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# Method and apparatus for aftertreatment of textile sheet by application of microwaves

## BACKGROUND OF THE INVENTION

The present invention relates to method and apparatus for aftertreatment of textile sheet by application of microwaves, and more particularly relates to improvement in effective drying of scoured or dyed textile sheet by means of irradiation of microwaves.

Fixing and development of dyes on dyed textile sheet have long been carried out by means of steaming the dyed textile sheet after interposed drying.

As a substitute for the steaming process, it has recently been proposed (FR—A—2.375.384, GB—A—1.124.787, GB—A—704.972, GB—A—817.134) to apply microwaves to dyed textile sheet in wet state. Here, the word "microwaves" refers to electromagnetic waves whose frequencies are in a range from 300 to 30,000 MHz (GB—A—1.482.755).

Microwaves are provided with various advantages in particular when they are used in treatment of textile sheet in a wet state. Firstly, they permeate into the textile sheet extremely quickly and heat it within a very short time. Secondly, since their heat generation is based on dielectric loss, they are selectively absorbed in objects with large dielectric loss in order to heat necessary object only whilst avoiding heating of unnecessary object or objects. Thirdly, the treated textile sheet generates heat by itself whilst avoiding the need for additionally heating the ambient atmosphere and/or the heater equipment, thereby assuring high rate of thermal efficiency resulting from heat saving. Fourthly, since they cause simultaneous temperature rise at different sections of the treated sheet, difference in temperature between the core and surface sections of the sheet is very small, thereby assuring ideally uniform heating of the sheet. Fifthly, adjustment of the output voltage for the microwaves enables simple and easy control of the heating condition in accordance with requirement in the actual treatment.

Irradiation of microwaves onto a textile sheet causes ionic conduction and dipole rotation of the fibers composing the textile sheet and water and/or agents contained in the sheet in order to cause rapid and uniform heating of the textile sheet.

A wide variety of systems have been proposed in order to practice the above-described microwave irradiation in treatment of textile sheet, but quite a few of them have been feasible in practical industrial scale.

One cause for this difficulty resides in the manner of irradiation of microwaves. An applicator is generally used for this purpose and the conventional applicators are roughly classified into three types, i.e. an applicator with a hairpin curved waveguide, an applicator with a densely hair-pin curved waveguide, and an oven-type applicator.

In the case of the applicator using the waveguide, heating effect is greatly affected by wave length of the microwave irradiated and uneven heating of the sheet tends to take place. Consequently, the applicators of these types are unsuited for treatment of dyed or scoured textile sheets, which required high rate of uniformity heating effect.

In the case of the oven-type applicator including a metallic hexahedral irradiation chamber, it is necessary to employ any expedient to equalize the intensity of the magnetic field surrounding the sheet in the chamber. Otherwise, the applicator of this type is quite unsuited for use in practical industrial scale although it may operate in order in laboratories.

The other cause for the above-described difficulty resides in fusion of fibers composing a textile sheet during, or as a result of, heating by application of microwaves. This is in particular a serious problem when the textile sheet is composed of thermoplastic synthetic fibers such as acrylic fibers. Such fusion of the textile sheet is caused by temperature rise in water as a dyeing medium and/or a high boiling point agent or agents as assistants, both being contained in the textile sheet after dyeing. For example, in the case of a textile sheet made of acrylic fibers which can be dyed at a temperature close to the boiling point of pure water, swelling of the dyed fibers starts at a temperature close to 100°C and, regardless of its dielectric constant, dipole rotation occurs in the fibers, which causes abrupt evacuation of water, temperature rise and eventual fusion of the fibers. In order to prevent such fusion of fibers composing the textile sheet, it is absolutely necessary to prevent evacuation of water contained in the fibers during the treatment.

A further cause for the above-described difficulty resides in the manner to prevent the above-described evacuation of water contained in the fibers during the treatment. For this effect, a textile sheet is transported through the microwave applicator zone or zones while being clamped between a pair of running endless belts or being placed in surface contact with a wet sheet. In either cases, possible contamination on the belts or sheet tends to develop spots on the textile sheet, which greatly degrades its commercial value.

