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**Description**

The invention relates to a vibratory conveyor, comprising an oscillating rail, at least one electromagnet having a coil and an armature, which is coupled to the oscillating rail and which can be moved through actuation of the coil, in order to generate an oscillation of the oscillating rail, wherein the coil is part of an oscillator circuit, wherein an oscillator frequency of an oscillator signal of the oscillator circuit depends upon an inductance of the coil, which inductance is influenced by a position of the armature with respect to the coil.

Vibratory conveyors are employed for the transport of materials along rails, for example for the infeed of small components or component parts in automated manufacturing processes. By means of an elliptical vibratory movement, the material to be conveyed is moved along a predefined track. The elliptical vibratory movement is generated by means of at least one electromagnet. The electromagnet periodically attracts an armature which is connected to the oscillating rail of the vibratory conveyor, wherein an elastic reset force is applied to the oscillating rail, and thus to the armature, typically by means of leaf springs.

The conveyor capacity is dependent upon the magnitude of the oscillation amplitude, as a result of which it is intended that the largest possible oscillation amplitude should be achieved. In order to achieve this with a limited energy input, the vibratory conveyor should operate close to its resonant frequency. Problematically, the oscillation of the vibratory conveyor, on the grounds of its design, is typically non-linear, wherein even minor deviations from the resonant frequency can result in strong variations in the oscillation amplitude, or in the breakdown of oscillation.

In order to achieve the excitation of a vibratory conveyor close to its resonant frequency, printed publication DE 195 31

674 proposes the evaluation of the inductance of an actuating coil of the vibratory conveyor which varies at the vibration pulse, in order to match this actuating pulse to the natural frequency of the conveyor. To this end, a digital counter, which increases in fixed frequency increments, is read out at pulse time intervals which are dictated by a resonant circuit, which incorporates the actuating coil as a frequency-defining element. The counter readout thus fluctuates at the pulse of the mechanical vibrations of the conveyor, such that a central unit can calculate a favourable time point for an actuating pulse.

The object of the invention is the disclosure of a vibratory conveyor which, with limited circuit complexity, can be reliably operated close to and/or at the resonant frequency of the vibratory conveyor.

According to the invention, this object is fulfilled by a vibratory conveyor of the above-mentioned type, wherein the vibratory conveyor comprises a feedback circuit which actuates the coil using a control signal that maps a time characteristic of a frequency change of the oscillator frequency.

According to the invention, it is proposed that, in place of external excitation of the vibratory conveyor, wherein the vibratory conveyor is driven by the introduction of a predefined oscillation or by the delivery of predefined current pulses to the coil, self-excitation is employed. Actuation of the coil of the vibratory conveyor proceeds by means of a signal, which is itself derived from the oscillation of the vibratory conveyor. The dependence of the inductance of the coil upon the position of the armature, with respect to the coil, is exploited for this purpose. A coil of an oscillating circuit can specifically be arranged on a yoke which concentrates the magnetic field lines of the coil. The inductance of the coil varies, depending upon the size of the air gap between the yoke and the armature.

If an oscillator circuit is provided which incorporates the coil, specifically as an element of a resonant circuit of the oscillator circuit, the oscillator frequency of the oscillator signal of the oscillator is dependent upon the clearance between the armature and the coil. If the clearance between the armature and the coil is small, the coil has a high inductance which, in an application in a resonant circuit, results in a lower resonant frequency of the resonant circuit, and thus a lower oscillator frequency. As the clearance between the armature and the coil increases, the oscillator circuit is tuned to higher frequencies. The relationship between the oscillator frequency and the clearance between the armature and the coil is thus strictly monotonous, wherein a frequency variation of the oscillator frequency can be approximately interpreted as a location signal for the armature. The frequency variation characteristic of the oscillator frequency thus corresponds to a "distorted" characteristic of the clearance between the armature and the coil. By the feedback of this signal, in the selection of a corresponding phase angle, the vibratory conveyor can be operated close to the resonant frequency. Given that, in this case, oscillation is self-excited, the amplitude of oscillation is stable.

The feedback circuit can comprise a demodulation circuit for frequency demodulation, which is configured to generate, from the oscillator signal, a control signal or a measurement signal, in accordance with which the control signal is provided. The oscillator signal, on the grounds of the oscillation of the vibratory conveyor, and thus on the grounds of the movement of the armature with respect to the coil, assumes a temporally variable oscillator frequency. The oscillator frequency can thus be interpreted as a signal having a carrier frequency, which is frequency-modulated by a modulation signal. By means of a demodulation circuit, it is possible to retrieve the modulation signal, i.e. the time characteristic of the frequency variation of the oscillator frequency.

