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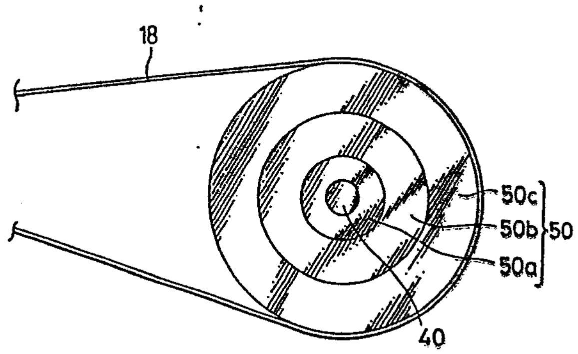
(54) Thermal transfer printer.

(57) A thermal transfer printer in accordance with the present invention is a printer in which the major scanning is carried out by a thermal head, and the minor scanning is carried out by intermittently turning the platen, via a timing belt (18), by means of a stepping motor. The timing pulley (50) on the platen side is given a three-part construction which includes an inner ring (50a) and an outer ring (50c) that is fitted to the inner ring via a buffer cylinder (50b) made of an elastic body.

FIG.4



EP 0 187 196 A1

Croydon Printing Company Ltd.

TITLE OF THE INVENTION

THERMAL TRANSFER PRINTER

1 BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a thermal transfer printer in which the major scanning is carried out by a thermal head and the minor scanning is carried out by the intermittent turning of the platen via a timing belt by means of a step motor.

Description of the Prior Art

As a thermal transfer printer there has generally been known a type in which one line is printed by pressing a thermal head, via an ink ribbon, against the recording paper which is wound on the platen, and the printing of the next line is carried out by intermittently turning the platen. An example of the prior art thermal transfer printer of the above kind will be described by referring to Figs. 1 to 3.

As shown in Figs. 1 and 2, the thermal transfer printer includes a step motor 10 which is arranged to turn a platen 14 intermittently through a timing pulley 12 and a timing belt 18 that is wound round a timing pulley mounted on the platen 14. Here, the upper running portion of the timing belt 18 is set to be the tension side of the belt.

On the other hand, an ink ribbon 20 is arranged to be forwarded a ribbon feeding motor 21 and by a conveyor roller for ribbon winding 22 to an ink ribbon reel 24 by passing directly underneath the platen 14. With the ink ribbon in between, a line-form thermal head 26 is arranged facing the platen 14.

Moreover, the recording paper 28 is fed from the paper supply cassette by a paper supply roller 32, runs between the platen 14 and the ink ribbon 20 through guide plates 33 and a guide roller 35, and is printed on by the thermal head 26 after running round the platen 14 for about one half of its circumference. The recording paper 28 which has been printed is sent out to the paper removal tray 36 by a forwarding roller 34. The thermal transfer printer further includes a power supply unit 37 for driving the step motor and a controller 38 for controlling the turning operation and the like of the platen 14. The shaft 40 of the platen 14 is supported by the bearings 44 prepared on the frame 42 (see fig. 3).

In the prior art thermal transfer printer with the above construction, the major scanning is carried out by the thermal head 26 while the minor scanning is carried out by the intermittent turning of the platen 14. Namely, the ink ribbon 20 is brought to a direct contact with the recording paper 28 which is wound round the platen 14, and the printing is accomplished by thermal transcription with the thermal head 26. In this operation, the thermal head 26 is pressed against the platen 14 with a force of several kg-weight so that there is required a large torque in order to turn the platen 14 intermittently. On the timing belt there is applied an intermittent tension due to the intermittent drive of the platen 14. Owing to the intermittent tension and the friction load on the thermal head 26, there is applied a force in the radial direction of the shaft of the platen 40 which varies periodically. The force is transmitted to the frame 42 to generate a noise by causing the frame to vibrate.

In order to prevent the transmission of vibrations like in the above and to suppress the generation of a noise, there has been tried in the past to insert cylindrical anti-vibration rubber pieces between the frame 42 and the bearings 44 that support the shaft 40 of the platen. However, such an attempt gives rise to a possibility of reducing the printing accuracy due to the relative shift in the positions between the thermal head 26 and the platen 14.

SUMMARY OF THE INVENTION

An object of the present invention is to provide a thermal transfer printer which produces a low noise and yet possesses a high printing accuracy.

Another object of the present invention is to provide a thermal transfer printer which is adapted for suppressing the generation of a noise caused by the intermittent turning of the platen.

One feature due to the present invention is that, in a thermal transfer printer for thermally recording an information on the recording paper, there are installed a platen for winding the recoridng paper, a thermal head for thermally recording an information on the recording paper, a step motor for intermittently turning the platen via a timing belt, and a timing pulley mounted on the platen that has a timing belt wound round it for transmitting the driving power from the step motor to the platen, and the timing pulley is given a construction in which it is composed of an inner ring, an outer ring and a buffer cylinder which is inserted between the inner and the outer rings.

These and other objects, features and advantages of the present invention will be more apparent from the following description of the preferred embodiments taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is an overall side view of a prior art thermal transfer printer;

Fig. 2 is the side view of the platen and step motor section of the printer shown in Fig. 1;

Fig. 3 is the plan view of the section shown in Fig. 2;

Fig. 4 is a schematic side view of the platen section of a thermal transfer printer embodying the present invention;

Fig. 5 is the plan view of the platen section shown in Fig. 4;

Fig. 6 is a block diagram for the vibration system corresponding to the embodiment shown in Fig. 4;

Figs. 7A and 7B are the block diagrams for the vibration systems corresponding to the prior art thermal transfer printers;

Fig. 8 is a power level chart of noises for the embodiment shown in Fig. 4 and the prior art device shown in Fig. 7A;

Fig. 9 is a schematic side view of a second embodiment in accordance with the present invention;

Fig. 10 is a graph illustrating a characteristic of the embodiment shown in Fig. 9;

Fig. 11 is a schematic side view of a third embodiment in accordance with the present invention;

Fig. 12 is a schematic side view of a fourth embodiment in accordance with the present invention; and Fig. 13 is a schematic side view of a fifth embodiment in accordance with the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to Figs. 4 and 5, there is shown the platen section of a thermal transfer printer embodying the present invention.

