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(54) DEVICE FOR AUTOMATICALLY EXCITING AND STABILISING RESONANCE OSCILLATIONS OF ULTRASONIC SYSTEMS

(57) The invention relates to production process automation and is directed at producing mechanical ultrasonic oscillations by using electric energy. The inventive oscillation exciting device with automatic frequency adjustment during operation comprises an electroacoustic converter connected to an amplifier, which is integrated into a feedback circuit, and a power supply. The device is provided with a current intensity sensor arranged in the power circuit of the electroacoustic converter which is formed by means of the feedback circuit provided with a phase shifter. The input of the phase shifter is connected to the current intensity sensor and the output thereof is connected to the amplifier input, the device exhibiting a high stability and making it possible to increase operational load.

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Description

Field of the invention

[0001] The invention relates to production process automation and is directed at producing mechanical ultrasonic oscillations by using electric energy.

Prior art

[0002] An ultrasonic phase stabilized oscillator is known, comprising serially connected driving oscillator and power amplifier, connected to an ultrasonic converter, connected to a current sensor output and a phase locked loop connected to an adjusting element, its output connected to the driving oscillator input (patent RU 25699, cl. B 06 B 1/0, 20.10.2002)

[0003] The disadvantage of the known device is an impossibility to implement the entire amplitude-frequency response, as there are branches instable is forced oscillation regimes. Precisely for this reason the device does not have sufficient stability what decreases possible technologic load.

[0004] Possible configurations of amplitude-frequency responses of such ultrasonic technologic system at various values of feeding force P are given in Fig.1. Sceleton curves «a» defining the dependence of natural frequency of non-linear system on the amplitude of oscillations and the line of limiting amplitudes «b», that is an envelope of resonance curves, are shown with thin solid lines.

[0005] At P=0, i.e. at idle running we have a typical amplitude-frequency response of a linear oscillating system. With the feeding force increase up to a certain critical value P_{cr} the resonance curve nature does not change, and the resonance frequency moves to a higher frequency area. Upon exceeding the critical value of the feeding force the resonance curve appearance leaps. An instable branch appears which is shown by a dot-and-dash line. In this case the resonance mode may be achieved either by pulling oscillations from the higher frequency area or by hard start, by imparting additional energy to the system. But even if the resonance regime is successfully achieved, it's rather problematical to keep near the resonance state, as a small exciting frequency decrease or small load increase lead to failure of oscillations as is shown by a vertical arrow in Fig.1

[0006] Therefore it is necessary to control frequency when the ultrasonic system operating conditions are changed. Apparently that at minor change of conditions the system oscillations amplitude, tuned to its natural frequency ω_O, falls sharply. The similar in operation device as well as majority of known devices with forced oscillations implementation attempt to implement control by changing the driving oscillator frequency. Meanwhile it is taken into account that at resonance the phase shift between voltage and current in the power circuit is a constant value and deviation from this constant value is used as a criterion of tuning to the resonance frequency.

[0007] It's worth while to note that regardless of the driving oscillator frequency control unit structure, the system operating in the forced oscillations regime is able to work only at feeding forces $P < P_{cr}$ until non-linear effects in resonance curves behavior do not show themselves. At $P > P_{cr}$ any overregulation leads to oscillations failure. That's why the known device does not allow to use all performance potentials of ultrasonic technologic systems. The case is that the implementation of non-linear resonance modes would allow to operate at feeding forces, several tens times exceeding the critical value P_{cr}.

[0008] The closest technical solution is the device for exciting and automatic stabilization of resonance oscillations of ultrasonic systems, comprising an electroacoustic converter and oscillation sensor connected to an amplifier, which is integrated into a feedback circuit, and a power supply (certificate of authorship SU 483148, cl. B 06 B 1/02, 05.09.1975). A microphone gapped with regard to a free butt-end of the oscillating system, excited by the electroacoustic converter, is used as an oscillation sensor.

[0009] The disadvantage of this device is constructive complexity of microphone installation into the oscillating system package, due to the necessity to ensure running wave emission by the free butt-end of the oscillating system because any wave reflections from the package walls result is standing waves generation and make the device unable to work.

