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Europäisches Patentamt
European Patent Office
Office européen des brevets

11 Publication number:

0 031 937
B1

12

EUROPEAN PATENT SPECIFICATION

45 Date of publication of patent specification: **21.11.85**

51 Int. Cl.⁴: **F 15 C 3/14, F 15 B 5/00**

21 Application number: **80108033.4**

22 Date of filing: **18.12.80**

54 **An electro-pneumatic or electro-hydraulic transducer.**

30 Priority: **21.12.79 FI 794041**

43 Date of publication of application:
15.07.81 Bulletin 81/28

45 Publication of the grant of the patent:
21.11.85 Bulletin 85/47

84 Designated Contracting States:
AT BE CH DE FR GB IT LI LU NL SE

56 References cited:
DE-A-2 239 060
DE-A-2 511 752
GB-A-2 016 746
US-A-3 099 995
US-A-3 456 669

78 Proprietor: **S-INSTALLATION Ky**
Pyssymiehenkatu 13
SF-40630 Jyväskylä 63 (FI)

72 Inventor: **Seppänen, Alpo, Dipl.-Ing.**
Pyssymiehenkatu 13
SF-40630 Jyväskylä 63 (FI)

74 Representative: **Tiedtke, Harro, Dipl.-Ing. et al**
Patentanwaltsbüro Tiedtke-Bühling-Kinne-
Grupe-Pellmann-Grams-Struif Bavariaring 4
Postfach 20 24 03
D-8000 München 2 (DE)

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Description

The present invention relates to an electro-pneumatic or electro-hydraulic transducer, in which there is a pneumatic or hydraulic nozzle-flap system, which flap is controlled by an electric control signal, as described in the preamble of claim 1.

A transducer comprising the features of the preamble of claim 1 is known from US—A—3 099 995. In this known transducer, an oscillating control signal with variable duty-cycle is applied to the flap, and thereby it is ensured that the adjustment drive for the flap and the flap itself can have a smaller mass, and thus a high response speed can be achieved. The known transducer operates in the manner that the flap opens and closes alternately the nozzle. In order to ensure that the thus adjusted pressure corresponds to the duty-cycle of the electric control signal, the pressure in the pressure chamber upstream of the nozzle shall change between inlet pressure and atmospheric pressure, and this necessitates an extremely small pressure chamber. Due to the necessity to have a small pressure chamber, the known transducer is subject to considerable precision requirements and constructive restrictions. Besides, an increase of the frequency is limited by the size of the pressure chamber. Moreover, the customary nozzle-flap systems, i.e. systems with the usual dimensions, cannot be used in the known transducer.

It is the object of the invention to develop the transducer according to the preamble in such a way that the precision requirements with view to the nozzle-flap system are not so strict, in particular, that it becomes possible to structurally use the same nozzle-flap system commonly used in transducers.

This object is achieved according to the invention by means of the features in the characterizing portion of claim 1, i.e. it is achieved mainly by the fact that, during the operation of the transducer, the range of movement of the flap is limited to a specific range excluding the positions of completely closed or opened nozzle.

In the transducer of the invention, the input pressure or the atmospheric pressure need not be produced in its pressure chamber. Therefore the pressure chamber resp. the volume between the nozzle and the restricted inlet orifice can be much greater in the transducer of the invention than in the known transducer (US—A—3 099 995). An extensive correspondence of the duty-cycle of the applied electric control signal to the output pressure out is still ensured, namely by limiting the range of movement of the nozzle flap. The precision requirements to the design of a small pressure chamber are therefore not as strict as in the case of the known transducer, and the increase of the frequency is not limited by the volume of the pressure chamber.

The subclaims specify advantageous developments of the invention.

Embodiments of the invention will now be described in detail, by way of examples only.

Figure 1 is an exemplary embodiment of an electro-pneumatic transducer.

Figure 2 is a qualitative representation of the characteristic curve of a pneumatic nozzle-flap system.

Figure 3 shows three electric control signals.

Figure 4 illustrates a second embodiment of the electro-pneumatic transducer.

Figure 5 illustrates a third embodiment of the electro-pneumatic transducer as provided to actuate a valve.