Alternatively, in the event of a sufficient frequency margin between the resonant frequency of the vibratory conveyor and the oscillator frequency, it would also be possible to measure the oscillation periods of the oscillator signal directly, and to determine the time characteristic of a frequency variation of the oscillator frequency from the latter. For the measurement of an oscillation period, for example, digital counters or analogue integrators can be employed, which are reset in response to a specific gradient and/or a specific value of the oscillator signal.

The demodulation circuit can specifically comprise a phase-locked control loop. The phase-locked control loop can comprise a voltage-controlled oscillator and a phase detector, wherein the phase detector determines a relative phase angle between the voltage-controlled internal oscillator and the infed oscillator signal. A phase detector can be configured such that the infed oscillator signal and the signal of the internal oscillator, for example by saturation, are converted into signals having exactly two potential values, and the two signals are associated by means of a XOR gate. Numerous further phase detectors are known from the prior art.

The output signal of the phase detector can be fed to a loop filter with a predefined limiting frequency. The output signal of the loop filter can be fed back to the voltage-controlled oscillator as a control voltage. If a voltage-controlled oscillator with linear frequency control is employed, the output signal of the loop filter, i.e. the control voltage of the oscillator, with the exception of a constant offset, essentially corresponds to the time characteristic of a frequency variation of the input signal. By means of a phase-locked control loop, to which the oscillator signal is fed as an input signal, a signal is thus delivered, as an output signal, which represents a time characteristic of a frequency variation of the oscillator frequency. Any offset in the output signal can be eliminated, for example, by means of a DC voltage filter and/or the feedback circuit can be balanced, such that the offset is equal to zero.

As an alternative to the employment of a phase-locked control loop in the demodulation circuit, other circuits can also be employed for frequency demodulation, for example discriminator circuits, specifically gradient, difference or phase discriminators.

The feedback circuit can comprise a phase shifter circuit, which is configured to change the phase angle of the measurement signal, in order to provide the control signal. As described above, the time characteristic of the frequency variation of the oscillator frequency approximately represents a change in the position of the armature. In the case of linear oscillations, i.e. oscillations in which the reset force corresponds to the second time derivative for location, it is known that, in the event of resonance, the time characteristic of the excitation force is displaced through 90° in relation to a locus diagram for oscillation. A 90° phase displacement can be achieved, for example, by means of a capacitor, specifically having a down-circuit operational amplifier, i.e. by means of a differentiator circuit. The phase angle of the control signal can be adjusted wherein, specifically, an ohmic resistor is arranged in parallel with the capacitor. Specifically, a variable ohmic resistor can be provided, in order to permit a subsequent adjustment of the phase angle. Alternatively, however, other phase shifter circuits can be employed, for example an all-pass filter.

Advantageously, the feedback circuit comprises an amplifier circuit, which is configured to amplify the measurement signal in order to provide the control signal. The coil of the electromagnets of the vibratory conveyor can be operated at relatively high voltages, for example 110 or 220 V, and high currents can flow therein. A signal processing function, specifically a demodulation of the oscillator signal, by means of power electronics is relatively complex and expensive. It is therefore advantageous to execute the processing of the oscillator signal described above at relatively low voltages and currents, for example in a voltage range of ± 10 V. As a final processing step, the control signal can be amplified, before it is delivered to the coil. Amplification is possible, for example, by means of MOSFETs, IGBTs or similar.

Specifically, it is possible for the measurement signal to be firstly phase displaced, and thereafter amplified, in order to provide the control signal. Before or after the phase displacement of the signal, the latter can additionally be filtered, for example in order to remove higher harmonic oscillation components which are included in the measurement signal, specifically on the grounds of the non-linear relationship between the position of the armature and the frequency variation of the oscillator frequency.

Advantageously, the vibratory conveyor comprises a starter circuit, which is configured to actuate the coil for a prescribed time interval using a prescribed actuation signal. Specifically, the starter circuit can be configured to feed a voltage or current pulse to the coil. Although it is possible for the starter circuit to be configured entirely separately from the feedback circuit, advantageously, the actuation signal of the starter circuit is routed via the above-mentioned amplifier circuit. The specific function of the control signal is to execute a one-off displacement of the vibratory conveyor, such that the vibratory conveyor is then free to oscillate at its resonant frequency thereafter. This free oscillation simultaneously results in a frequency variation of the oscillator frequency, by means of which, as described above, a control signal is provided which permits the vibratory conveyor to operate by self-excitation. Alternatively, it would also be possible to start the vibratory conveyor by means of mechanical excitation.