Disclosure of the invention

[0010] The purpose of the invention is to remove the above disadvantages. The technical result of the invention implementation is simplification of the construction of the device for exciting and stabilization of ultrasonic systems, enhancement of a possible technological load and increase of the device operation stability. The set task is solved and the technical result is achieved by the fact that the device for exciting and automatic stabilization of resonance oscillations of ultrasonic systems, comprising an electroacoustic converter connected to an amplifier, which is integrated into a feedback circuit, and a power supply is equipped with a current intensity sensor in the power circuit of the electroacoustic converter which is formed by means of the feedback circuit equipped with the phase shifter, the input thereof is connected to the current intensity sensor and the output thereof is connected to the amplifier input. The proposed device does not have the prior art disadvantages, because the feedback is arranged using electric parameters instead of mechanic ones.

Short description of drawings

[0011]

Fig.1 shows change of amplitude-frequency responses of an ultrasonic technologic system working

into a non-linear technologic load upon its change;
Fig.2 shows the device block structure;
Fig.3 shows the amplifier response.

Best method for carrying out the invention

[0012] The device for exciting and automatic stabilization of resonance oscillations of ultrasonic systems comprises an oscillation system, its oscillations are excited by electroacoustic converter, piezoelectric converter 1, connected to amplifier 2, which is integrated into a feedback circuit, and power supply 3. Current intensity sensor 4 is connected to electroacoustic converter power circuit I_3 which is formed by means of the feedback circuit. The feedback circuit is also equipped with phase shifter 5, the input thereof is connected to the current intensity sensor 4 and the output thereof is connected to the amplifier input 2. Alternative electric voltage is fed to converter 1 coatings what results in exciting of mechanical oscillations that are transferred to a tool installed at a free end of the concentrator. The whole system is squeezed up against the work piece (marked by section lining) by static force (Fig.2). A vibrating tool performs the technological operation. The technology process execution efficiency depends mainly on amount of pressure effort and tool oscillation amplitude. The more are these amounts the higher is the performance of the device.

[0013] This circuit lacks the driving oscillator, and the oscillation frequency is not imposed on the device from the outside. The system operates in the self-excited oscillation regime instead of that of forced oscillations. In this case the oscillations are excited using the positive feedback circuit.

[0014] In the proposed device the positive feedback circuit is made using electric parameters, i.e. the intensity of current in the converter power circuit. In order to ensure excitation and maintain resonance oscillations upon technologic load variation over a wide range, a phase shifter is integrated into the feedback circuit, ensuring phase shift between the converter supply current and voltage, corresponding to the resonance regime.

[0015] As the device operates in the self-excited oscillation regime the non-linear amplifier is constructed so as to ensure the self-excitation of oscillations. Self-excitation occurs if the initial amplification factor is big enough. The self-excitation occurs always in case of relay characteristic. The oscillation amplitude is adjusted by amplifier response limiting level (Fig.3), where U_S is sensor voltage, proportional to the current intensity in the power circuit and U_H is electroacoustic converter supply voltage. The slope of the initial part of the response defines the initial amplification factor. If a certain value of the initial amplification factor is exceeded the self-excitation of oscillations occurs.

[0016] The amplitude of steady oscillations is determined by U_V saturation level. At a certain phase shift value, set by the phase shifter, the oscillations of the ultrasonic system occur at its resonance frequency even if it changes owing to change of system or technologic load parameters over a wide range.

Industrial applicability

[0017] Owing to its implementation in the self-oscillation regime device, by changing the phase in the feedback circuit the entire amplitude-frequency response can be implemented, including the branches instable in the forced oscillation regime. Due to precisely this reason the claimed device is absolutely stable and allows to increase the technologic load in tens of times compared to equally powerful systems operating in the forced oscillation regime. This device can be used for turning, wire drawing, strengthening surface treatment, etc.

Claims

1. Device for exciting and automatic stabilization of resonance oscillations of ultrasonic systems, comprising an electroacoustic converter, connected to an amplifier, which is integrated into a feedback circuit, and power supply, **characterized in that** the device is equipped with a current intensity sensor arranged in the electroacoustic converter power circuit, formed by means of the feedback circuit, equipped with a phase shifter, the input thereof is connected to the current intensity sensor and the output thereof is connected to the amplifier input.

