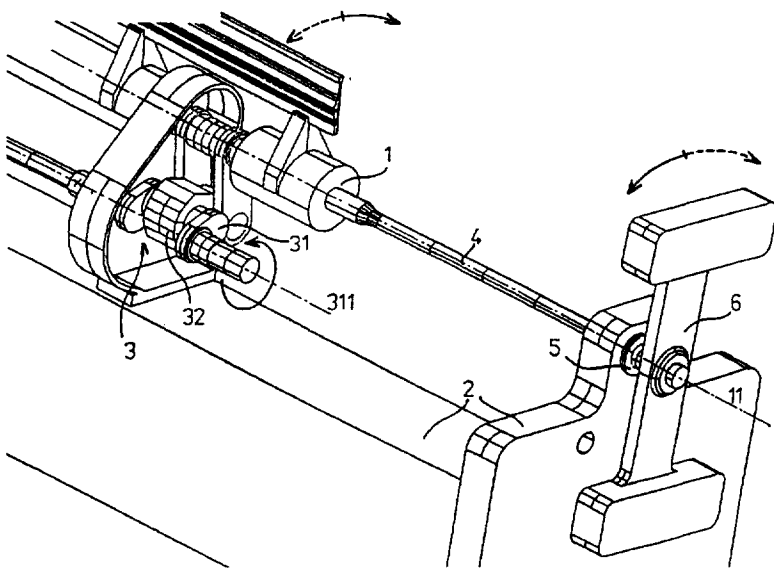


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(54) Title: A METHOD OF BALANCING THE DYNAMIC EFFECTS OF A MATERIAL BODY WITH A PERIODIC REVERSING MOTION AND A DEVICE FOR CARRYING OUT THE METHOD 		
(57) Abstract A method of balancing the dynamic effects of a material body to be balanced and carrying out a periodic reversing motion, for instance of the batten (1) of a weaving machine, by means of a balancing material body (6) in which, under the action of both the periodic reversing motion of the material body to be balanced and of the elastic coupling between the material body to be balanced and the balancing material body (6), a periodic reversing motion of the balancing material body (6) of equal frequency, lower amplitude, and with a phase shift (π) is produced. Thus is achieved the reduction of both the dynamic effects of the material body to be balanced and of the required drive effects. The invention also proposes a device for carrying out the method.		

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A method of balancing the dynamic effects of a material body with a periodic reversing motion and a device for carrying out the method

Technical field

The invention relates to a method of balancing the dynamic effects of a material body with a periodic reversing motion by means of a balancing material body.

The invention also proposes a device for carrying out the method.

Background art

The operation of machines and mechanisms whose at least one component carries out a periodic reversing motion gives rise, due to such motion of said component (and of its drive mechanism), to inertial effects imposing stress on, and generating oscillations of, said machines or mechanisms.

Up to now, the inertial effects of each body or the specific components of such effects or the resulting inertial effects of a plurality of bodies have been balanced by inertial effects of each balancing body or by inertial effects of a plurality of balancing bodies. The balancing body/bodies is/are attached to a suitable section of the mechanism to be balanced or of an auxiliary mechanism by means of a mechanism comprising rigid members such as gear wheels or articulation mechanisms. The motion of the balancing body is periodic and opposite in direction to the motion of the component to be balanced.

The aim to be achieved by such balancing consists in reducing the effects acting in the mechanism and spreading to its surroundings, i.e., in most cases, to the machine frame. Relevant for the function of such balancing bodies is the motion that would be effected by an absolutely rigid mechanism. Both the compliance and the oscillations of the mechanism have no influence on the function of the balancing

body. Consequently, the effect of the balancing of the mechanism in this way does not depend on its operating frequency. Its drawback consists in high stress imposed on some parts of the mechanism, in particular of the drive mechanism balancing the periodic motions both of the component to be balanced and of the balancing body.

Another well-known method of balancing the dynamic effects of a material body carrying out a periodic reversing motion consists in the application of a dynamic absorber. This method is used in order to reduce the machine frame oscillations. The balancing body is attached by means of an elastic member to the section of the machine where the oscillations shall be suppressed, and represents a system of the balancing body with elastic coupling.