The oscillator circuit can specifically comprise capacitors which are connected in series with one another and in parallel with the coil, wherein a tap for the oscillator signal is provided between the capacitors. As already described, it is advantageous if the signal processing of the oscillator signal is executed, at least partially, at lower voltages than those applied to the coil. Advantageously, this is possible in that, in the vibratory conveyor according to the invention, the two mutually series-connected capacitors are employed as voltage dividers.

It is possible for the oscillator signal itself to be fed back to the resonant circuit which comprises the coil, in order to maintain the self-oscillation of the oscillator. In order to permit this to be achieved at relatively low voltages, it is possible for the oscillator circuit to comprise two further capacitors which are connected in series with one another and in parallel with the coil, wherein a feedback point for the oscillator signal is provided between the further capacitors.

In the vibratory conveyor according to the invention, the oscillator frequency can be at least five times, and specifically at least ten times as high as a resonant frequency of the oscillation of the oscillating rail. It is thus achieved that the frequency of the characteristic frequency variation of the oscillator frequency is substantially lower than the oscillator frequency itself, as a result of which demodulation can be facilitated. Specifically, in the event of the employment of a demodulation circuit with a phase-locked control loop, a loop filter can be employed, the limiting frequency of which is significantly lower than the oscillator frequency, for example by a factor of five, as a result of which a smooth output signal can be provided.

It is possible for the oscillating rail in the vibratory conveyor according to the invention to be mounted on at least one leaf spring having a plurality of spring layers, wherein the spring layers are each spaced apart by a spacer element and/or wherein a friction-reducing element is arranged between the spring layers. In vibratory conveyors, friction between the spring layers of the leaf springs upon which the oscillating rail is mounted is typically employed for the damping of the oscillation of the oscillating rail, thereby reducing the quality factor of oscillation. This is necessary on the grounds that the oscillation of a vibratory conveyor is typically non-linear, and stable oscillation close to the resonant frequency, in the event of externally-excited non-linear oscillation, is scarcely possible. A temperature variation in the vibratory conveyor, or similar, in the absence of the further damping of externally-excited oscillations, would result in significant amplitude variations in oscillation. However, the vibratory conveyor according to the invention is self-exciting, as a result of which, even in the absence of the additional damping of the vibratory conveyor, i.e. with a high quality factor of oscillation, it is possible to achieve stable operation at, or close to the resonant frequency.

In addition to the vibratory conveyor, the invention further relates to a method for operating a vibratory conveyor which comprises an oscillating rail, at least one electromagnet having a coil and an armature, which is coupled to the oscillating rail, wherein the armature is moved through actuation of the coil, as a result of which an oscillation of the oscillating rail is generated, wherein the coil is part of an oscillator circuit, wherein an oscillator frequency of an oscillator signal of the oscillator circuit depends upon an inductance of the coil which is influenced by the position of the armature with respect to the coil, wherein the vibratory conveyor comprises a feedback circuit, wherein the coil is actuated by the feedback circuit using a control signal that maps a time characteristic of a frequency variation of the oscillator frequency.

The feedback circuit can comprise a demodulation circuit for frequency demodulation, by means of which the control signal or a measurement signal, depending upon which the control signal is provided, is generated from the oscillator signal.

It is possible for the feedback circuit to comprise a phase shifter circuit, by means of which the phase angle of the measurement signal is varied, in order to provide the control signal. Alternatively or additionally, the feedback circuit can comprise an amplifier circuit, by means of which the measurement signal is amplified in order to provide the control signal.

The vibratory conveyor can comprise a starter circuit, by means of which the coil is actuated for a prescribed time interval using a prescribed actuation signal.

Moreover, the method according to the invention can be further developed, in accordance with the characteristics described with respect to the vibratory conveyor according to the invention.

Further advantages and details of the invention proceed from the following exemplary embodiments, and from the associated drawings. In the drawings, schematically:

Fig. 1 shows an exemplary embodiment of a vibratory conveyor according to the invention,

Fig. 2 shows the control electronics of the vibratory conveyor represented in Fig. 1,

Fig. 3 shows a detailed view of a leaf spring in the vibratory conveyor represented in Fig. 1, and

Fig. 4 shows a flow diagram for the method according to the invention.