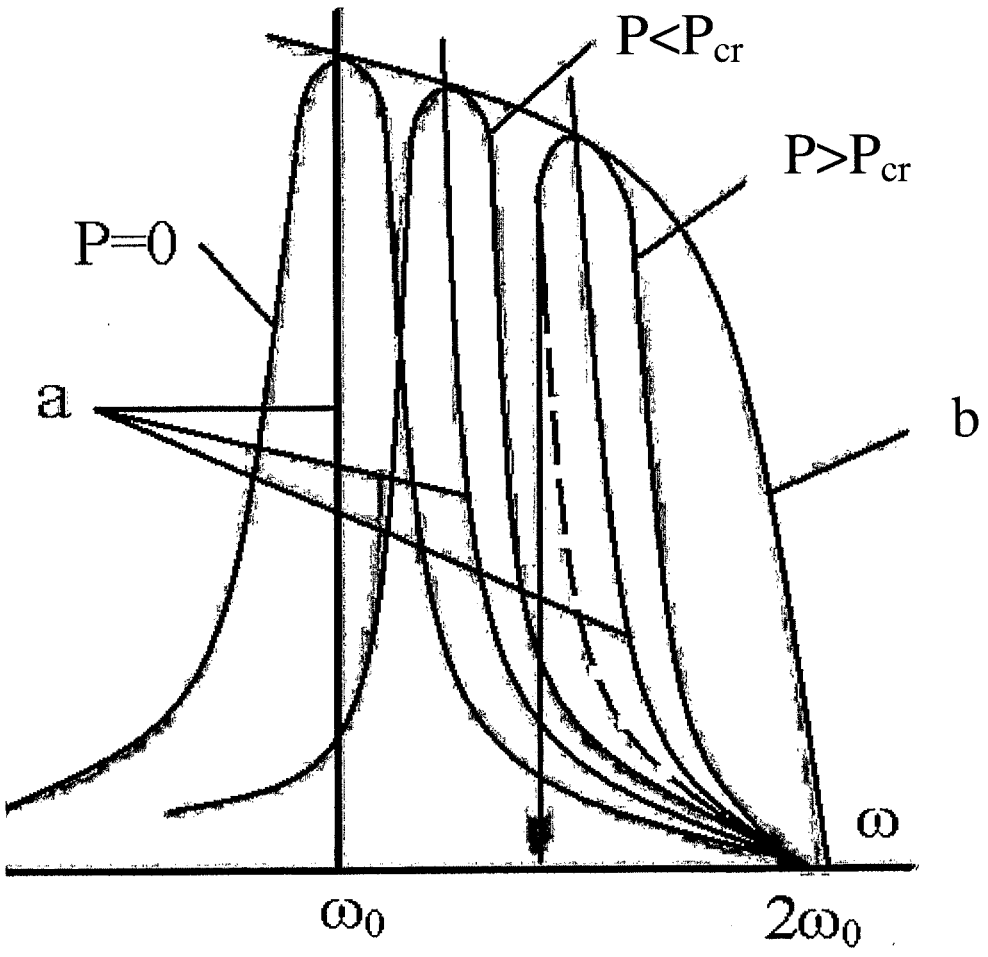

Fig. 1

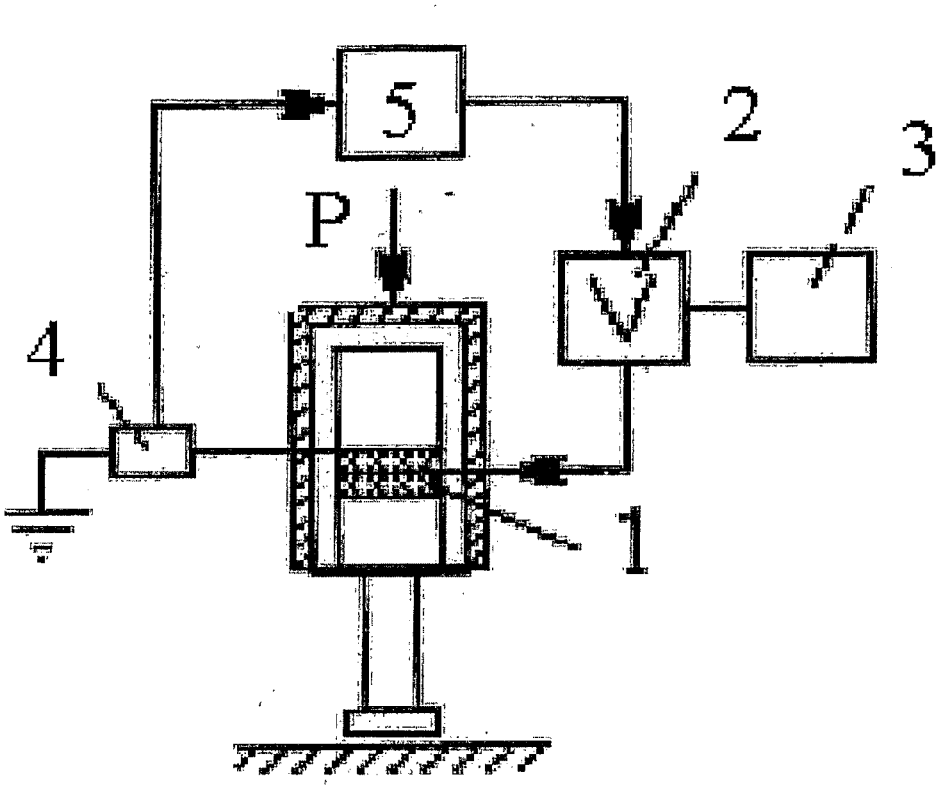

Fig. 2

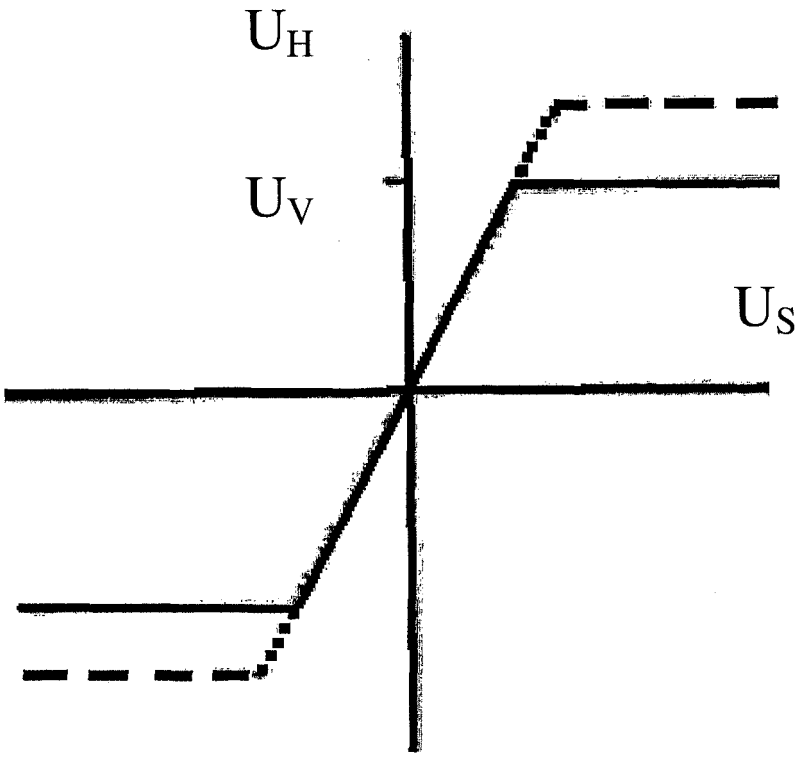

Fig. 3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/RU 2007/000699

A. CLASSIFICATION OF SUBJECT MATTER

B06B 1/06 *(2006.01)*

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B06B 1/00, 1/02, 1/06, B23K 20/00, 20/10, G01N 29/00, 29/34, G05B 13/00, 13/02, H01L 41/00, 41/04, H02N 2/00, H02K 35/00, 35/02, H03L 7/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	SU 483148 A (GOSUDARSTVENNIY NAUCHNO-ISSLEDOVATELSKII INSTITUT MASHINOVEDENIYA) 11.12.1975	1
A	SU 612356 A (ROSTOVSKII-NA-DONU INSTITUT SELSKOKHOZYAISTVENNOGO MASHINOSTROENIYA) 08.06.1978	1
A	SU 557825 A (M.S. GULKO) 20.06.1977	1
A	JP 10226196 A (HONDA ELECTRONIC et al.) 25.08.1998	1
A	JP 4275075 A (NIPPON ELECTRIC CO) 30.09.1992	1

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
21 March 2008 (21.03.2008)	27 March 2008 (27.03.2008)
Name and mailing address of the ISA/ **RU**	Authorized officer
Facsimile No.	Telephone No.

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- RU 25699 **[0002]**
- SU 483148 **[0008]**