## SUMMARY OF THE INVENTION

It is one object of the present invention is to provide ideal aftertreatment of textile sheet by application of microwaves with highly uniform heating effect.

It is another object of the present invention to provide successful aftertreatment of textile sheet by

application of microwaves without causing any accidental fusion of fibers composing the sheet during the treatment.

It is the other object of the present invention to provide advantageous aftertreatment of textile sheet by application of microwaves without development of any spots on the treated sheet.

It is a further object of the present invention to provide economical aftertreatment of textile sheet by application of microwaves with simple construction in equipment.

The method of the present invention is defined in claim 1 and the apparatus in claim 8.

DESCRIPTION OF THE DRAWINGS

Fig. 1 is a side view, partly in section, of an embodiment of the apparatus in accordance with the present invention, and

Fig. 2 is an enlarged side sectional view of the sheltered construction of the inlet used in the apparatus shown in Fig. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

It should be understood that, although the following description is focussed upon treatment of dyed textile sheet, the present invention is equally applicable to treatment of scoured textile sheet.

A basic embodiment of the apparatus in accordance with the present invention is shown in Fig. 1, in which the apparatus includes, as the major elements, a preparatory heating chamber 1 and a microwave irradiation chamber 2 arranged in sequence with each other along the path of travel of a textile sheet M.

It should be understood that the present invention is well applicable to treatment of a textile sheet of any form. It may be a woven cloth, a knitted cloth or flat sheet of threads arranged side-by-side relationship to each other.

It should be further understood that the present invention is well applicable to treatment of a textile sheet dyed in any manner. It may be dyed by winch dyeing, jigger dyeing, beam dyeing, pad winch process, pad jig process, pad batch process, pad steam process, or screen or roll printing.

It should be further understood that the present invention is well applicable to treatment of a scoured or dyed textile sheet made of any fibers including natural, regenerated and synthetic fibers, although it is most advantageously applied to treatment of a textile sheet made of synthetic fibers.

The chambers 1 and 2 are both connected to a steam pipe 3 for feeding steam of a proper pressure to their interiors.

The preparatory heating chamber 1 is internally provided with a feed guide roller 11 arranged near its inlet, a delivery guide roller 12 arranged near its outlet, and a number of intermediate guide rollers 13 arranged in the zone between the two rollers 11 and 12. The number and arrangement of the intermediate guide rollers 13 can be freely designed depending on requirement for the length of the travelling path of the textile material through the chamber 1.

Preparatory heating should be applied to the textile sheet in a wet state. In application of the present invention, the preparatory heating has its particular significance when the textile sheet is made of synthetic fibers such as polyamide, polyester and acrylic fibers, since such fibers may fuse during the treatment depending on the length of the treatment and the output power of the microwaves.

In the case of hydrophilic fibers such as cellulose fibers, colour fixing starts several seconds after imitation of microwave irradiation and its dyeing affinity arrives at the highest value within about 20 seconds. In contrast to this, hydrophobic fibers such as polyamide fibers require microwave irradiation over a period of 5 minutes or longer. This is because of the fact that a relatively long time is required to cause swelling of the textile sheet to an extent enough to allow appreciable diffusion of dyes into the fibers composing the textile sheet. However, as described already, long irradiation of microwaves on a textile sheet inevitably causes fusion of the fibers composing the textile sheet.

In order to obviate such a trouble, it may be thinkable to employ relatively long irradiation of microwaves whilst cutting down the output power of the microwaves. But, such a long irradiation degrades the basic merit of treatment by application of microwaves, i.e. rapid processing.

In accordance with the present invention, the preparatory heating preceding the microwave irradiation causes appreciable, though not enough, swelling of the textile sheet, thereby enabling relatively short microwave irradiation for diffusion of dyes.