An electro-pneumatic transducer illustrated in Figure 1 comprises a nozzle-flap device, essentially known as such. This device comprises flap 10 made of flexible material or supported by bearings at 11. The nozzle-flap device comprises pipe 15 with throttle 16 forming a restricted inlet orifice and, near flap 10, nozzle 14. Nozzle pipe 15 the interior of which is forming a pressure chamber is connected by pipe 17 to variable-pressure tank (pressure P), where the output pressure P_{out} of the transducer is taken from. On the other side of flap 10, opposite to nozzle 14, there is an electromagnetic coil 12. An electric pulse sequence $I(\tau)$, illustrated in Figure 3, oscillating at a certain basic frequency f_0 or alternately at a certain variable frequency f , and of an amplitude I_0 as constant as possible, is conducted to terminals 13 of electromagnetic coil 12. In accordance with the invention, and as shown in Fig. 3, the duty-cycle τ/T_0 of the pulse that raises and lowers the pneumatic or hydraulic pressure proportionally to input signal I_{in} is varied within cycle period T_0 corresponding to basic frequency f_0 . As illustrated in Figure 3, in its top curve, pulse τ_1 whose amplitude is I_0 is very short compared with the cycle period T_0 ; therefore the output pressure P_{out} of Figure 1 is rather low. In the middle curve the pressure-raising pulse τ_2 is approx. $0.5 \times T_0$ and P_{out} then is in the middle area of its dynamic range. In the bottom curve of Figure 3, the pressure-raising pulse τ_3 is relatively long, and output pressure P_{out} is in the top area of its dynamic range. It has been emphasized that pulses can of course be pressure-lowering pulses as well.

Figure 2 illustrates the ratio of the adjusted pressure P and the input pressure P_s as a function of the distance S between the nozzle 14 and the flap 10. ΔS illustrates the linear operation range, on which the transducers in accordance with the invention function. Thus nozzle 14 is never completely closed or opened much enough to enter the unlinear bottom section of the characteristic curve. In the figure, $P/P_s=1$ naturally represents the position in which flap 10 is completely closed, and $P/P_s=0$ represents the position in which flap 10 is completely open. In a transducer in accordance with the invention, the flap 10 is made to vibrate, for instance magnetically. Due to electrical and mechanical quantities, such as resistance, inductance, and the masses of the moving springs of the flap and the pneumatic

or hydraulic amplifying unit possibly following it, the flap will not, when vibrating, reach the extreme positions (Figure 2). According to Figure 2, reaching the extreme positions is avoided, as this would impair the amplification factor or the system linearity. In practice it has also been found out that the response speed of a transducer in accordance with the invention will, to a certain extent, be increased as the basic frequency f_0 increases.

In transducer systems illustrated in Figures 4 and 5, there is an electronic unit 20, which works as a combined signal/pulse converter and as a difference organ (Σ). Because of facts described above, pulses leaving the electronic unit 20 tend to integrate in mechanical and pneumatic or hydraulic circuits that follow unit 20. A mathematical representation of this phenomenon is:

$$k \cdot P = \frac{1}{T_0} \int_0^{\tau} I dt$$

where

K=proportionality factor

P=pneumatic or hydraulic pressure

T_0 =basic cycle

τ =length of the pulse raising or lowering the pressure

I=electrical pulse sequence leaving the electronic unit (e.g. a constant current of the magnetic circuit).

An electro-pneumatic system illustrated in Figure 4 comprises a device 21 comprised of the above described elements 15, 16, 17 and 18, to which the pneumatic input pressure P_s is brought. Output pressure P_{out} of the nozzle-flap system 10, 14 operating as described above is adjusted so to be proportional to input signal I_{in} . A feedback loop of the system comprises pneumatic bellows 27 and element 37 which converts the force of the bellows 27 into an electrical feedback signal I_1 . Feedback control I_1 is conducted via wire 26 to unit 20. Control signal $I(\tau)$ illustrated in Figure 3, is formed according to the difference signal $I_{in} - I_1$.

Figure 5 illustrates an electro-pneumatic transducer in accordance with the invention, as provided to actuate a valve 23. The system comprises the device 21, whose pressure P_{out} is conducted to diaphragm motor 22 actuating the control valve 23. The feedback loop of the system comprises an element 24 that converts the position of valve 23 into an electrical signal. This element 24 conducts the feedback signal I_1 via wire 26 to unit 20.

The output quantity of the system is for instance the flow F_{out} controlled by valve 23.