In the thermal transfer printer, identical symbols are given to the elements that are identical to those in the prior art thermal transfer printer shown in Figs. 1 to 3 to omit further explanation.

The thermal transfer printer includes a timing pulley 50 constructed by a plain cylindrical inner ring 50a which is fitted and fixed directly to the shaft 40 of the platen, and an outer ring 50c, with teeth on its outer peripheral surface, which is fitted to the inner ring 50a via an elastic buffer cylinder 50b.

In the thermal transfer printer of the present invention with the above construction, the force that is exerted on the platen in its radial direction by the timing belt 18 at the time of intermittent turning of the timing pulley 50, is mollified by the buffer cylinder 50b. In Fig. 6, there is illustrated a vibration model for the radial direction of the shaft of the platen in the thermal transfer printer of the present invention shown in Fig. 4, in Fig. 7A is illustrated a vibration model for the radial direction of the shaft of the platen for the prior art thermal transfer printer in which no use is made of a buffer, and in Fig. 7B is illustrated a vibration model for the radial direction of the shaft of the platen for the prior art thermal transfer printer in which a buffer is inserted between the bearings and the frame. In these figures, Ma represents the mass of the outer ring 50c of the timing pulley on the platen side, m_a is the sum of the masses of the platen 14 and the inner ring 50a of the timing pulley 50, Mal is the mass of the timing pulley 50, m_{al} is the mass of the platen 14, K and Kl represent the spring constant, and F represents the external force that acts on the timing pulley 50 due to the intermittent tension on the timing belt 18.

In the prior art device shown in Fig. 7A, the external force F is transmitted to the frame 42 as is beacuse of the rigid joining of the varions elements such as the timing pulley 50 and the shaft 40 of the platen. In the case of the prior art device in which a buffer cylinder is inserted between the frame 42 and the bearings 44, as shown by Fig. 7B, the timing pulley 50 and the platen (with mass Mal + mal) constitute a system of forced vibration with one degree of freedom. That the transmissibility of the external force F to the frame 42 in this case will be less than unity for the range of frequency which is above the square root of two times the resonance frequency

$$1 / 2\pi \sqrt{Kl / (Mal + mal)}$$

is well known. However, since the platen 14 in the vibration model is situated nearer the external force F than the elastic body, the displacement is larger than in the case of rigid joining to the frame as shown in Fig. 7A. Therefore, there is generated a relative displacement of the platen with respect to the thermal head 26, readucing the printing accuracy. In the vibration model shown in Fig. 6 for the thermal transfer printer in accordance with the present invention, what appears on the side of the external force F is the outer ring 50c with mass Ma, of the timing pulley, and there is formed a system of forced vibration with one degree of freedom. The transmissibility of the external force F becomes less than unity for the range of frequency which is above square root of two times the resonance frequency

$1 / 2\pi\sqrt{K / Ma}$, so that it becomes possible to reduce the generation of noise due to the external force F in the radial direction of the shaft of the platen 40. It is to be noted that what is displaced due to the intermittent tension on the timing belt 18 is the outer ring 50c alone of the timing pulley 50. Since there will be created no relative displacement between the platen 14 and the thermal head 26, no reduction in the printing accuracy will be generated.

In Fig. 8 are compared the results of measurement on the acoustic power level for the prior art thermal transfer printer shown in Fig. 7A and for the thermal transfer printer in accordance with the present invention. From the figure, it will be seen that a reduction of 5 dB in the acoustic power level of the noise can be achieved by the use of the device of the present invention.

Referring to Fig. 9, there is illustrated a second embodiment of the thermal transfer printer in accordance with the present invention. This embodiment shows an example in which the present invention is applied to the case where a high accuracy in the direction of paper feeding is required for carrying out superposed impressions as for the color printing. In the embodiment, there are created on the buffer cylinder 50b a plurality of equally spaced radial notches 54 that extend from its outer periphery toward the center, and on the inner periphery of the outer ring 50c there are fixed wings 56, consisting of projections that fit the notches 54, that are made of a material, such as metal or plastic, with elastic modulus greater than that for the elastic body constituting the buffer cylinder 50b.

Generally, the torsional spring constant k of a cylindrical anti-vibration rubber piece is given by the following expression.

$$k = 4\pi.G.I / (1/r_1^2 - 1/r_2^2) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

In the above expression, G is the shearing modulus, I is the axial length of the cylinder, and r_1 and r_2 represent the inner and outer radius, respectively.

Equation (1) may be rewritten as

$$k = 4\pi.G.I.r_1^2 r_2^2 / (r_2^2 - r_1^2) = 4\pi.G.I.[\alpha^2/(\alpha^2-1)].r_1^2, \ldots \quad (2)$$

where $r_2/r_1 = \alpha (>1)$. Shown in fig. 10 is $\alpha^2/(\alpha^2-1)$ as a function of α . It will be seen from the figure that the spring constant K increases as approaches unity.

Now, it should be noted that the provision of wings 56 as in the embodiment shown in fig. 9 results in a reduction in the effective length in which there is generated a shearing stress in the direction of rotation of the buffer cylinder 50b, which becomes approximately equivalent to letting α approach unity.

On the other hand, the spring constant in the radial direction of the buffer cylinder 50b can be represented as the sum of spring cosntant due to shearing stress and the spring constant due to compression and tension. Generally speaking, the spring constant due to shearing is small compared with that due to compression and tension so that the spring constant in the radial direction of the cylindrical anti-vibration rubber piece is dominated by the spring constant due to compression and tension. Therefore, even when the torsional spring constant of the buffer cylinder 50b is increased by the wings 56, the increase in the spring constant in the radial direction will not be appreciable. As a result, it becomes possible to suppress the transmissibility vibrations to the platen 14 and the shaft of the platen 40, as well as to secure the accuracy in the direction of paper feeding.