The microwave irradiation chamber 2 is provided with a microwave applicator 21 electrically connected in a known manner to a microwave generator (not shown). The textile sheet M introduced into the chamber 2 is wound up onto a roll R via a feed guide roller 22 and an intermediate guide roller 23. A known driving mechanism is arranged in order to rotate the roll R following any programmed sequence including positive rotation after complete winding-up.

The winding-up speed of the textile sheet is in a range from 50 to 100 MPM and the length of a unit textile sheet is about 2,000 meters for the unit weight 100 g/m$^2$, and about 1,000 meters for the unit weight 200 g/m$^2$.

A microwave generator of the maximum output power 10 KW at 2450 MHz frequency may be used. Oscillation of microwaves is carried out by two sets of water-cooling type magnetron of 5 KW output power. Any known type of waveguide may be used as long as it assures uniform irradiation on

the textile sheet in the roll form.

The microwave irradiation should be carried out under saturation of the chamber 2 with steam. In case any animal fiber such as wool is to be treated, high pressure steam of about 4 kg/cm$^2$ should preferably be introduced into the chamber 2.

Consequently, the interior of the irradiation chamber 2 is replete with microwaves and steam during the treatment. In order to prevent accidental leakage of the microwaves and the steam outside the chamber 2 whilst allowing free introduction of the textile sheet M into the chamber, a particular shelter construction 24 is arranged in the zone between the feed and intermediate rollers 22 and 23, which is shown in detail in Fig. 2.

The shelter construction 24 is arranged within a space defined by a pair of relatively thick vertical walls 25 and 26 which prevent depositing of dews on the construction. The outer wall 25 is provided with a ventilation duct 27 whose inner opening is covered with a punched plate 28 for preventing leakage of electric waves via the duct 27. The top of the space is covered by an adjustable slit plate 241 whose opening is freely adjustable in size in accordance with the processing conditions. A blocking filter 242 is arranged vertically below the slit plate 241, which includes a plurality of electric wave damping elements 242a aligned vertically whilst facing the travelling path of the textile sheet M. An electric wave absorber plate 242b is vertically arranged on the opposite side of the travelling path. Even when the microwaves in the chamber 2 leak outside via the slit plate 241, they are almost fully attenuated during their travel through the blocking filter 242. Leakage of the steam in the chamber 2 is extremely minimized due to the presence of the slit plate 241. A water reservoir 243 is arranged in the proximity of the inlet guide roller 22 below the inner wall 26, which absorbs microwaves surviving even after passage through the blocking filter 242.

Irradiation of the microwaves should be carried out with the roll being in rotation. In the ordinary case, the irradiation lasts during winding-up of the textile material on the roll and subsequent positive rotation of the roll. This positive rotation may last for 10 to 20 minutes. The irradiation may last during the winding-up of the textile sheet only. It may also last during the subsequent positive rotation only for 10 to 20 minutes. Choice of the irradiation is dependent upon the process conditions.

EXAMPLES

Example 1.

A textile sheet in the form of a woven cloth made of an acrylic fiber was dyed in a dye bath of the following composition.

| | |
|---|---|
| Kayacryl Yellow 2RL (C.I. Basic Yellow 67) | 10 g/l |
| Kayacryl Red GRL (C.I. Basic Red 67) | 12 g/l |
| Kayacryl Blue BGL (C.I. Basic Blue 116) | 10 g/l |
| Tio-di-ethylene glycol | 20 g/l |
| Acetic acid | 50 g/l |
| Nonionic penetrant | 2 g/l |

The dyed textile sheet was squeezed on a padder to 80% pick-up.

Irradiation of microwaves was carried out on the apparatus of the present invention with an output power of 10 KW at a frequency of 2450 MHz for 10 minutes during the subsequent positive rotation of the roll.

Ideal effects were obtained in shade, tone and value, which were all by far better than those obtained by any conventional treatment.

Example 2.

