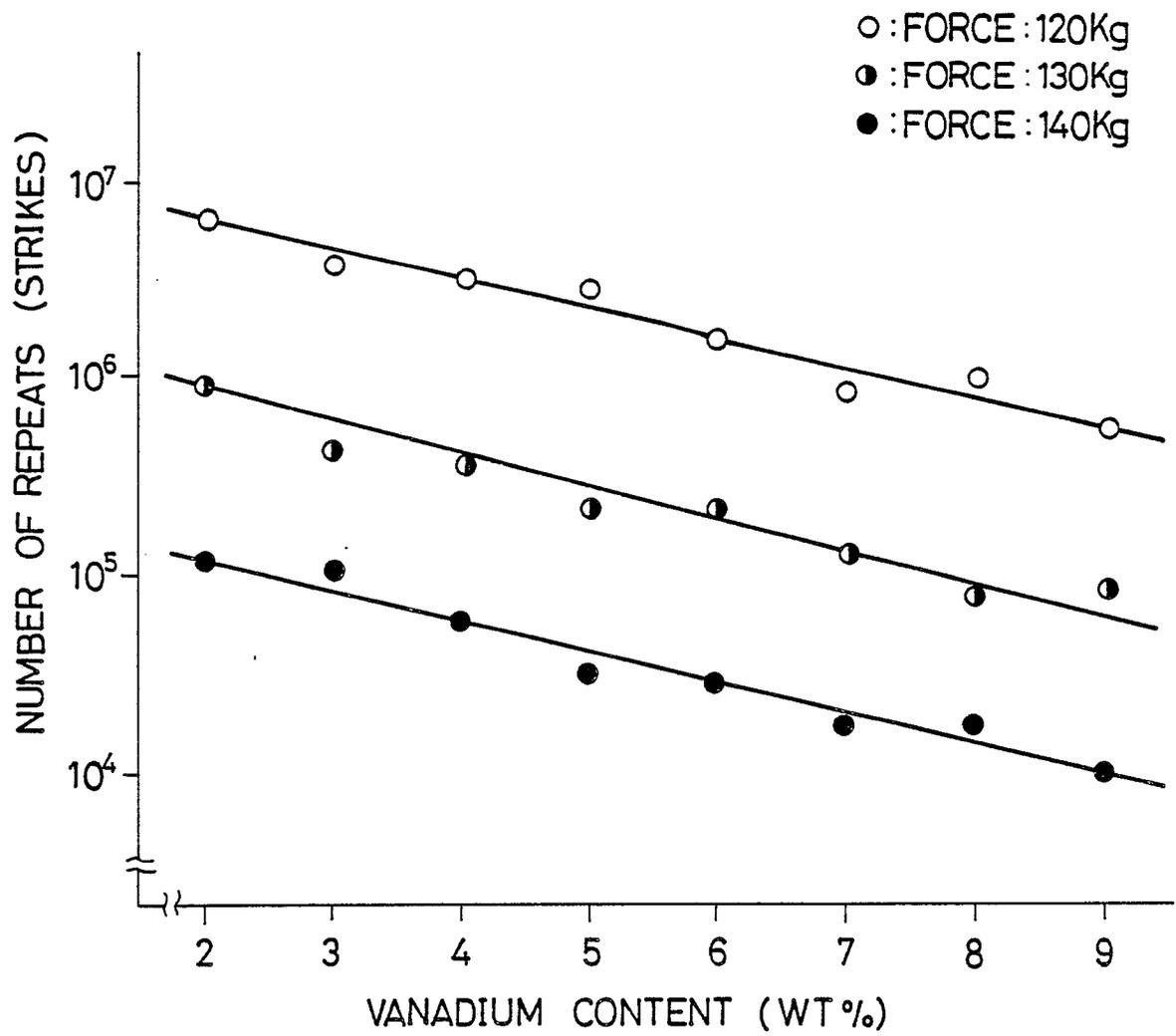


FIG.4

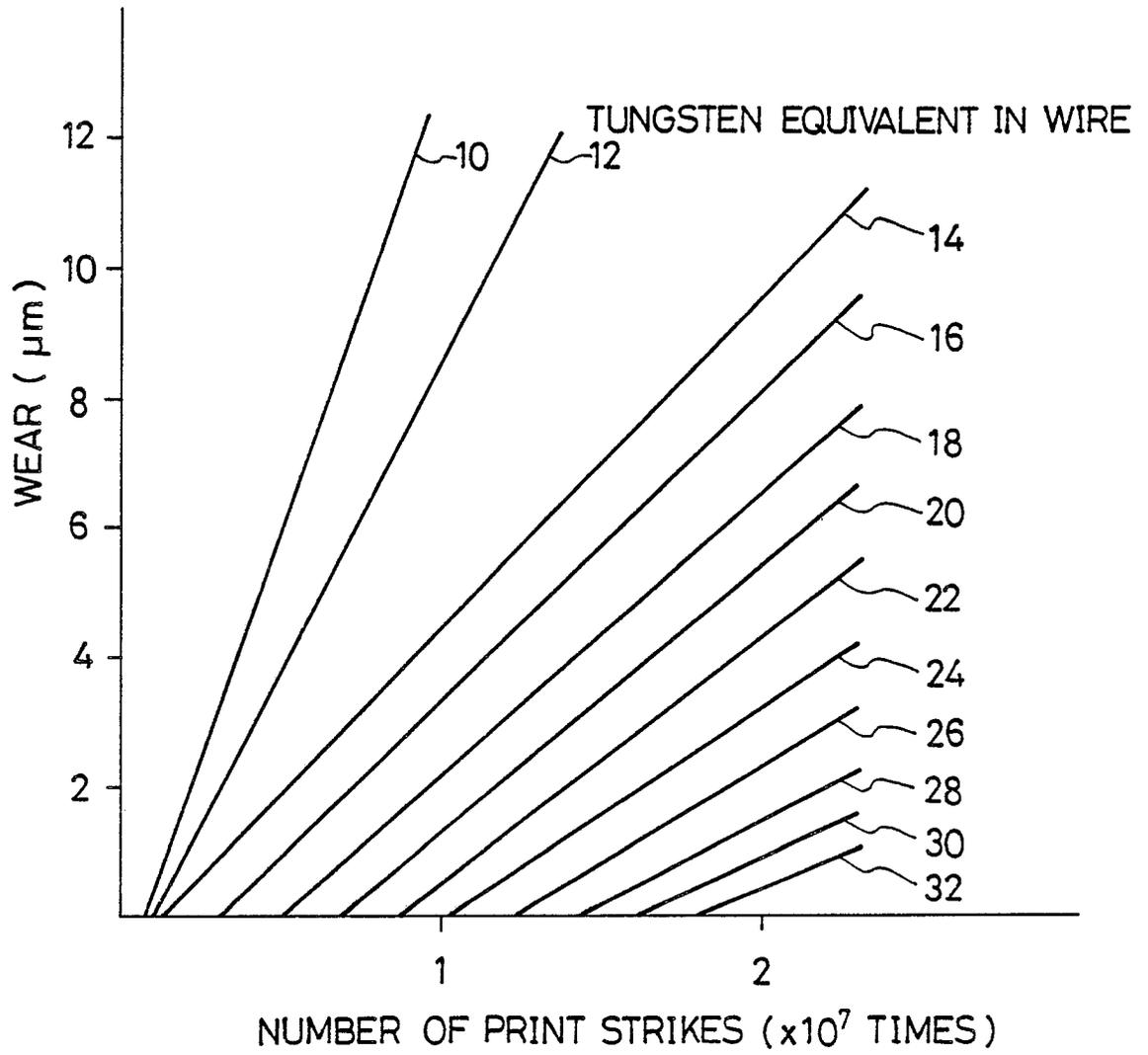


FIG. 5

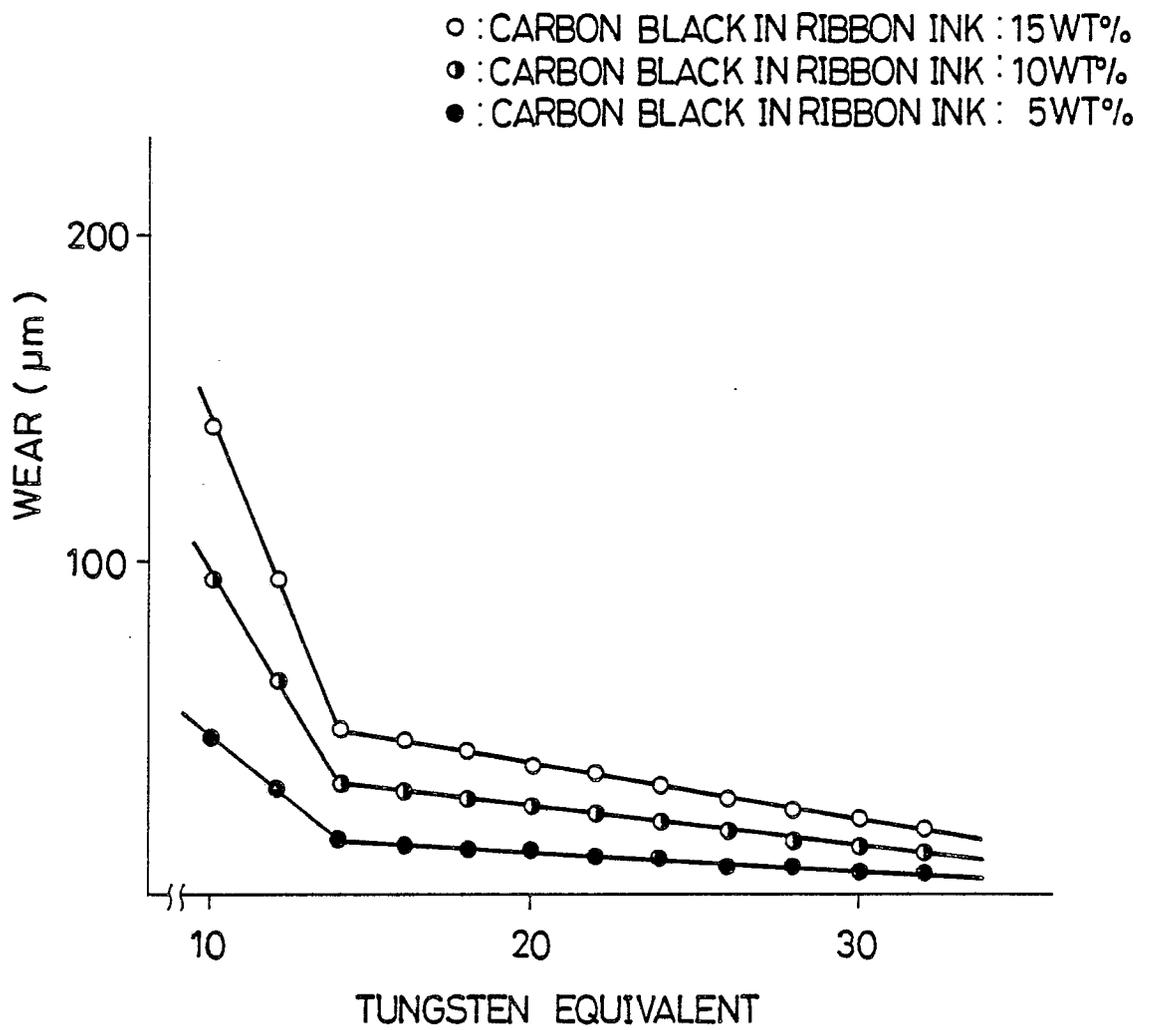


FIG. 6

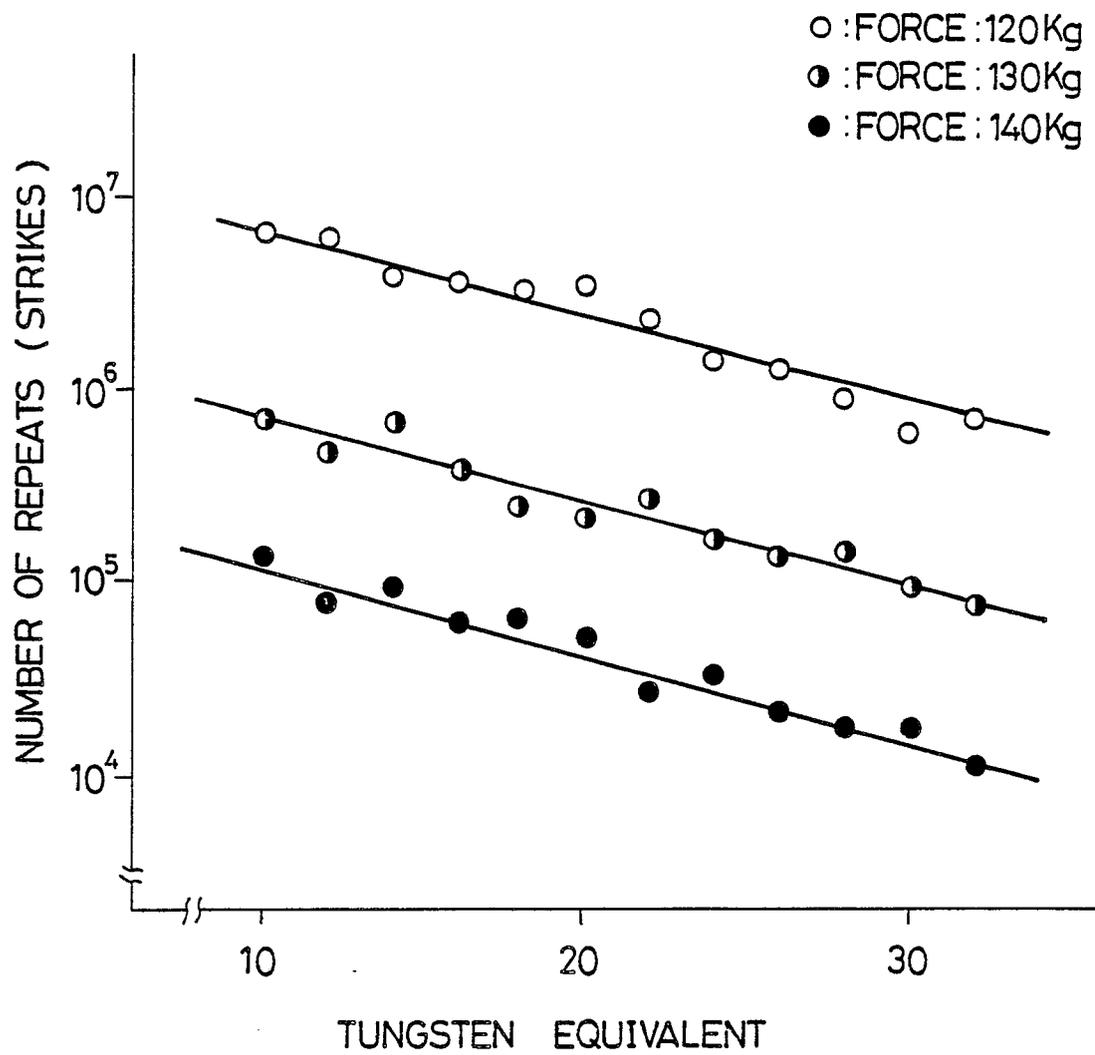


FIG. 7

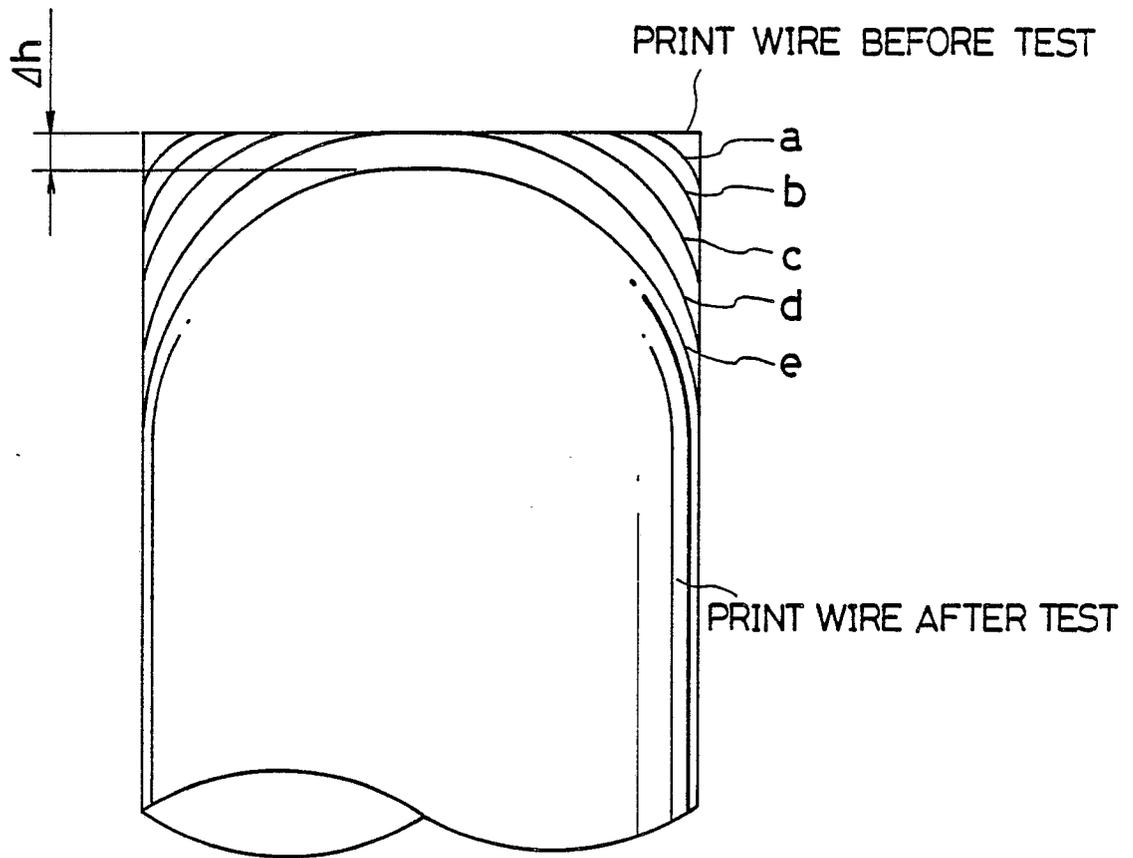