Referring to Fig. 11, there is shown a third embodiment of the thermal transfer printer in accordance with the present invention. In this embodiment, there are provided notches 54a, which are similar to the previous notches 54, on the inner periphery of the buffer cylinder 50b, and on the inner ring 50a of the timing pulley 50 there are provided wings 56a which are similar to the previous wings 56. For this embodiment, the same effects as in the embodiment shown in Fig. 9 can be obtained.

Referring to Fig. 12, there is shown a fourth embodiment of the thermal transfer printer in accordance with the present invention. In this embodiment, wings 56a on the inner ring 50a of the timing pulley and wings 58 on the outer ring 50c of the timing pulley are installed with their respective positions alternating. For this embodiment, too, there are obtained effects similar to those in the previous embodiments.

Referring to Fig. 13, there is shown a fifth embodiment of the thermal transfer printer in accordance with the present invention.

In this embodiment, there are previded cylindrical projections 60 along the inner periphery of the outer ring 50c of the timing pulley. These projections 60 are made of a material with elastic modulus which is greater than that of the elastic body that constitutes the buffer cylinder 50b. For this embodiment, too, effects similar to those of the embodiments described in the foregoing can be obtained.

In summary, a thermal transfer printer in accordance with the present invention can suppress the generation of the noise created by the intermittent turning of the platen, without reducing the printing accuracy to any degree. Therefore, it can prevent the increase in noise within an office accompanying the spread of office automation.

Various modifications will become possible for those skilled in the art after receiving the teachings of the present disclosure without departing from the scope thereof.

Claims:

1. A thermal transfer printer for thermally recording information on a recording paper, characterized by:

a platen (14) for winding the recording paper;

a thermal head (26) for thermally recording information on the recording paper;

a timing pulley (50) installed at said platen (14) for transmitting to said platen the driving power which is supplied through a timing belt (18), in order to turn said platen (14) intermittently; and

buffer means (50b) arranged on the external force side of said platen (14) for absorbing the external force that acts on said timing pulley (50) due to the intermittent tension of the timing belt (18).

2. A thermal transfer printer as claimed in Claim 1, in which said thermal head (26) is mounted fixedly to the frame that supports said platen (14).

3. A thermal transfer printer as claimed in Claim 1 or 2, in which said buffer means (50b) is disposed in said timing pulley (50).

4. A thermal transfer printer as claimed in Claim 3, in which said timing pulley comprises an outer ring (50c) and an inner ring (50a), and said buffer means comprises a buffer cylinder (50b) inserted between the outer ring and the inner ring.

5. A thermal transfer printer as claimed in Claim 4, in which the buffer cylinder comprises an elastic body.

6. A thermal transfer printer as claimed in Claim 5, in which the buffer means further comprises a plurality

of projecting parts installed protrusively in the radial direction of said timing pulley from the inner periphery of the outer ring (50c) of said timing pulley, so as to fit notches provided in the buffer cylinder (50b), and the projecting parts are made of a material with elastic modulus which is greater than that of the elastic body that constitutes the buffer cylinder.

7. A thermal transfer printer as claimed in Claim 5, in which said buffer means further comprises a plurality of projecting parts installed protrusively in the radial direction of said timing pulley from the outer periphery of the inner ring (50a) of said timing pulley, so as to fit notches provided in the buffer cylinder (50b), and the projecting parts are made of a material with elastic modulus which is greater than that of the elastic body that constitutes the buffer cylinder.

8. A thermal transfer printer as claimed in Claim 5, in which said buffer means further comprises a plurality of projecting parts that are installed alternately on the inner periphery of the outer ring (50c) and on the outer periphery of the inner ring (50a), of said timing pulley, in the radial direction of said timing pulley, so as to fit notches provided in the buffer cylinder (50b), and the projecting parts are made of a material with elastic modulus which is greater than that for the elastic body that constitutes the buffer cylinder.

9. A thermal transfer printer as claimed in Claim 5, in which said buffer means further comprises projecting parts that are installed protrusively along the inner periphery of the outer ring of said timing pulley, and the projecting parts are made of a material with elastic modulus which is greater than that of the elastic body that constitutes the buffer cylinder.

10. A thermal transfer printer for thermally recording information on a recording paper, characterized by:

a platen (14) for winding the recording paper;

a thermal head (26) for thermally recording information on the recording paper;

a stepping motor (10) for intermittently turning said platen (14) via a timing belt (18); and

a timing pulley (50) with wound timing belt (18) installed at said platen (14) for transmitting the driving power from said stepping motor (10) to said platen (14), said timing pulley (50) comprising an inner ring (50a), and outer ring (50c), and a buffer cylinder (50b) which is inserted between the inner and outer rings.

11. A thermal transfer printer as claimed in Claim 10, in which said thermal head (26) is mounted fixedly on the frame which supports said platen.

12. A thermal transfer printer as claimed in Claim 10 or 11, in which the buffer cylinder (50b) comprises an elastic body.

13. A thermal transfer printer as claimed in Claim 12, in which a plurality of projecting parts are installed protrusively from the inner periphery of the outer ring (50c) of said timing pulley (50), in the radial direction of said timing pulley, so as to fit notches provided in the buffer cylinder (50b) and the projecting parts are made of a material with elastic modulus which is greater than that of the elastic body that constitutes the buffer cylinder.

14. A thermal transfer printer as claimed in Claim 12, in which a plurality of projecting parts are installed protrusivley from the outer periphery of the inner ring

(50a) of said timing pulley (50), in the radial direction of said timing pulley (50), so as to fit notches provided in the buffer cylinder (50b), and the projecting parts are made of a material with elastic modulus which is greater than that of the elastic body that constitutes the buffer cylinder.