A textile sheet in the form of a woven cloth made of a cellulose fiber was dyed in a dye bath of the following composition.

| | |
|---|---|
| Procion Yellow H3R (C.I. Reactive Orange 12) | 10 g/l |
| Procion Red H3B (C.I. Reactive Red 3) | 12 g/l |
| Procion Blue H-3R (C.I. Reactive Blue 49) | 10 g/l |
| Urea | 100 g/l |
| Sodium carbonate | 30 g/l |

Squeezing and irradiation of microwaves were carried out in manners similar to those in Example 1.

Ideal effects were obtained in shade, tone and value, which were all by far better than those obtained by any conventional treatment.

It was confirmed also that sodium-bi-carbonate could be substituted for sodium carbonate without any lowering in the effects.

Example 3.

A textile sheet in the form of a woven cloth made of wool was dyed in a dye bath of the following composition.

| | |
|---|---|
| Acilan Yellow (C.I. Acid Yellow 9) | 8 g/l |
| Telon Red BLL (C.I. Acid Red 42) | 3 g/l |
| Telon Fast Blue (C.I. Acid Blue 127:1) | 7 g/l |
| Ammonium sulfate | 50 g/l |
| Tio-di-ethylene glycol | 50 g/l |
| Urea | 30 g/l |

Squeezing and irradiation of microwaves were same as those in Example 1, but the latter lasted for 25 minutes.

Excellent effects were obtained in shade, tone and value, which were all by far better than those obtained by any conventional treatment for wool.

Example 4.

A textile sheet in the form of a woven cloth made of polyamides 6 and 66 was dyed in a dye bath of the following composition.

| | |
|---|---|
| Palatine Yellow ELN (C.I. Acid Yellow 54) | 10 g/l |
| Palatine Red BZN (C.I. Acid Red 214) | 3 g/l |
| Palatine Blue GGN (C.I. Acid Blue 158) | 6 g/l |
| Tio-di-ethylene glycol | 20 g/l |
| Acetic acid | 10 g/l |

Squeezing was same as that in Example 1. Irradiation of microwaves was carried out with an output power of 5 KW at a frequency of 2450 MHz for 15 minutes during the subsequent positive rotation of the roll.

Excellent effects were obtained in shade, tone and value, which were all by far better than those obtained by any conventional treatment.

Example 5.

A textile sheet in the form of a woven cloth made of polyester fiber was dyed in a dye bath of the following composition.

| | |
|---|---|
| Kayalon Polyester Yellow YL-SE (C.I. Disperse Yellow 42) | 10 g/l |
| Kayalon Polyester Red T-S (C.I. Disperse Red 146) | 15 g/l |
| Kayalon Polyester Blue T-S (C.I. Disperse Blue 158) | 15 g/l |
| Sodium Alginate | 2 g/l |

Squeezing was same as that in Example 1. Irradiation of microwaves was carried out with an output power of 8 KW at a frequency of 2450 MHz for 15 minutes during the subsequent positive rotation of the roll.

Excellent effects were obtained in shade, tone and value, which were all by far better than those obtained by any conventional treatment.

## Claims

1. Method for treating a textile sheet after scouring or dyeing with microwaves wherein the textile sheet in a wet state is introduced into a confined microwave irradiation chamber replete with steam, characterized in that the textile sheet (M) is subjected to preparatory heating under steam supply before introduction into the microwave irradiation chamber (2), that the textile sheet is wound into a roll, within the chamber and that microwaves are applied to the roll during its rotation.

2. Method as claimed in claim 1 in which said application of microwaves lasts during rotation of said roll for winding up said textile sheet and subsequent positive rotation of said roll.

3. Method as claimed in claim 1 in which said application of microwaves lasts during said rotation of said roll for winding up said textile sheet.

4. Method as claimed in claim 1 in which said application of microwaves lasts during said subsequent positive rotation of said roll.

5. Method as claimed in claim 1 or 4 in which said subsequent positive rotation of said roll lasts 10 to 20 minutes.

6. Method as claimed in claim 1, 2 or 3 in which said application of microwaves is carried out in a substantially confined chamber saturated with steam.