Figure 1 shows a vibratory conveyor 1, which comprises an oscillating rail 2, upon which goods are transportable by means of vibrations of the oscillating rail 2. The oscillating rail 2 is mounted by means of leaf springs 3 on a base plate 4. In order to excite oscillations in the oscillating rail 2, the vibratory conveyor 1 comprises a coil 5, which is energized by means of a power electronics unit 6. If the coil 5 is energized, a magnetic field is generated, which is concentrated by the yoke 7, as a result of which the armature 8, which is coupled to the oscillating rail 2, is drawn in the direction of the yoke 7, i.e. in the direction of the coil 5.

If the coil 5 is energized with a periodic signal by means of the power electronics unit 6, the force of attraction of the coil 5 to the armature 8 varies periodically, as a result of which an oscillation is generated in the armature 8, and thus in the oscillating rail 2. In order to achieve high amplitudes of oscillation in the oscillating rail 2, and thus a high conveyor capacity with a low energy input, energization of the coil 5 should be executed at a frequency which corresponds to a mechanical resonant frequency of the vibratory conveyor 1.

Stable excitation at, or close to the mechanical resonant frequency of the vibratory conveyor 1 is achieved in the vibratory conveyor 1, wherein self-excitation of the vibratory conveyor is provided, wherein the coil 5 is energized by the power electronics unit 6 with a signal, which is generated in accordance with the oscillation of the oscillating rail 2 of the vibratory conveyor 1. To this end, the property is exploited whereby, in the event of an oscillation of the oscillating rail 2, the armature 8 also oscillates, and the clearance between the yoke 7 and the armature 8 varies accordingly. As a result of the varying air gap between the yoke 7 and the 8, the inductance of the coil 5 also varies in response to an oscillation of the oscillating rail 2. The power electronics unit 6 is configured to evaluate the variation in the inductance of the coil 5 and, in accordance with these variations in inductance, to deliver a control signal for the energization of the coil 5. This is described in greater detail hereinafter, with reference to Figure 2.

Figure 2 shows a schematic representation of the layout of the power electronics unit 6, and the connection of the power electronics unit 6 to the coil 5. The coil 5, in combination with the capacitors 9, 10, 11, 12, constitutes a resonant circuit. A resonant frequency of the resonant circuit is dependent upon the inductance of the coil 5, which varies in accordance with the oscillation of the oscillating rail 2. The resonant circuit, in combination with a driver circuit 13, constitutes an oscillator circuit 21, wherein the resonant frequency of the resonant circuit dictates the oscillator frequency of an oscillator signal of the oscillator circuit 21.

The oscillator signal of the oscillator circuit 21 is tapped-off at a tap 14 between the capacitors 9 and 10. The capacitors 9 and 10 function as voltage dividers wherein, on the tap 14, lower maximum voltages are achieved than those which are applied to the coil 5 during the operation of the vibratory conveyor 1. Relatively high voltages, for example up to 220 V, are fed to the coil. The capacitors 9, 10 are selected such that the maximum voltage on the tap 14 does not exceed a predefined value, for example 12 V. Accordingly, the feedback of the oscillator signal and the evaluation of the oscillator frequency, which is described in greater detail hereinafter, can be executed using circuits which are configured for low-voltage operation.

In order to maintain oscillation in the resonant circuit, the driver circuit 13 amplifies a signal which is tapped-off at the tap 14, adjusts the phase of the signal, and injects it back into the resonant circuit at a point 15 between the capacitors 11 and 12. The capacitors 11, 12, correspondingly to the capacitors 9, 10, function as voltage dividers. By means of feedback from the tap 14 via the driver circuit 13 to the injection point 15, stable self-oscillation of the oscillator circuit 21 is achieved at an oscillator frequency which is dictated by the resonant circuit, specifically by the coil 5.

The resonant frequency of a resonant circuit, and thus the oscillator frequency of the oscillator signal of the oscillator circuit 21, is inversely proportional to the root of the inductance of the coil of the resonant circuit. If the armature 8 approaches the yoke 7, the inductance of the coil 5 is increased and the oscillator frequency is reduced correspondingly, and vice versa. In the event of an oscillation of the oscillating rail, the oscillator frequency thus varies at a frequency which corresponds to the frequency of oscillation of the oscillating rail. The variation of the oscillator frequency moreover assumes a specifically defined phase angle in relation to the oscillation of the oscillating rail 2. The time characteristic of the frequency variation of the oscillator frequency is thus an appropriate measurement signal, which can be employed as a control signal for the coil 5, or from which a control signal for the coil 5 can be derived, in order to operate the vibratory conveyor at, or close to the resonant frequency of the vibratory conveyor 1.