15. A thermal transfer printer as claimed in Claim 12, in which a plurality of projecting parts are alternately installed protrusively from the inner periphery of the outer ring (50c) and the outer periphery of the inner ring (50a) of said timing pulley, in the radial direction of said timing pulley (50), so as to fit notches provided in the buffer cylinder (50b), and the projecting parts are made of a material with elastic modulus which is greater than that of the elastic body that constitutes the buffer cylinder.

16. A thermal transfer printer as claimed in Claim 12, in which a plurality of projecting parts are further installed along the inner periphery of the outer ring (50c) of said timing pulley (50), and the projecting parts are made of a material with elastic modulus which is greater than that of the elastic body that constitutes the buffer cylinder.

FIG.1

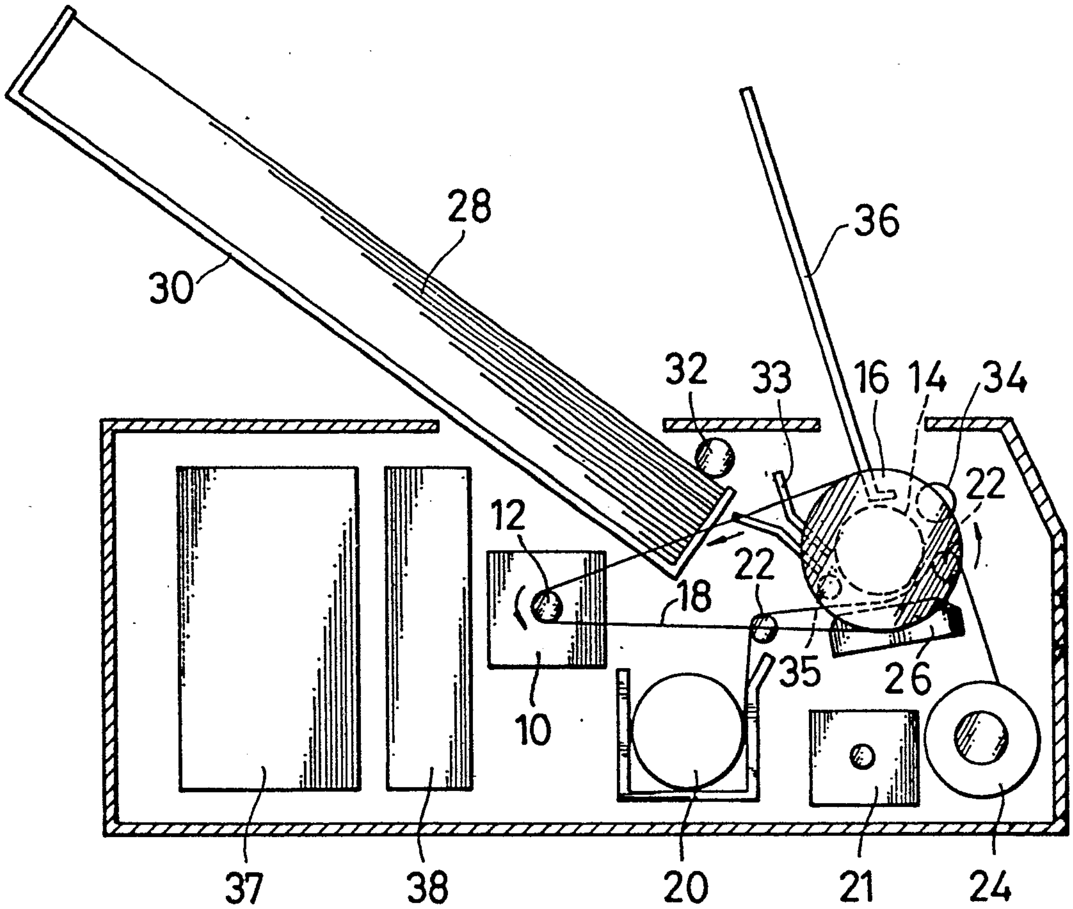

28
30
36
32
33
16
14
34
22
12
22
18
35