7. Method as claimed in claim 1, 2 or 3 in which said application of microwaves is carried out in a confined chamber filled with high pressure steam.

8. Apparatus for treating a textile sheet after scouring or dyeing with microwaves wherein the textile sheet in a wet state is introduced into a confined microwave irradiation chamber replete with steam, characterized in that a preparatory heating chamber (1) is located on the upstream side of the microwave irradiation chamber (2) and replete with steam, that the microwave irradiation chamber is internally provided with means for winding up the textile sheet into a roll, and means for rotating the roll following a predetermined programme.

9. Apparatus as claimed in claim 8 further comprising a shelter construction arranged near the inlet of said microwave irradiation chamber for blocking leakage of said steam and microwaves.

10. Apparatus as claimed in claim 9 in which said shelter construction includes a pair of vertical walls defining a space, an adjustable slit plate closing the top of said space whilst allowing passage of said textile sheet, and a blocking filter arranged within said space which said textile sheet passes through.

11. Apparatus as claimed in claim 10 in which said blocking filter includes a plurality of electric wave damping elements aligned vertically on the one side of travelling path of said textile sheet and a vertically elongated electric wave absorbable plate arranged on the other side of said travelling path.

## Patentansprüche

1. Verfahren zur Behandlung eines Textilstückes nach dem Waschen oder Färben mit Mikrowellen, wobei das Textilstück in nassem Zustand in eine geschlossene Mikrowellen-Strahlenkammer, die mit Dampf gefüllt ist, eingeführt wird, dadurch gekennzeichnet, dass das Textilstück (M) einem vorbereitenden Aufheizvorgang unter Dampzufuhr unterworfen wird, bevor es in die Mikrowellen-Strahlenkammer (2) eingeführt wird, dass das Textilstück innerhalb der Kammer in eine Rollenform gewunden wird und dass die Mikrowellen auf die Rolle angewandt werden während diese sich dreht.

2. Verfahren nach Anspruch 1, dadurch gekennzeichnet, dass die Anwendung der Mikrowellen während der Rotation der genannten Rolle zum Aufwickeln des genannten Textilstückes und nachfolgend der tatsächlichen Rotation der genannten Rolle andauert.

3. Verfahren nach Anspruch 1, dadurch gekennzeichnet, dass die Anwendung der Mikrowellen während der genannten Rotation der genannten Rolle zum Aufwickeln des Textilstückes andauert.

4. Verfahren nach Anspruch 1, dadurch gekennzeichnet, dass die Anwendung der Mikrowellen während der nachfolgenden tatsächlichen Rotation der genannten Rolle andauert.

5. Verfahren nach Anspruch 1 oder 4, dadurch gekennzeichnet, dass die nachfolgende tatsächliche Rotation der genannten Rolle 10 bis 20 Minuten andauert.

6. Verfahren nach Anspruch 1, 2 oder 3, dadurch gekennzeichnet, dass die Anwendung der Mikrowellen in einer im wesentlichen geschlossenen, mit Sattdampf gefüllten Kammer durchgeführt wird.

7. Verfahren nach Anspruch 1, 2 oder 3, dadurch gekennzeichnet, dass die Anwendung der Mikrowellen in einer geschlossenen, mit Hochdruck-Dampf gefüllten Kammer erfolgt.

8. Vorrichtung zur Behandlung eines Textilstückes nach dem Waschen oder Färben mit Mikrowellen, wobei das Textilstück in nassen Zustand in eine geschlossene Mikrowellen-Strahlenkammer eingeführt wird, die mit Dampf gefüllt ist, dadurch gekennzeichnet, dass eine vorbereitende Heizkammer (1) in der Zustromseite der Mikrowellen-Strahlenkammer (2) angeordnet und mit Dampf gefüllt ist, dass die Mikrowellen-Strahlenkammer im Inneren Mittel zum Aufwickeln des Textilstückes in eine Rollenform aufweist und dass Mittel für die Rotation der Rolle nach einem vorbestimmten Programm vorgesehen ist.