If the electric control signal is a current signal, it should be within range 4...20 mA.

By using a sufficiently high frequency the nozzle-flap system 10; 14 can be made operate in the linear area ΔS shown in Figure 2 in such a way that nozzle 14 is never completely closed or opened. In some cases the lower limit of frequency f_0 is approx. 15 Hz. However, the most

favourable frequency range from the point of view of the invention is over 30 Hz, for instance 30...40 Hz. In some cases the frequency can be of the order of 100 Hz.

If, for some reason, it is not desired to maintain the flap movement in said linear range by choosing a sufficiently high frequency f_0 , which, however, is usually the best solution, it is possible, in addition to a sufficiently high frequency, to use mechanical stoppers which limit the vibration amplitude of flap 10.

Although a basic frequency f_0 has been under consideration, it should be emphasized that the invention can also be applied in such a way as to make frequency $f = 1/T$ variable. Thus it is possible to maintain pulse τ constant and change the output pressure P_{out} by varying the cycle $T = 1/f$ and consequently also the duty-cycle

$$\frac{\tau}{T}$$

In the framework of the invention both the pulse length τ and cycle T_0 or T can be varied for control purposes. In some applications amplitude I_0 can also be varied for control purposes.

Claims

1. An electro-pneumatic or electro-hydraulic transducer comprising a controlled pressure chamber (15), which is pressurized through a restricted inlet orifice (16) and depressurized by an electrically operated pneumatic or hydraulic nozzle-flap system (10, 11, 14) which comprises a flap (10) and a nozzle (14), the movement of said flap (10) being controlled by an electric control signal, wherein the electrical control signal is a pulse sequence ($I(\tau)$) oscillating at a certain frequency (f or f_0) in which pulse sequence the duty-cycle (τ/T_0) of the pulses is varied proportionally to an input signal (I_{in}) and within the cycle period (T_0) corresponding to said frequency (f or f_0) characterized in that said nozzle-flap system (10, 11, 14) has a characteristic curve with a linear range (Δs), which curve is defined by the dependency of the relative adjusted pressure (P/P_s) on the distance (S) between the nozzle (14) and the flap (10), and in that the movement of said flap (10) during operation of the transducer is essentially limited to said linear range (ΔS) of said characteristic curve (Figure 2) so that said flap (10) never completely opens or closes the nozzle (14), which feature is provided by mechanical stoppers and/or by selecting said frequency (f or f_0) sufficiently high.

2. A transducer in accordance with claim 1, wherein said certain frequency (f_0) is higher than approx. 30 Hz.

3. A transducer in accordance with claim 1 or 2, wherein said certain frequency (f_0) of said pulse sequence ($I(\tau)$) is within the range 30...40 Hz.

4. A transducer in accordance with claim 1, 2 or

3, wherein an electromagnetic coil (12) is provided for oscillating the flap (10).

5. A transducer in accordance with claim 1, 2, 3 or 4, wherein an electric feedback signal (I_1) is formed from the output signal (P_{out}) of the transducer, and that said feedback signal (I_1) is conducted to an electronic unit (20) which is additionally fed with said input signal (I_{in}) in analog form and which provides said pulse sequence ($I(\tau)$) as difference signal ($I_{in}-I_1$).

Revendications

1. Transducteur électro-pneumatique ou électro-hydraulique comportant une chambre (15) à pression réglable, qui est mise sous pression à travers un orifice d'entrée étranglé (16) et décomprimée par un mécanisme tuyère-volet pneumatique ou hydraulique (10, 11, 14) actionné électriquement qui comprend un volet (10) et une tuyère (14), le mouvement du volet (10) étant commandé par un signal de commande électrique, lequel signal est une séquence d'impulsions ($I(\tau)$) oscillant à une certaine fréquence (f ou f_0), séquence dans laquelle le cycle de service (τ/T_0) des impulsions varie proportionnellement à un signal d'entrée (I_{in}) et à l'intérieur de la période (T_0) correspondant à ladite fréquence (f ou f_0), caractérisé en ce que le mécanisme tuyère-volet (10, 11, 14) présente une courbe caractéristique comprenant une portion linéaire (ΔS), courbe définie par les variations de la pression réglée relative (P/P_s) en fonction de la distance (S) entre la tuyère (14) et le volet (10) et en ce que le mouvement du volet (10) pendant le fonctionnement du transducteur est essentiellement limité à ladite portion linéaire (ΔS) de la courbe caractéristique (figure 2) de telle sorte que le volet (10) ne ferme ni n'ouvre jamais totalement la tuyère (14), ce qui est assuré à l'aide de butées mécaniques et/ou en choisissant la susdite fréquence (f ou f_0) suffisamment élevée.