In operating in this way, said balancing body can rotate or slide only in the direction in which the oscillations shall be suppressed. The mass of the balancing body and the compliance of the elastic member attaching it to the frame are selected so as to ensure, at the operation speed, such oscillations of the balancing body as are required to suppress said oscillations of the frame. This is achieved by the resonance tuning of the system of the balancing body with elastic coupling.

Indispensable for the application of this balancing method are the frame oscillations and the compliance of the attaching member. Its drawback consists in particular in its being operative only within a narrow range of operating frequency.

Principle of the invention

The aim of the proposed method of balancing is the balancing or reduction of dynamic effects of a material body carrying out a periodic reversing motion, and the creation of a device for carrying out this method of balancing.

This is achieved by the method according to the invention whose principle consists in exciting, under the action of both the periodic reversing motion of the material body to be balanced and of the elastic coupling between the material body

to be balanced and the balancing material body, a periodic reversible motion of the balancing material body of equal frequency but oscillating in opposite direction i.e. in opposite phase as compared with the body to be balanced. The coupling proper is such that without said elasticity the balancing material body would oscillate concurrently. In this way, the reduction of both the dynamic effects of the material body to be balanced and of the required drive effects is achieved.

This is due to the fact that in a stabilized state the sum of the kinetic energy of the material body to be balanced and of the potential energy of the elastic coupling between them is approximately constant so that the energy required for the drive need not be supplied by the drive mechanism alone as is the case of an unbalanced material body.

The principle of the device for carrying out the method of balancing according to the invention consists in that the material balancing body is connected with the material body to be balanced by means of a coupling comprising an elastic member.

Thus, the balancing material body is mounted movable with respect both to the machine frame and to the material body to be balanced, due to the elastic member inserted between said bodies. Then, the balancing material body carries out a periodic reversing motion in the direction opposite to the component to be balanced of the inertial effects of the material body and thus creates balancing inertial effects reducing the inertial effects to be balanced.

The advantage of the proposed method of, and device for, balancing the dynamic effects of the material body with periodic reversing motion consists in the reduction of the stress the drive mechanism is exposed to in a stabilized state under the force action of the compensation system consisting of the balancing material body and the elastic member, on the material body to be balanced.

Another advantage of the proposed solution consists in the elimination of

the need to tune the compensation system exactly to the exciting frequency as is the case in dynamic absorbers requiring great intensification. In the proposed solution, the amplitudes of the periodic reversing motion are comparable or inferior to the amplitudes of the harmonic components of the periodic reversing motion of the material body to be balanced.

To balance the dynamic effects of a material body to be balanced and carrying out a rotary reversible motion, there is proposed a device whose principle consists in that one end of the material body to be balanced has attached thereto, in the rotation axis of the body, one end of a torsion spring mounted for rotation in the machine frame and having fastened thereto the balancing material body.

The preceding embodiment can be advantageously applied on a weaving machine with its batten as the material body to be balanced.

In this, the material balancing body is preferably mounted on the free end of the torsion spring from the outer side of the machine frame.

Description of the drawings

An example of embodiment of the device for carrying out the method of balancing according to the invention is schematically shown in Fig. 1 relating to the balancing of the batten of a weaving machine. To facilitate the understanding and the explanation of the effects of the invention, further drawings are attached showing, respectively, Fig. 2 a schematic representation of the beat-up mechanism of the weaving machine, Fig. 3 the dependance of the rotation angle of the batten on the rotation angle of the crank of a four-linked mechanism, Fig. 4 the dependance of the angular acceleration of the batten on the rotation angle of the crank of the four-linked mechanism, and Fig. 5 the dependance of the moment acting into the machine frame on the rotation angle of the crank of the four-linked mechanism.

Specific description

The method of balancing the dynamic effects of a body to be balanced and carrying out a periodic reversing motion will be explained on a mechanism carrying out a rotary periodic reversing motion in a given angular range, i.e., a swinging motion. Such a mechanism is for instance the batten of a weaving machine.