26
10
37
38
20
21
24

FIG.2

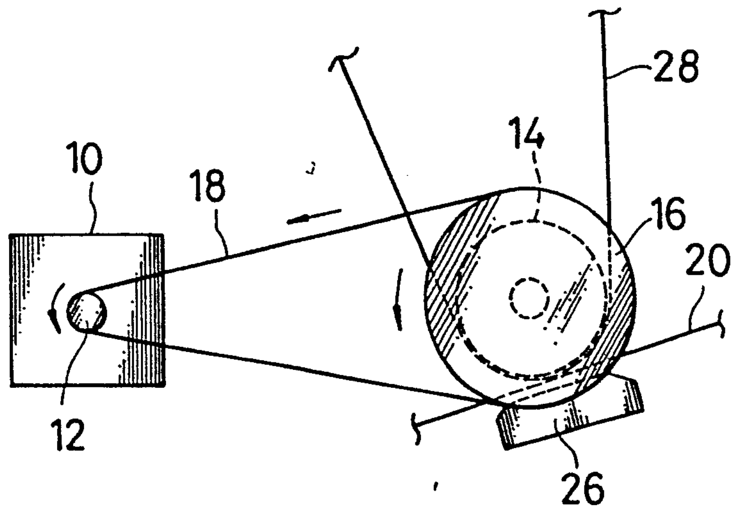

28
14
10
18
16
20
12
26

FIG.3

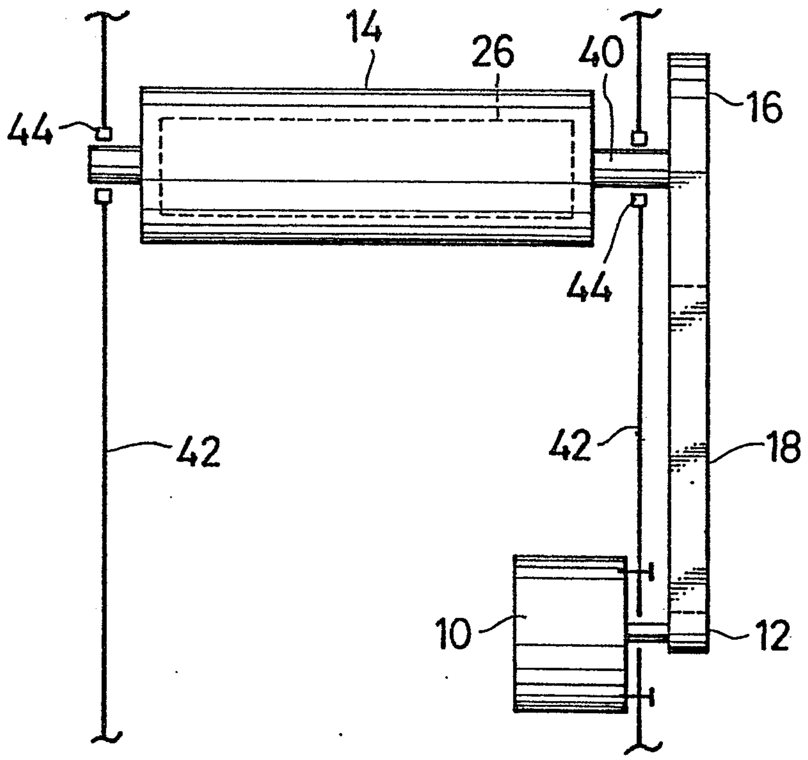


FIG.4

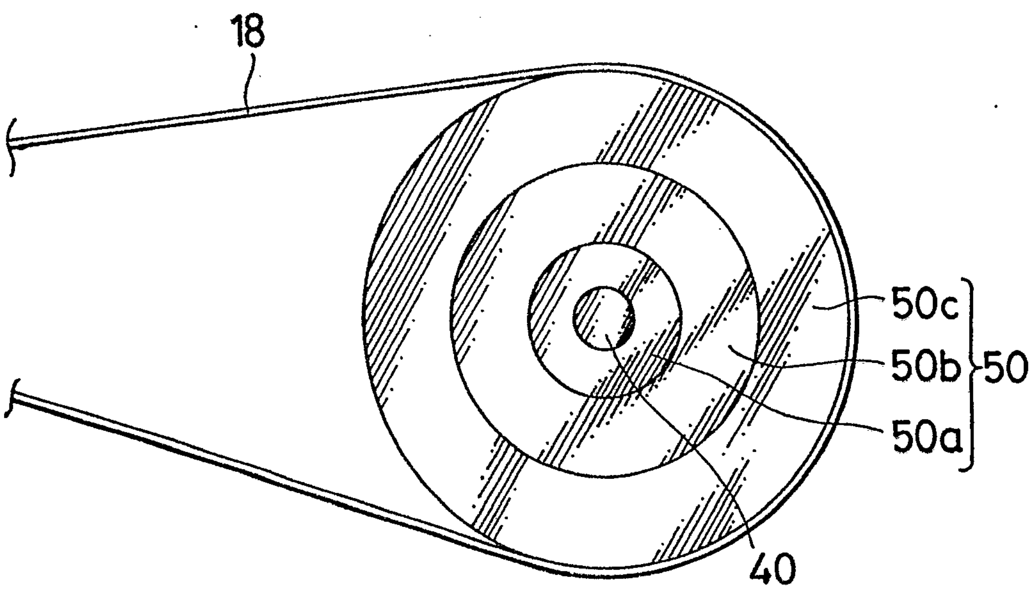


FIG.5

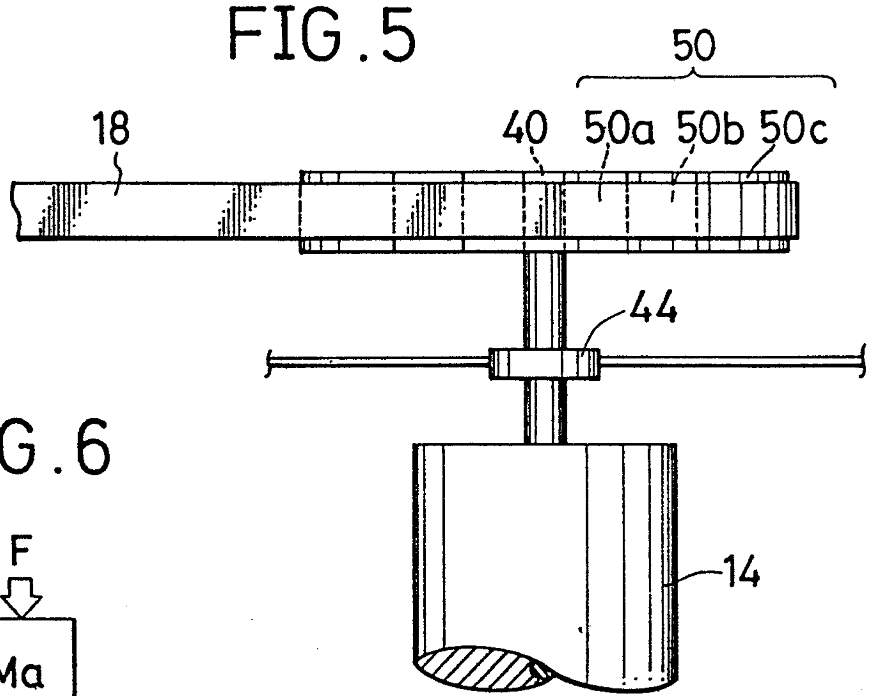


FIG.6

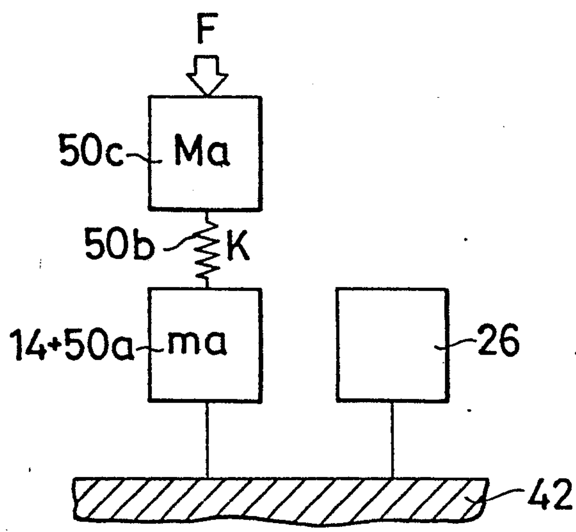


FIG.7A

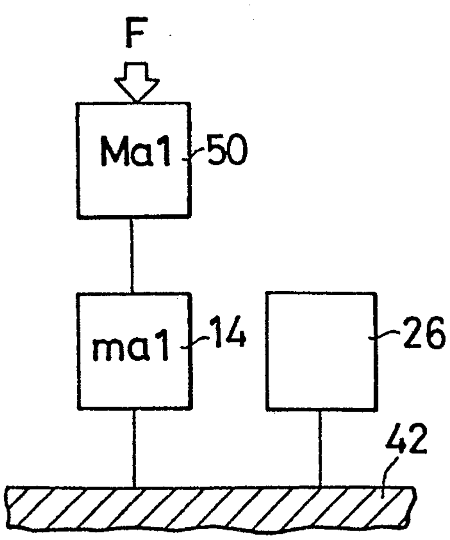


FIG.7B

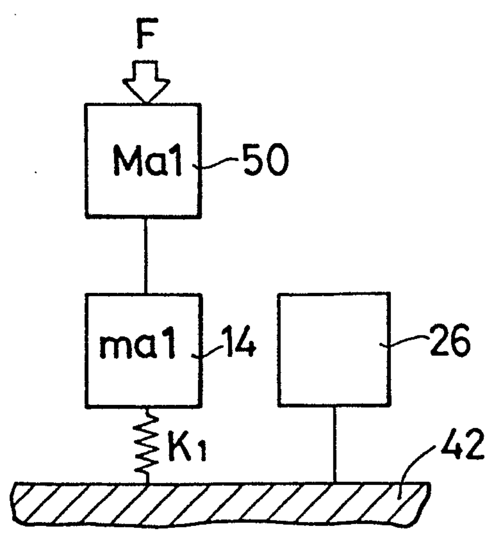
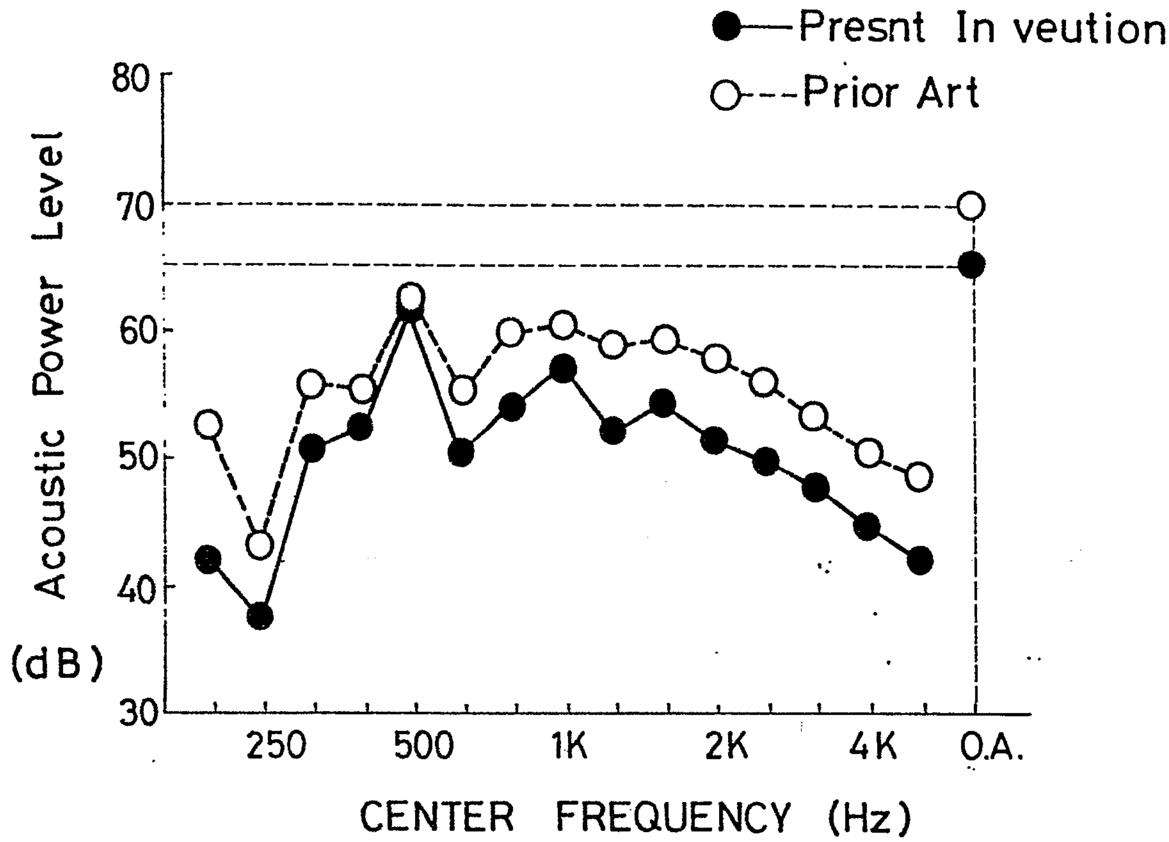
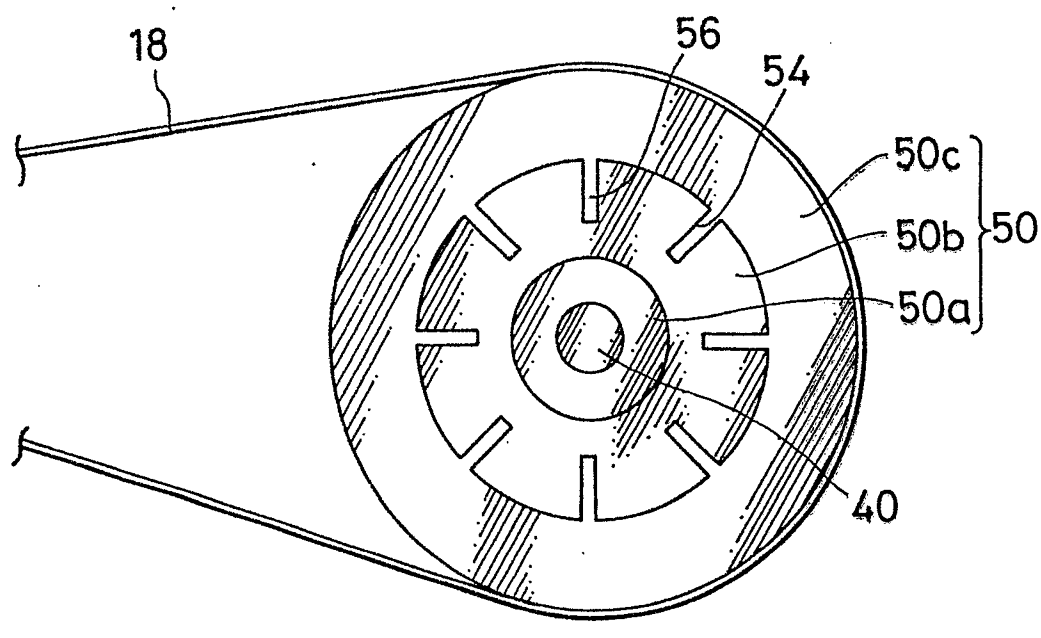