2. Transducteur selon la revendication 1, caractérisé en ce que la fréquence (f_0) est supérieure à environ 30 Hz.

3. Transducteur selon la revendication 1 ou 2, caractérisé en ce que la fréquence (f_0) de la séquence d'impulsions ($I(\tau)$) est comprise entre 30 et 40 Hz.

4. Transducteur selon la revendication 1, 2, ou 3, caractérisé en ce qu'une bobine électromagnétique (12) est prévue pour faire osciller le volet (10).

5. Transducteur selon la revendication 1, 2, 3 ou 4 caractérisé en ce qu'un signal de réaction électrique (I_1) est formé à partir du signal de sortie (P_{out}) du transducteur et en ce que ledit signal de réaction (I_1) est appliqué sur un circuit électronique (20) qui est alimenté additionnelle-

ment par ledit signal d'entrée (I_{in}) sous forme analogique et qui élabore ladite séquence d'impulsions ($I(\tau)$) en tant qu'un signal de différence ($I_{in}-I_1$).

Patentansprüche

1. Elektro-pneumatischer oder elektro-hydraulischer Wandler, der eine geregelte Druckkammer (15) aufweist, die durch eine begrenzte Einlaßöffnung (16) unter Druck gesetzt wird und den Druck abbaut durch ein elektrisch betätigtes pneumatisches oder hydraulisches Düsenklappensystem (10, 11, 14), daß eine Klappe (10) eine Düse (14) aufweist, wobei die Bewegung der Klappe (10) von einem elektrischen Steuersignal gesteuert wird, wobei das Steuersignal eine Pulsfolge ($I(\tau)$) ist, die in einer bestimmten Frequenz (f oder f_0) schwingt, in welcher Pulsfolge der Abzeitszyklus (τ/T_0) der Impulse proportional zu einem Eingangssignal (I_{in}) und innerhalb der Schwingungsperiode (T_0) entsprechend der Frequenz (f oder f_0) verändert wird, dadurch gekennzeichnet, daß das Düsenklappensystem (10, 11, 14) eine charakteristische Kurve mit einem linearen Bereich (ΔS) aufweist, wobei die Kurve bestimmt wird von der Abhängigkeit des relativ eingestellten Druckes (P/P_s) auf der Strecke (S) zwischen der Düse (14) und der Klappe (10), sowie dadurch daß die Bewegung der Klappen (10) während des Betriebs des Wandlers im wesentlichen begrenzt ist auf den linearen Bereich (ΔS) der charakteristischen Kurve (Fig. 2), so daß die Klappe (10) die Düse (14) nie vollständig öffnet oder schließt, wobei diese Vorteil durch mechanische Stopper und/oder ausreichend hohe Auswahl der Frequenz (f oder f_0) erzielt wird.

2. Wandler nach Anspruch 1, dadurch gekennzeichnet, daß die bestimmte Frequenz (f_0) höher ist als ca. 30 Hz.

3. Wandler nach Anspruch 1 oder 2, dadurch gekennzeichnet, daß die bestimmte Frequenz (f_0) der Impulsfolge ($I(\tau)$) im Bereich von 30 bis 40 Hz liegt.

4. Wandler nach Anspruch 1, 2 oder 3, dadurch gekennzeichnet, daß eine elektromagnetische Spule (12) zum Oszillieren der Klappe (10) vorgesehen ist.

5. Wandler nach Anspruch 1, 2, 3 oder 4, dadurch gekennzeichnet, daß ein elektrisches rückgeleitetes Signal (I_1) von dem Ausgangssignal (P_{out}) des Wandlers gebildet wird und daß das rückgeleitete Signal (I_1) zu einer elektronischen Einheit (20) geführt wird, die zusätzlich mit dem Eingangssignal (I_{in}) in analoger Form versorgt wird und die die Impulsfolge ($I(\tau)$) als Differenzsignal ($I_{in}-I_1$) vorsieht.