A batten 1 is in a well-known way rotatably mounted in a frame 2 of a weaving machine and is in a well-known way coupled with a well-known four-linked mechanism 3 coupled with a wellknown not represented drive of the weaving machine. Thus, the batten 1 is the driven member of the four-linked mechanism 3 receiving from it its swinging motion, i.e., its reversing rotary motion around the rotation axis 11 of the batten 1.

The well-known four-linked mechanism 3 consists of the frame 2 having housed therein a crank 31 coupled with a well-known not represented drive and adapted to turn around the rotation axis 311 of the crank 31. Rotatably mounted on the crank 31 there is a crank arm 32 rotatably connected with the batten 1, the latter being at the same time mounted in the frame 2 of the weaving machine rotatably around the axis 11 of rotation of the batten 1.

To one end of the batten 1 there is in its axis 11 attached one end of a torsion spring 4 mounted near its other end rotatably in the frame 2 of the weaving machine, for instance by means of a bearing 5, the other end of the torsion spring 4 having fixed thereto a balancing material body 6.

In a stabilized operation of the weaving machine, the fourlinked mechanism 3 generates a reversing rotary motion of the batten 1 exciting via the torsion spring 4 a reversing rotary motion of the balancing material body 6 having the same frequency as the reversible rotary motion of the batten 1 and, due to defined elasticity and mass characteristics of the torsion spring 4 and of the balancing material body 6, lower amplitude, and phase shift π .

The balancing material body 6 and the torsion spring 4 form together a compensation system whose natural frequency, determined by the mass of the balancing material body 6 and the elasticity of the torsion spring 4, is inferior to the frequency of the to-be-balanced harmonic component of the dynamic effects of the batten 1 so that the compensation system is excited in an over-resonance way, thus achieving the above effect.

If the compensation system receives its over-resonance excitation from the motion of the material body to be balanced, i.e., in our example of embodiment, of the batten 1, the motion of the balancing material body 6 is opposite in direction to the motion of the material body to be balanced. In case of an ideally rigid coupling without the elastic member or in case of a sub-resonance excitation, the balancing material body 6 would move concurrently with the material body to be balanced.

As may be seen from the above description, the dynamic effects of the moving balancing body 6 are in the described example of embodiment opposite and compensate the dynamic effects of the to-be-balanced harmonic component of the dynamic effects generated by the reversing rotary motion of the batten 1. At the same time, the energy produced by the moving balancing material body 6 and by the torsion spring 4 being twisted is accumulated and transmitted to the batten 1 thus reducing the stress imposed on the drive four-linked mechanism 3.

Fig. 2 shows schematically a four-linked mechanism 3 acting as the beat-up mechanism of a weaving machine. L₁ represents the distance between the batten rotation axis 11 and the axis 311 of the drive crank 31; L₂, the length of the crank 31; L₃, the length of the crank arm 32; and L₄, the distance between the rotation axis 11 of the batten 1 and the axis of connection with the crank arm 32. The other symbols mean: ω the angular velocity of the crank 31; J₆, the axial moment of inertia of the batten 1, i.e., of the material body to be balanced; J, the axial moment of inertia of the balancing material body 6; τ , the angle of revolution of the crank 31

from the beat-up position; and ϑ , the angle of rotation of the batten 1 from the beat-up position.

If, in a specific mechanism, the above values as well as the rigidity constant c of the torsion spring 4 are known, the natural frequency Ω of the compensation system consisting of the torsion spring 4 and the balancing material body 6 can be calculated as follows:

$$\Omega = \sqrt{\frac{c}{J}} = \text{rad / s}$$

The balancing of the first harmonic component is governed by the following equation:

$$J_0 \left[1 - \left(\frac{\omega}{\Omega} \right)^2 \right] + J = 0$$

The moment transmitted into the machine frame 2 by an unbalanced mechanism:

$$M_0(\tau) = \sum_{k=1}^{\infty} m_{0,k} \sin(k\tau + \varphi_k) \quad , \quad m_{0,k} = J_0 a_k (k\omega)^2$$