To this end, at the connection point 16, the oscillator signal is extracted from the oscillator circuit 21 and fed to a demodulation circuit 17. The function of the demodulation circuit 17 is the frequency demodulation of the oscillator signal, in order to provide a time characteristic of a frequency variation of the oscillator frequency. Demodulation of the oscillator signal is executed by the use of a phase-locked control loop. The oscillator signal is routed to one input of a phase detector, the other input of which is connected to the output of an internal, voltage-controlled oscillator of the phase-locked control loop. The output signal of the phase detector corresponds to a phase difference between the signal of the internal oscillator and the oscillator circuit. Numerous phase detector circuits are known, on the grounds of which a saturation of both signals and the routing of the saturated signals to a digital XOR gate is mentioned for exemplary purposes only. The output signal of the phase detector is fed to a loop filter, and the signal thus filtered is employed for the voltage control of the internal oscillator. By the “locking home” of the phase-locked control loop, the output voltage of the loop filter, excluding any potential offset, corresponds to the frequency of the incoming signal, and thus to the oscillator frequency of the oscillator circuit 21. By a corresponding equalization of the demodulation circuit 17, or by means of a high-pass filter, a signal is provided which maps a time characteristic of a frequency variation of the oscillator frequency of the oscillator circuit 21.

The signal is routed by way of a measurement signal to a phase shifter circuit 18, which can alter the phase of the measurement signal. Phase displacement is possible, for example, by the routing of the measurement signal to a parallel circuit between a resistor and a capacitor. According to the relative ratings of the resistor and the capacitor, a phase of the resulting current is dictated accordingly. Thereafter, for example by means of an operational amplifier, the current can be converted back into a voltage. The inductance of the coil 5, and thus the oscillator frequency of the oscillator circuit 21 fluctuate, as described, according to a clearance between the armature 8 and the yoke 7 or the coil 5. The oscillator frequency thus represents, with a degree of distortion, a position of the armature 8, and thus of the oscillating rail 2. If the oscillation of the vibratory conveyor 1 were a harmonic oscillation, a signal would be selected, by way of an excitation signal, which is phase displaced through 90° in relation to a position of the oscillation of the oscillating rail 2. Even in the event of a non-harmonic oscillation of the vibratory conveyor 1, as anticipated for the vibratory conveyor 1, a phase displacement by the phase shifter circuit 18 of the order of 90° is advantageous.

Before or after phase displacement, the measurement signal can additionally be filtered by means of an unrepresented filter circuit, in order to damp higher harmonic oscillations in the measurement signal. Specifically on the grounds of the non-linear relationships between the clearance of the armature 8 from the yoke 7 and the inductance of the coil 5, and between the oscillator frequency of the oscillator signal of the oscillator circuit 21 and the inductance of the coil 5, the measurement signal can incorporate significant harmonic components, the feedback of which is not desired.

Thereafter, the measurement signal is fed to the amplifier circuit 19, which amplifies the measurement signal and delivers a control signal. By means of the amplifier circuit 19, a changeover is executed to a higher voltage range, at which the coil 5 is operated, for example a voltage range of up to 220 V. The amplified control signal is injected into the resonant circuit at the point 22, and is thus applied to the coil 5.

The demodulation circuit 17, the phase shifter circuit 18 and the amplifier circuit 19, in combination, thus constitute a feedback circuit 23, which actuates the coil by means of a control signal which maps a time characteristic of a frequency variation of the oscillator frequency. By means of this actuation, self-excitation of the vibratory conveyor 1 is achieved such that, by a one-off excitation, stable oscillation of the vibratory conveyor 1 at or close to the resonant frequency is maintained. The amplitude of oscillation can be dictated by the amplification factor of the amplifier circuit 19. Alternatively or additionally, the amplitude, and additionally the oscillating frequency with respect to the resonant frequency of the vibratory conveyor 1, can be adapted by an adjustment of the magnitude of the phase variation in the phase shifter circuit 18.