9. Vorrichtung nach Anspruch 8, dadurch gekennzeichnet, dass eine Schutzdach-Konstruktion nahe des Einlasses der genannten Mikrowellen-Strahlenkammer angeordnet ist, die eine Leckage von Dampf und Mikrowellen behindert.

10. Vorrichtung nach Anspruch 9, dadurch gekennzeichnet, dass die Schutzdach-Konstruktion ein Paar, vertikaler Abstand voneinander aufweisender Wände, eine einstellbare Schlitzplatte zum Schliessen der Spitze des Zwischenraumes, wobei das Textilstück durchlaufen kann, und einen Sperrfilter umfasst, der in dem Zwischenraum angeordnet ist und den das Textilstück durchlaufen kann.

11. Vorrichtung nach Anspruch 10, dadurch gekennzeichnet, dass der Sperrfilter eine Vielzahl von Dämpfungselementen für elektrische Wellen umfasst, die vertikal auf einer Seite des Durchlaufpfades des Textilstückes aufgereiht sind, sowie eine vertikal verlängerte Absorberplatte für elektrische Wellen, die auf der anderen Seite des genannten Durchlaufpfades angeordnet ist.

**Revendications**

1. Procédé pour traiter une bande de matière textile par micro-ondes après son débouillissage ou son séchage, selon lequel on introduit la bande à l'état humide dans une chambre close d'irradiation par micro-ondes remplie de vapeur, caractérisé en ce que, avant de l'introduire dans la chambre d'irradiation par micro-ondes (2), on soumet la bande de matière textile (M) à un chauffage préparatoire, que l'on enroule la bande en une bobine à l'interieur de la chambre d'irradiation et que l'on applique des micro-ondes à la bobine pendant la rotation de celle-ci.

2. Procédé selon la revendication 1, où l'on applique les micro-ondes pendant la rotation de la bobine pour l'enroulement de la bande de matière textile et pendant un entrainement en rotation consécutif de la bobine.

3. Procédé selon la revendication 1, où l'on applique les micro-ondes pendant la rotation de la bobine pour l'enroulement de la bande de matière textile.

4. Procédé selon la revendication 1, où l'on applique les micro-ondes pendant l'entrainement en rotation consécutif de la bobine.

5. Procédé selon la revendication 1 ou 4, où l'entrainement en rotation consécutif de la bobine dure de 10 à 20 min.

6. Procédé selon la revendication 1, 2 ou 3, où l'on applique les micro-ondes dans une chambre sensiblement close saturée de vapeur.

7. Procédé selon la revendication 1, 2 ou 3, où l'on applique les micro-ondes dans une chambre close remplie de vapeur sous haute pression.

8. Appareil pour traiter une bande de matière textile par micro-ondes après son débouillissage ou son séchage, dans lequel la bande de matière textile est introduite à l'état humide dans une chambre close d'irradiation par micro-ondes remplie de vapeur, caractérisé en ce qu'une chambre de chauffage préparatoire (1) remplie de vapeur est située en amont de la chambre d'irradiation par micro-ondes (2) et est traversée par la bande de matière textile, que la chambre d'irradiation par micro-ondes est pourvue intérieurement de moyens pour enrouler la bande de matière textile en une bobine et de moyens pour faire tourner la bobine selon un programme prédéterminé.

9. Appareil selon la revendication 8, comprenant en outre une construction de protection disposée près de l'entrée de la chambre d'irradiation par micro-ondes et destinée à empêcher l'échappement de vapeur et de micro-ondes.

10. Appareil selon la revendication 9, dont la construction de protection comporte deux parois verticales définissant un espace, une plaque à fente réglable qui ferme cet espace en haut tout en permettant le passage de la bande de matière textile, ainsi qu'un filtre d'arrêt disposé dans ledit espace, lequel est traversé par la bande de matière textile.