The moment transmitted into the machine frame 2 by a balanced mechanism:

$$M(\tau) = \sum_{k=1}^{\infty} m_k \sin(k\tau + \varphi_k) \quad , \quad m_k = \left[J_0 + \frac{J}{1 - \left(\frac{k\omega}{\Omega} \right)^2} \right] a_k (k\omega)^2$$

The angle of rotation of the batten 1 during a uniform turning of the crank 31:

$$\vartheta = a_0 + \sum_{k=1}^{\infty} a_k \sin(k\tau + \varphi_k)$$

where: k stands for the order of the harmonic component; φ_k , for the phase offset; m_k , for the moment related to the k -th harmonic component; a_0 , for the mean

value of the batten 1 rotation angle, representing the nullth harmonic component.

To understand better the effects of the invention, Figs. 3 to 5 show the course of development of the angle ϑ of the batten rotation, of the angular acceleration of the batten 1, and of the moment acting into the frame 2 of the machine depending on the angle τ of rotation of the crank 31 of the four-linked mechanism 3 of a given mechanism. The comparison of the moment $\underline{M}_0$ of an unbalanced mechanism with the moment $\underline{M}$ of the mechanism balanced by the method according to this invention shows clearly the reduction of the moment $\underline{M}$ acting into the frame 2 with the balanced mechanism.

Dynamic effects arising during reversing rectilinear motion of a material body can be balanced in a similar way.

PATENT CLAIMS

1. A method of balancing the dynamic effects of a material body to be balanced and carrying out a periodic reversing motion, characterized by exciting, under the action of both the periodic reversing motion of the material body to be balanced and of the elastic coupling between the material body to be balanced and the balancing material body (6), a periodic reversing motion of the balancing material body (6) of equal frequency but with a phase shift (π), thus reducing both the dynamic effects of the material body to be balanced and the required drive effects.

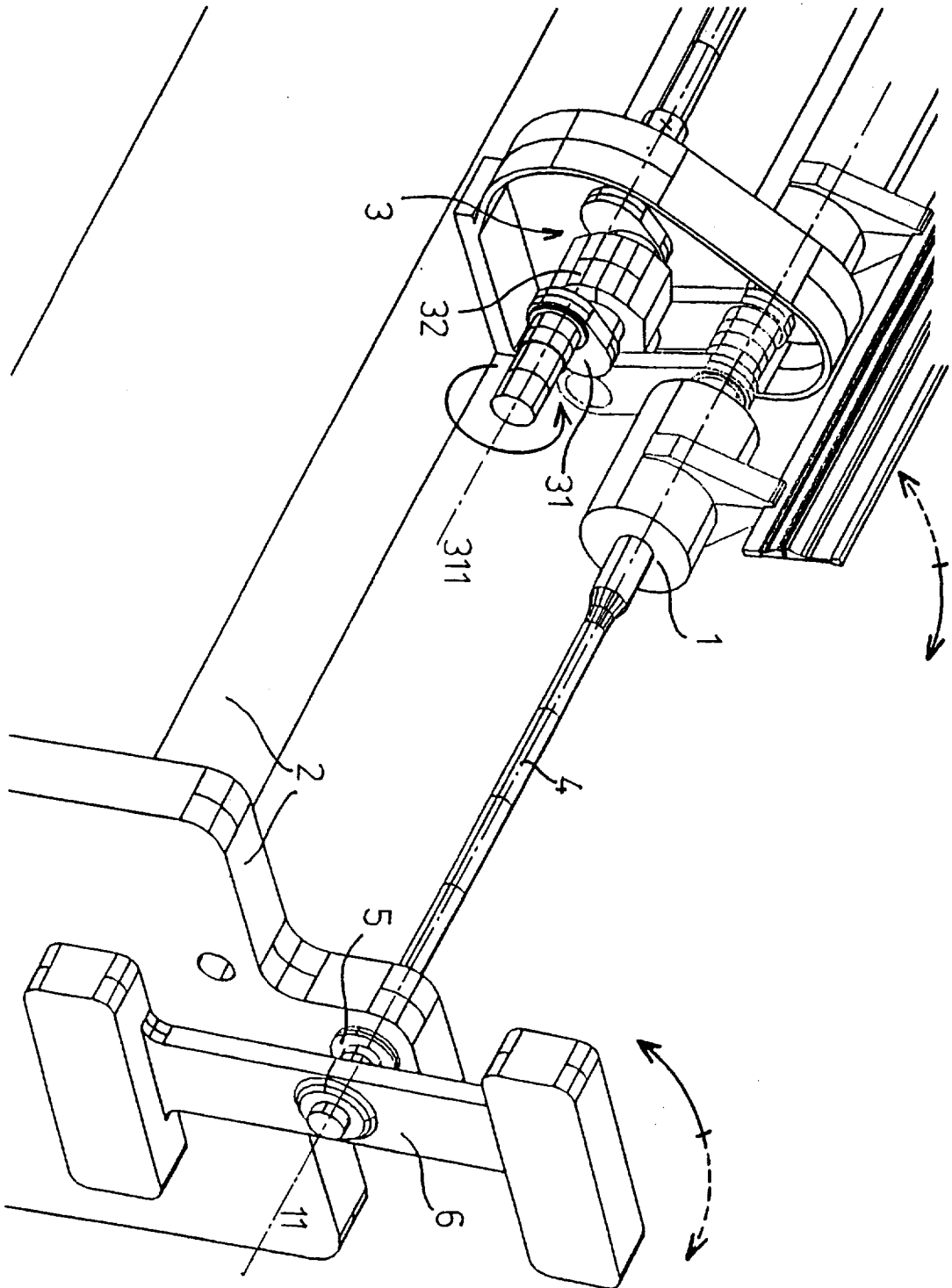
2. A device for carrying out the method as claimed in Claim 1, characterized by that the balancing material body (6) is connected with the material body to be balanced by means of a coupling comprising an elastic member.