If only self-excitation of the vibratory conveyor 1 is executed, the start-up of the vibratory conveyor 1 must proceed by the mechanical excitation of oscillation. In order to permit the simple and reliable start-up of the vibratory conveyor 1, the power electronics unit 6 comprises a starter circuit 20, which actuates the coil for a prescribed time interval using a prescribed actuation signal. By means of the starter circuit 20, the amplifier circuit 19 is thus employed in combination. The actuation signal is a current pulse of a defined length. By means of the current pulse, the armature 8, and thus the oscillating rail 2, is displaced on a one-off basis, and oscillates thereafter, at the end of the current pulse, at the resonant frequency of the vibratory conveyor 1. Correspondingly, the oscillator frequency of the oscillator circuit 21 varies in response to this oscillation and, by means of the demodulation circuit 17, a measurement signal is obtained which, as described, can be further processed and fed back, in order to maintain oscillation.

A key advantage of self-excited oscillations is provided in that a stable operation of the vibratory conveyor at, or close to the resonant frequency is possible, even where no additional damping of the vibratory conveyor 1 is provided. In typical vibratory conveyors, for the purposes of additional damping, leaf springs are employed, the spring layers of which engage in friction contact, thereby decreasing the energy of oscillation. Additional damping of this type is not necessary in the vibratory conveyor 1 according to the invention. The efficiency of the vibratory conveyor 1 according to the invention can thus be further enhanced by the omission of such additional damping. Accordingly, in the vibratory conveyor according to Figure 1, leaf springs 3 are employed, the structure of which is illustrated in Figure 3. The leaf springs 3 comprise a plurality of spring layers 24, which are connected by means of an edge-mounted connecting element 25. Between the spring layers 24, spacers 26 are arranged, as a result of which voids 27 are constituted between the spring layers 24. As the spring layers 24 are spaced from one another by the voids 27, they do not engage or, in the event of substantial bending, engage in friction contact to a far lesser extent than in customary leaf springs, in which the spring layers are arranged directly against one another. The oscillation of the vibratory conveyor 1 is thus damped to a lesser extent than in customary vibratory conveyors.

Figure 4 illustrates a method for operating a vibratory conveyor 1, wherein the vibratory conveyor 1 operates by self-excitation. The design of the vibratory conveyor 1 corresponds to the vibratory conveyor described with reference to Figures 1 to 3. In step S1, an oscillation of the oscillator circuit 21, which comprises the coil 5, is tapped-off at a tap 14. The oscillator oscillation is firstly fed back to the resonant circuit, which is constituted by the coil 5 and the capacitors 9, 10, 11, 12, and is secondly routed to a demodulation circuit 17.

In step S2, the oscillator oscillation is demodulated by the demodulation circuit 17, wherein a signal is delivered, the characteristic of which corresponds to a frequency variation of the oscillator frequency. In step S3, this signal undergoes phase displacement by means of the phase shifter circuit 18.

In step S4, the phase displaced signal is amplified, in order to provide a control signal which is employed in step S5 for the actuation of the coil.

Patentkrav

1. Rystetransportør omfattende en rysteskinne (2), i det mindste en elektromagnet med en spole (5) og et med rysteskinnen (2) forbundet anker (8), som kan bevæges ved hjælp af en styring af spolen (5) til frembringelse af en svingning i rysteskinnen (2), idet spolen (5) er en del af et oscillatorkredsløb (21), idet en oscillatorfrekvens i et oscillatorsignal i oscillatorkredsløbet (21) afhænger af en ved hjælp af ankerets (8) position i forhold til spolen (5) påvirket induktivitet i spolen (5), idet spolen (5) er et element i en svingningskreds i oscillatorkredsløbet (21), idet resonansfrekvensen i svingningskredsen bestemmer oscillatorfrekvensen i oscillatorsignalet, kendetegnet ved, at rystetransportøren (1) omfatter et tilbagekoblingskredsløb (23), som styrer spolen (5) med et styresignal, som illustrerer et tidsmæssigt forløb i en frekvensændring i oscillatorfrekvensen.

2. Rystetransportør ifølge krav 1, kendetegnet ved, at tilbagekoblingskredsløbet (23) omfatter et demodulationskredsløb (17) til frekvens-demodulationen, som er udformet til ud fra oscillatorsignalet at generere styresignalet eller et målesignal, afhængigt af hvilket styresignalet tilvejebringes.

3. Rystetransportør ifølge krav 2, kendetegnet ved, at demodulationskredsløbet (17) omfatter en faselåst reguleringskreds.