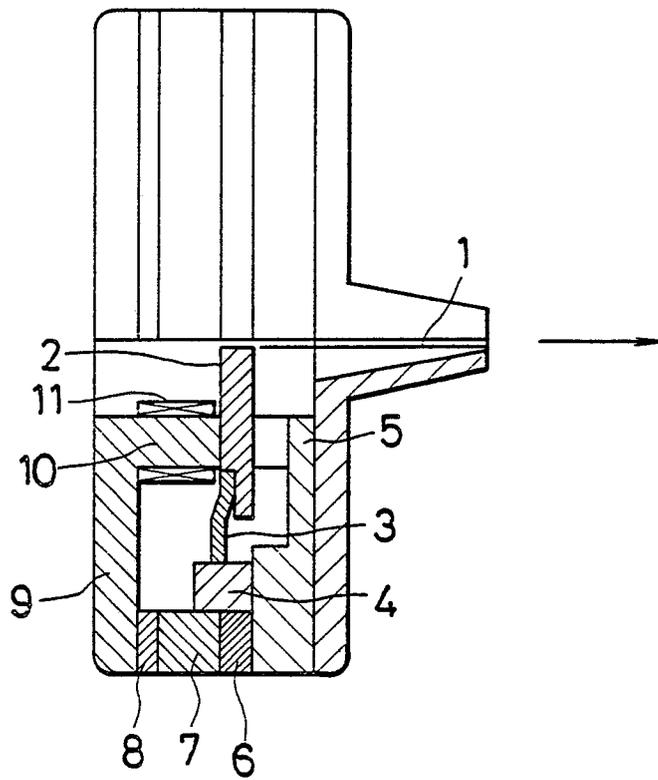


FIG. 8





DOCUMENTS CONSIDERED TO BE RELEVANT			EP 88300001.0
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
X	DERWENT ACCESSION NO. 86-274 634, Questele Telesystemes (WPIL) DERWENT PUBLICATIONS LTD., London * Abstract * & JP-A-61-199 055 (HITACHI) --	1-3	B 41 J 3/12
P,A	DERWENT ACCESSION NO. 87-274 871, Questele Telesystemes (WPIL) DERWENT PUBLICATIONS LTD., London * Abstract * & JP-A-62-192 574 (KOBE STEEL) --	1-3	
A	DERWENT ACCESSION NO. 83-732 685, Questele Telesystemes (WPIL) DERWENT PUBLICATIONS LTD., London * Abstract * & JP-A-58-112 761 (HITACHI) --	1-3	
A	US - A - 3 828 908 (SCHNEIDER) * Totality * -----	1-3	
The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (Int. Cl.4)
			B 41 J
Place of search VIENNA	Date of completion of the search 14-04-1988	Examiner WITTMANN	
CATEGORY OF CITED DOCUMENTS		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document			