3. A device as claimed in Claim 2, characterized by that the material body to be balanced consists of a material body intended to carry out a rotary reversible motion and having attached to one of its ends in its rotation axis one end of a torsion spring (4) mounted for rotation in the frame (2) of a machine and having fixed thereto the balancing material body.

4. A device as claimed in Claim 3, characterized by that the material body to be balanced is the batten (1) of a weaving machine.

5. A device as claimed in Claim 3 or 4, characterized by that the balancing material body (6) is fixed to the torsion spring (4) from the outer side of the machine frame (2).

Fig. 1



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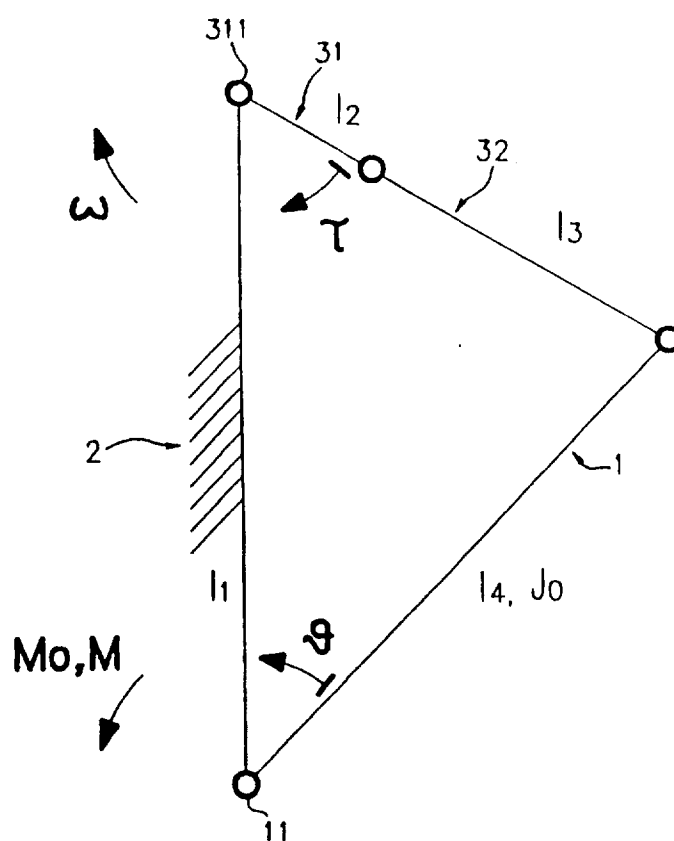