4. Rystetransportør ifølge krav 2 eller 3, kendetegnet ved, at tilbagekoblingskredsløbet (23) omfatter et fasevenderkredsløb (18), som er udformet til at ændre fasepositionen i målesignalet for at tilvejebringe styresignalet.

5. Rystetransportør ifølge et af kravene 2 til 4, kendetegnet ved, at tilbagekoblingskredsløbet (23) omfatter et

forstærkerkredsløb (19), som er udformet til at forstærke målesignalet for at tilvejebringe styresignalet

6. Rystetransportør ifølge et af de foregående krav, kendetegnet ved, at den omfatter et starterkredsløb (20), som er udformet til at styre spolen (5) i et forud angivet tidsinterval med et forud givet styresignal.

7. Rystetransportør ifølge et af de foregående krav, kendetegnet ved, at oscillatorkredsløbet (21) omfatter to indbyrdes serieforbundne og i forhold til spolen (5) parallelt forbundne (5) koblede kondensatorer (9, 10), idet der mellem kondensatorerne (9, 10) er tilvejebragt en sensor (14) til oscillatorsignalet.

8. Rystetransportør ifølge et af de foregående krav, kendetegnet ved, at oscillatorfrekvensen er i det mindste fem gange, navnlig i det mindste 10 gange, så stor som resonansfrekvensen for svingningerne i rysteskinnen (2).

9. Rystetransportør ifølge et af de foregående krav, kendetegnet ved, at rysteskinnen er lejret ved hjælp af i det mindste en bladfjeder (3) med flere fjederlejer (24), idet fjederlejerne (24) hver især har en afstand til hinanden ved hjælp af et afstandselement (26), og/eller idet der er placeret et friktionsreducerende element mellem fjederlejerne.

10. Fremgangsmåde til drift af en rystetransportør, som omfatter en rysteskinne, i det mindste en elektromagnet med en spole og et med rysteskinnen forbundet anker, idet ankeret bevæges ved hjælp af en styring af spolen, hvorved der frembringes en svingning i rysteskinnen, idet spolen er en del af et oscillatorkredsløb, idet en oscillatorfrekvens i et oscillatorsignal i oscillatorkredsløbet afhænger af en ved hjælp af ankerets position i forhold til spolen påvirket induktivitet i spolen, idet spolen (5) er et element i en svingningskreds i oscillatorkredsløbet (21), idet resonansfrekvensen i svingningskredsen bestemmer

oscillatorfrekvensen i oscillatorsignalet, kendetegnet ved, at rystetransportøren omfatter et tilbagekoblingskredsløb, idet spolen styres af tilbagekoblingskredsløbet med et styresignal, som illustrerer et tidsmæssigt forløb i en frekvensændring i oscillatorfrekvensen.

11. Fremgangsmåde ifølge krav 10, kendetegnet ved, at tilbagekoblingskredsløbet omfatter et demodulationskredsløb til frekvens-demodulationen, ved hjælp af hvilken der ud fra oscillatorsignalet genereres styresignalet eller et målesignal, afhængigt af hvilket styresignalet tilvejebringes.

12. Fremgangsmåde ifølge krav 11, kendetegnet ved, at tilbagekoblingskredsløbet omfatter et fasevenderkredsløb, ved hjælp af hvilket fasepositionen i målesignalet ændres til at tilvejebringe styresignalet.

13. Fremgangsmåde ifølge krav 11 eller 12, kendetegnet ved, at tilbagekoblingskredsløbet omfatter et forstærkerkredsløb, ved hjælp af hvilket målesignalet forstærkes til at tilvejebringe styresignalet.

14. Fremgangsmåde ifølge et af de foregående krav, kendetegnet ved, at rystetransportøren omfatter et starterkredsløb, ved hjælp af hvilket spolen styres i et forud givet tidsinterval med et forud givet styresignal.