FIG.8



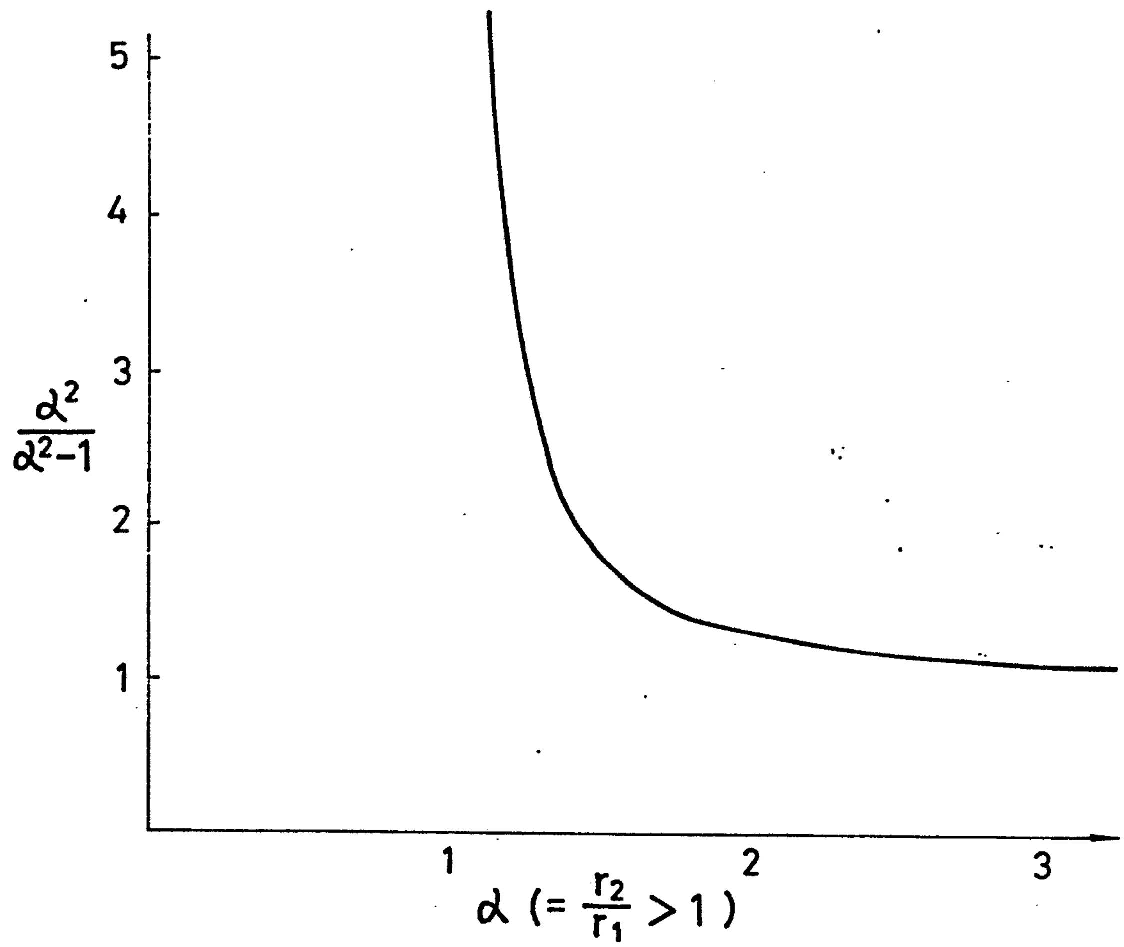
Presnt In veution
Prior Art
80
70
60
50
40
30
Acoustic Power Level
(dB)
250
500
1K
2K
4K
O.A.
CENTER FREQUENCY (Hz)