Fig.2

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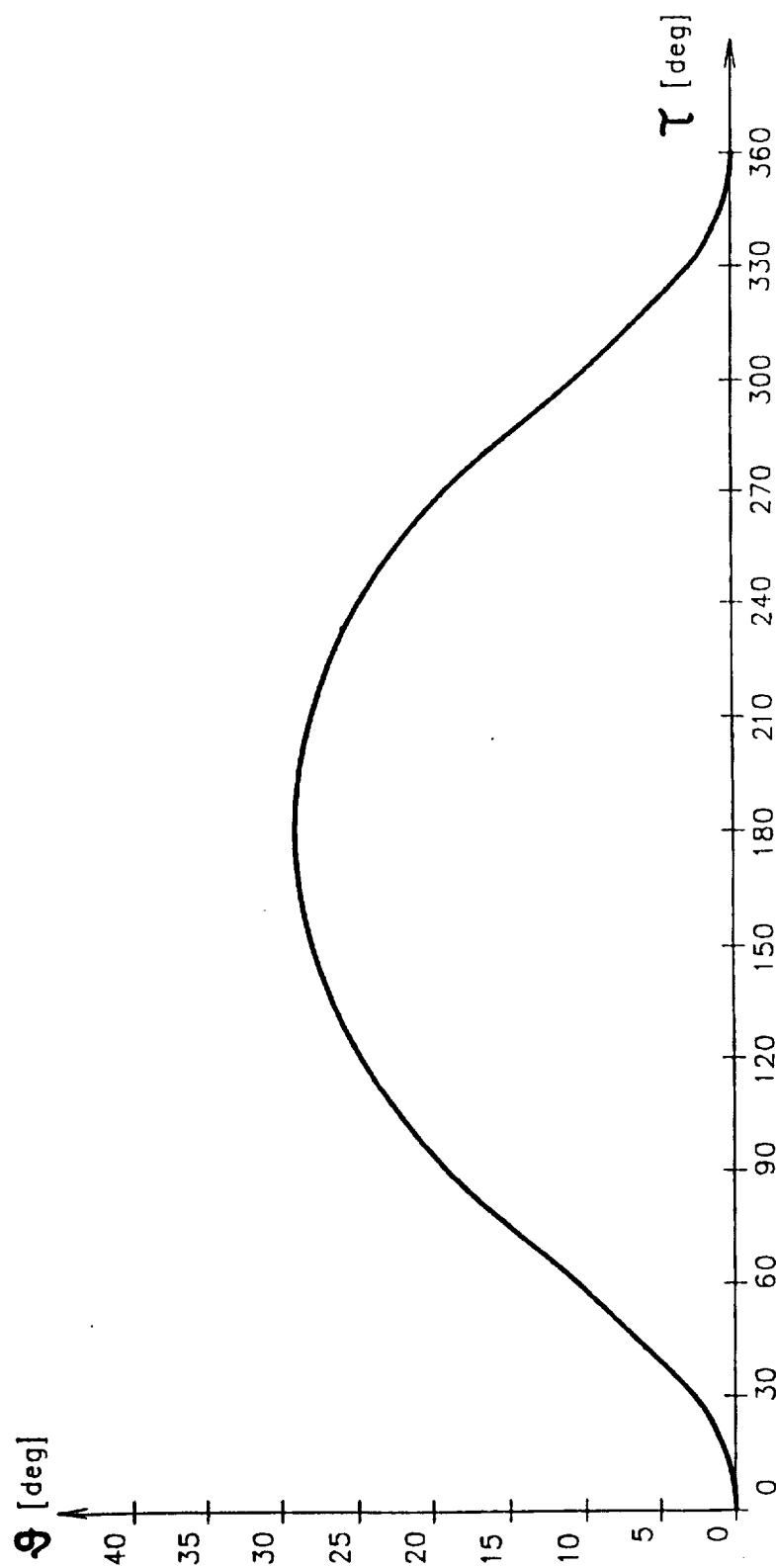