FIG. 1

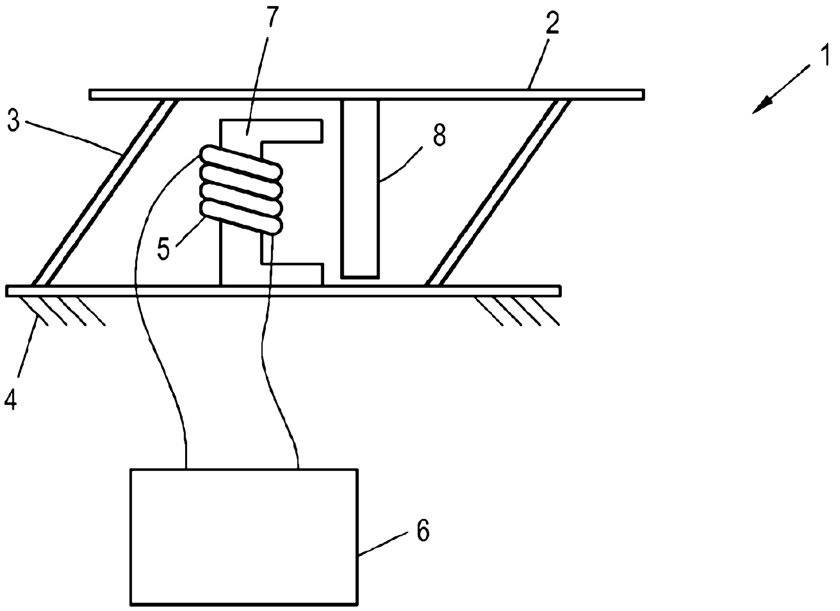


FIG. 2

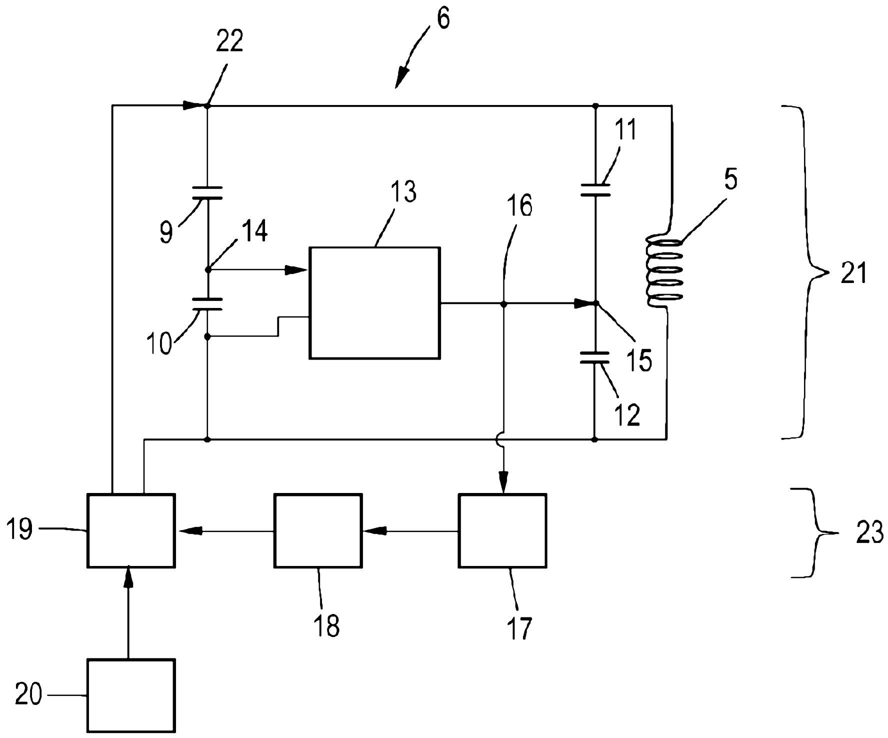

FIG. 3

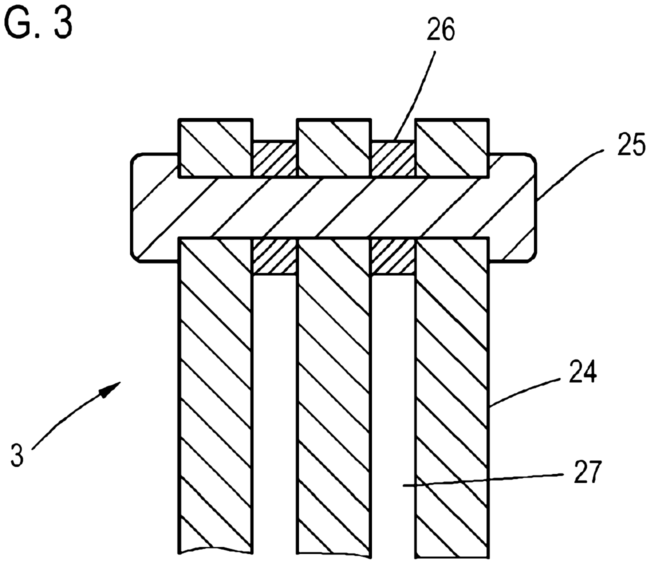


FIG. 4