FIG.9



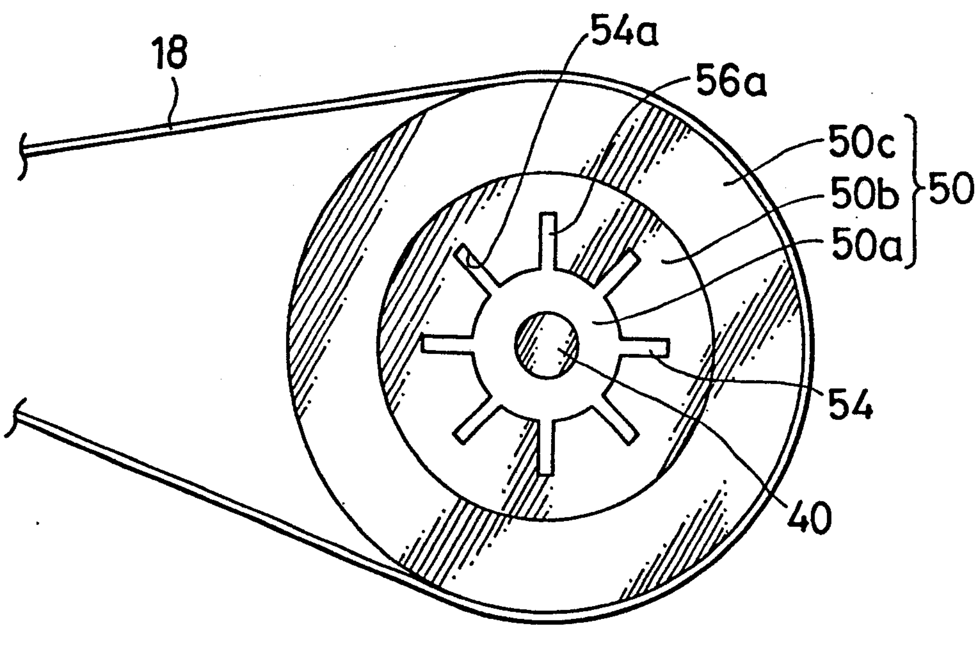
18
56
54
50c
50b
50
50a
40

FIG.10



5
4
3
$\frac{\alpha^2}{\alpha^2-1}$
2
1
1
2
3
$\alpha \ (= \frac{r_2}{r_1} > 1)$

FIG.11



18
54a
56a
50c
50b
50a
50
54
40

FIG.12

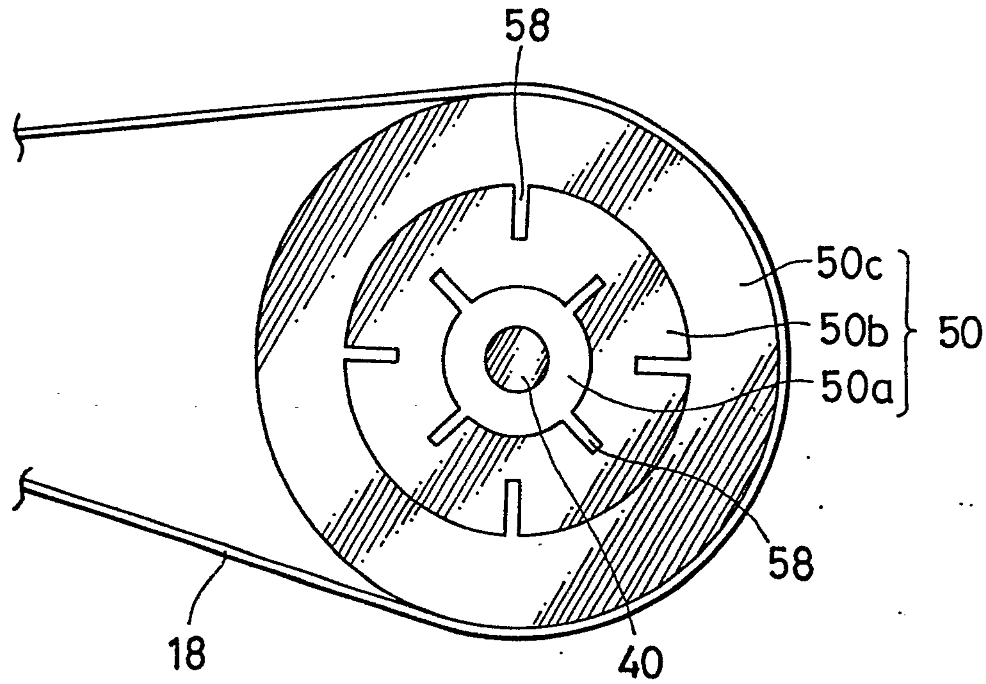
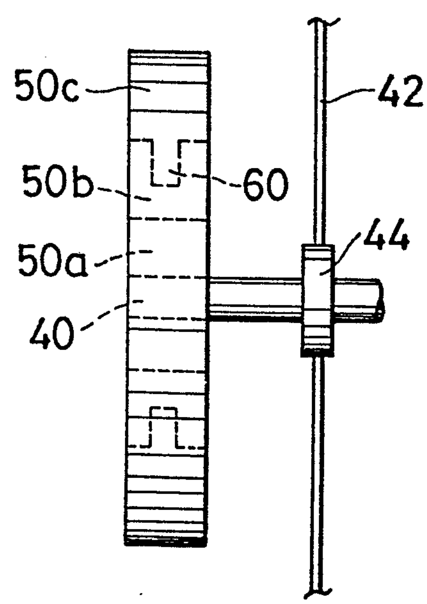


FIG.13



European Patent Office

EUROPEAN SEARCH REPORT

0187196
Application number
EP 85110877.9

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
Y	EP - A2 - 0 098 033 (TOKYO SHIBAURA DENKI KABUSHIKI KAISHA) * Fig. 3,5,6 *	1	B 41 J 3/20 F 16 H 55/42
A		2,10,11	
Y	DE - A1 - 2 642 380 (PLATT SACO LOWELL CORP.) * Claims *	1	
A		3-5,10, 12	
A	US - A - 4 366 609 (SPEER)		
A	US - A - 4 486 183 (POSIVIATA)		

TECHNICAL FIELDS SEARCHED (Int. Cl.4)

B 41 J
F 16 H

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
VIENNA	30-01-1986	WITTMANN

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
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D : document cited in the application
L : document cited for other reasons

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