Fig. 3

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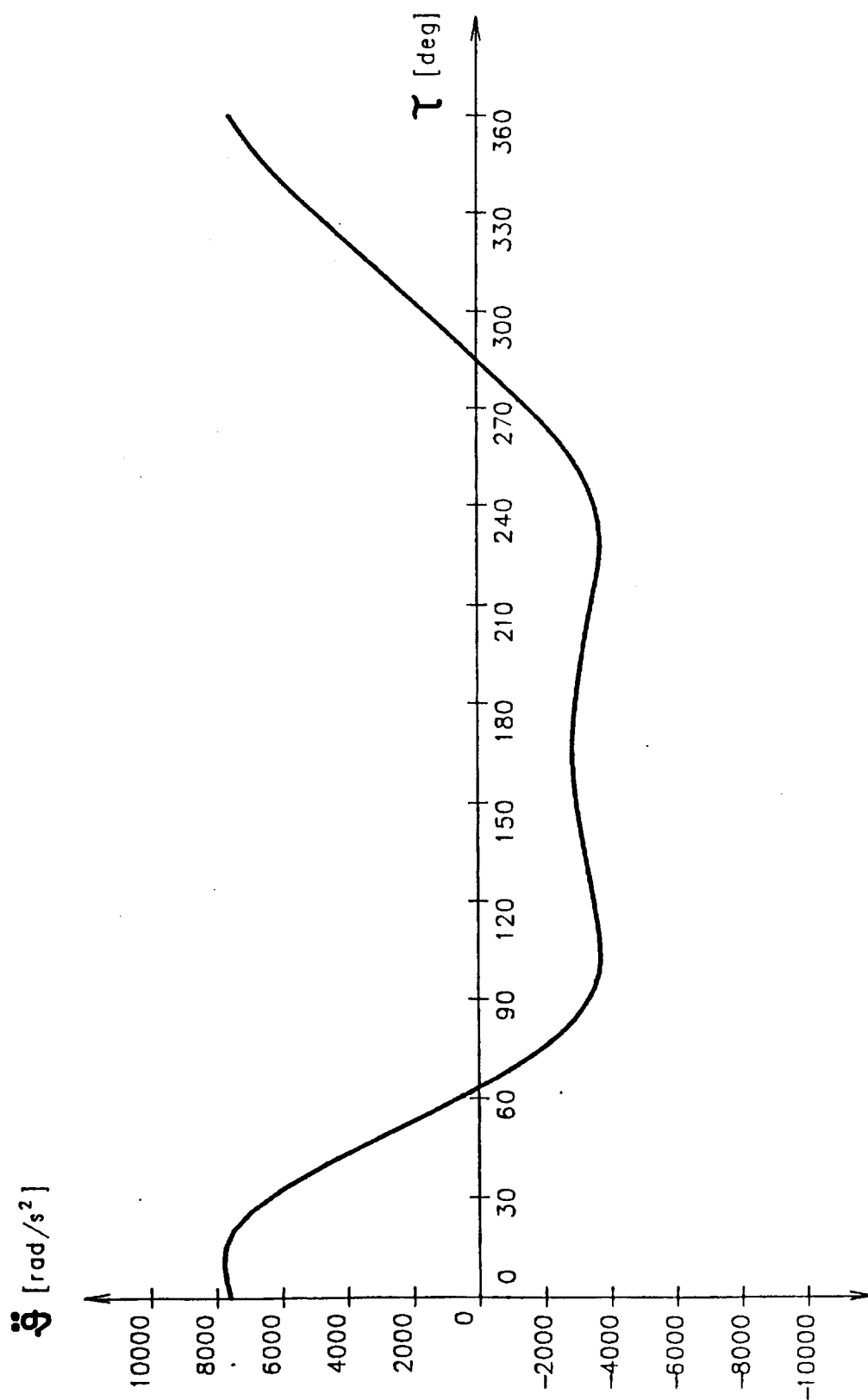