11. Appareil selon la revendication 10, dans lequel le filtre d'arrêt comporte plusieurs élèments amortisseurs d'ondes électriques, qui sont alignés verticalement sur un côté du parcours de la bande de matière textile, ainsi qu'une plaque de forme allongée dans le sens vertical et capable d'absorber des ondes électriques, qui est disposée de l'autre côté de ce parcours.

Fig. 1

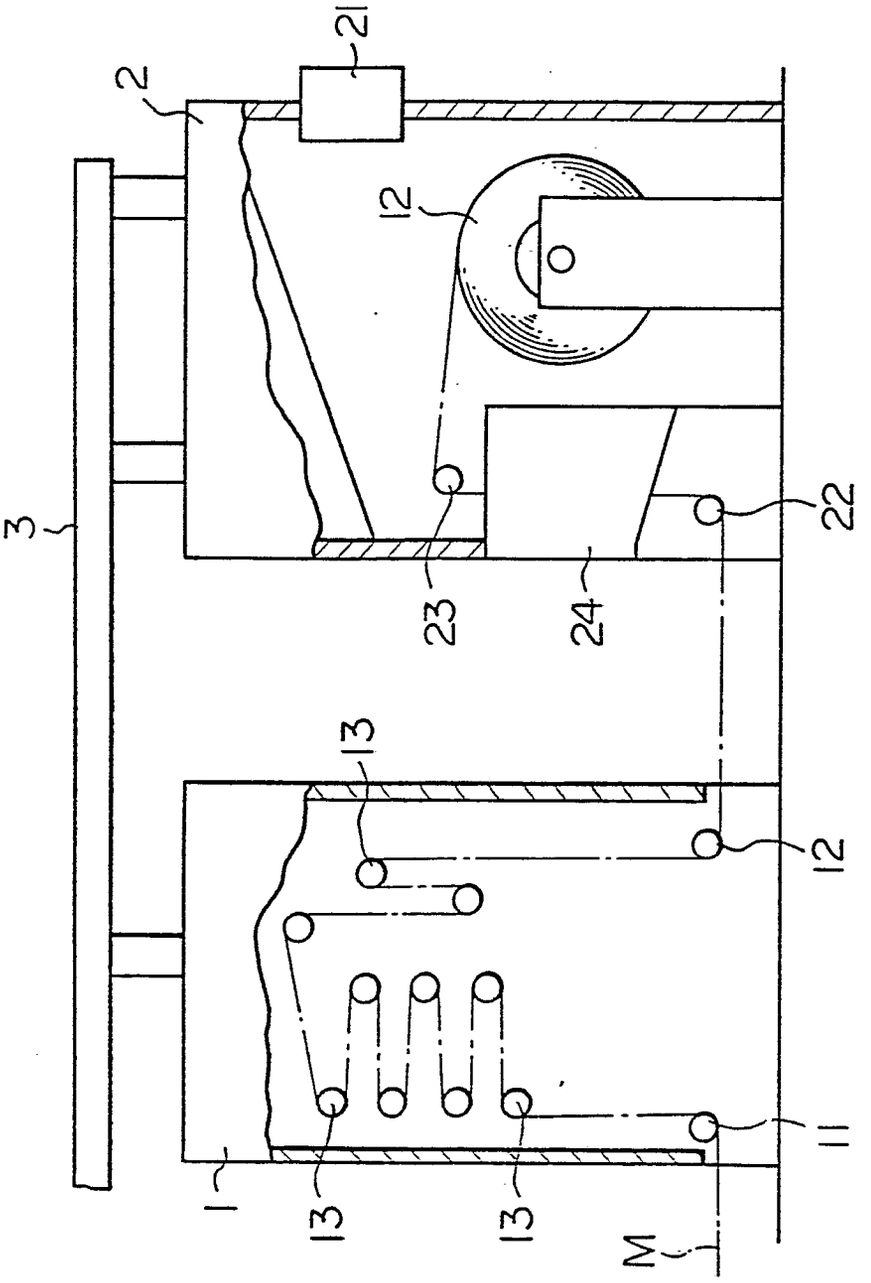

Fig. 2