Fig. 4

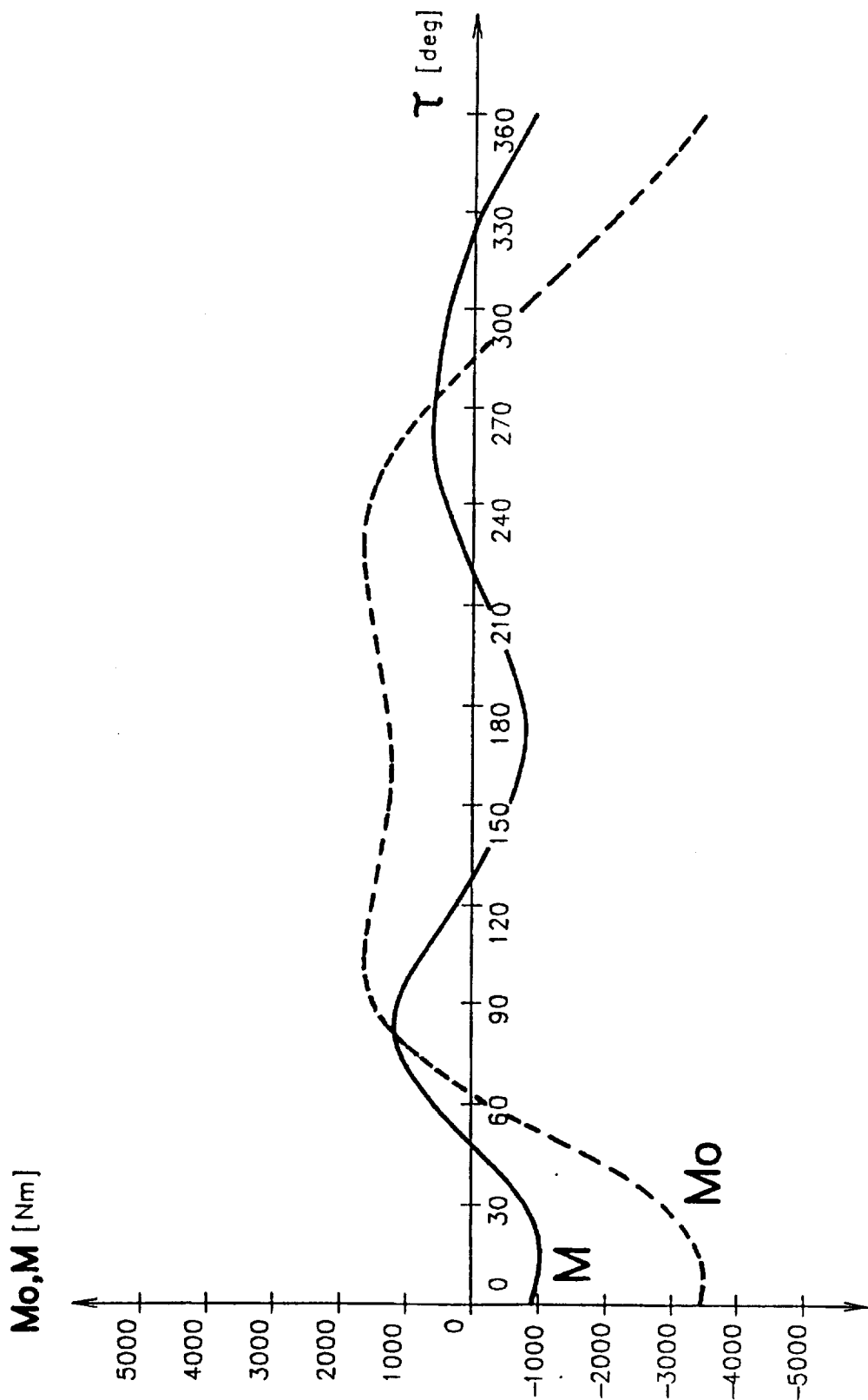


Fig.5