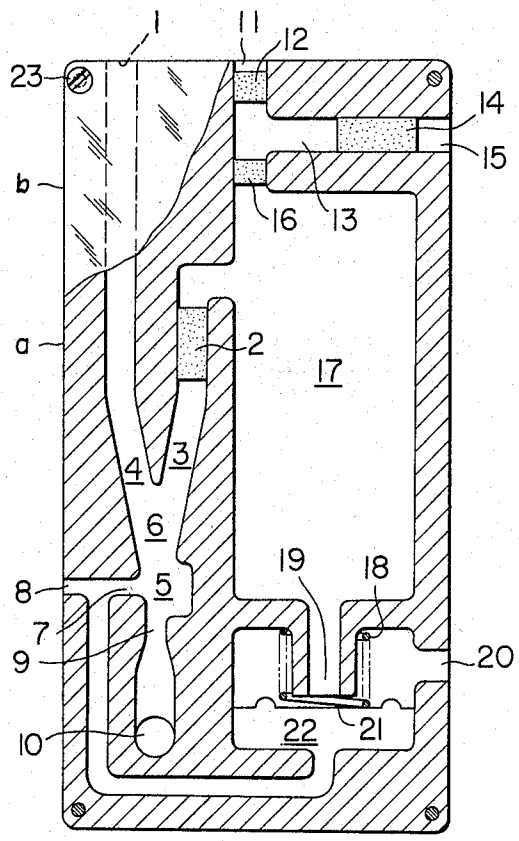
Nov. 29, 1966 AKIRA SHIIKI 3,288,365

DIGITAL-ANALOGUE CONVERTER

Filed June 30, 1965 2 Sheets-Sheet 1

Fig. 1



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Fig. 2

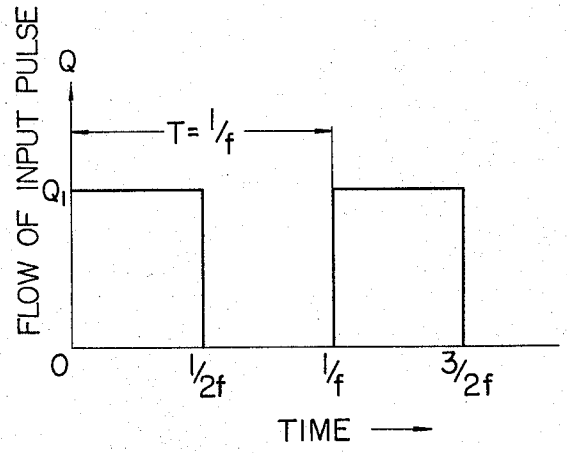
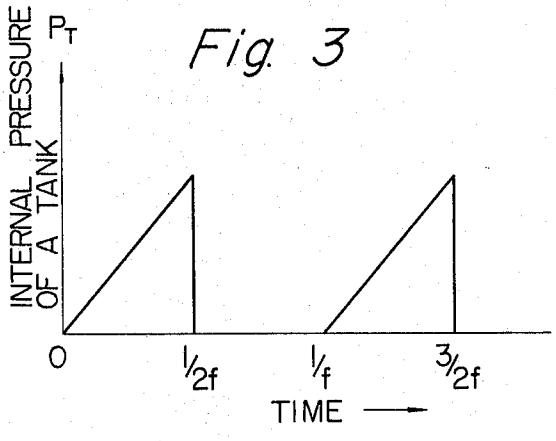


Fig. 3



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DIGITAL-ANALOGUE CONVERTER

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2 Claims. (Cl. 235—201)

This invention relates to a D-A converter used in an automatic control system to convert a signal obtained by a digital device to an analogue and more particularly to a D-A converter which uses a bias action of a control fluid stream jetted from a nozzle, senses an air pulse as an input and supplies air pressure in analogue as an output. Therefore, there is almost no mechanical operating parts in the D-A converter, which operates in precise and in almost no accident in response to fluid operation.

The object and nature of the present invention will be illustrated in conjunction with the attached drawings.

FIG. 1 is a fragmental sectional elevation of an embodiment of D-A converter provided in accordance with the present invention,

FIG. 2 is curves showing the relation between the flow of an input pulse and the time, and

FIG. 3 is curves showing the relation between the internal pressure of a tank and the time.

Referring to FIG. 1, *a* is a base plate provided with punched fluid channels thereon and the base plate *a* is sandwiched at the both side surfaces thereof by two cover plates *b*, **23** are holding screws used for the said sandwich construction. The resistances of restriction valves **2**, **12**, **14** and **16** are R_1, R_2, R_3 and R_4, respectively. **10** and **11** are supply inlets of the actuating air, and **9** is a jet nozzle. **8** is an inlet of an input air pulse. Inlet **8** is connected to a pressure chamber **22** and a control gate **7** opened to a jet outlet **5** of jet nozzle **9**. **3** and **4** are branch channels, one channel **3** of which being connected to a tank **17** and the other channel **4** of which being connected through an exhaust outlet **1** to the atmosphere. A channel **13** is connected through restriction valve **14** to a connection gate **15** of a load. An exhaust outlet **19** of said tank is closed and opened under the control of a diaphragm **21**. Furthermore, **18** and **20** are a spring and an air exhaust outlet, respectively.

In case of an input signal being zero, an air supplied from air supply inlet **10** is jetted into a domain **6** by jet nozzle **9**, and there being no supplement of the input signal air from control inlet **7**, the domain **6** becomes decreased in pressure therein considerably by the fact that the domain is surrounded by the approached walls thereof and the air stream and no air is supplied from the external of said domain. Accordingly, the air stream is biased to flow into the left channel **4** and exhausted to the atmosphere from exhaust outlet **1**.

Moreover, as the result of absence of the input signal, the internal pressure of a pressure chamber **22** is maintained at the atmosphere pressure and diaphragm **21** is depressed by spring **18** to make exhaust outlet **19** open. Therefore, the air from supply inlet **11** is exhausted through restriction valves **12** and **16**, tank **17**, exhaust outlet **19** and air exhaust outlet **20**.

On the other hand, in case of input signal being supplied from input air pulse inlet **8**, the supplied signal air operates to push up diaphragm **21** in pressure chamber **22** so as to close exhaust outlet **19**, and at the same time the supplied signal air enters domain **6** from control gate **7** to bias the jet air stream to the right and then to guide the jet air stream through branch channel **3** and restriction valve **2** to tank **17**. Moreover, the air supplied from supply inlet **11** also enters tank **17** to increase the internal pressure P_T thereof.

Supposing that the input signal has the rectangular wave form oscillating at frequency f as shown in FIG. 2, during the time t of

$$0<t<\frac{1}{2f}$$

the constant flow coming from control gate **7**, supply inlets **10** and **11** enters together into tank **17** to increase the internal pressure P_T thereof. In other words,

$$C\frac{dP_T}{dt}=Q_1+Q_2+Q_3$$

$$P_T=\frac{Q_1+Q_2+Q_3}{C}t \qquad (1)$$

wherein, Q_1, Q_2 and Q_3 are the constant flow from control gate **7**, supply inlets **10** and **11**, respectively, and C is a capacity of tank **17**; Q is in terms of mass flow rate, while temperature and the equation constant are not considered for simplicity.

Furthermore it is noted that the input signal is zero during the time of

$$\frac{1}{2f}<t<\frac{1}{f}$$

Accordingly, in this duration air supplied from supply inlet **10** is exhausted from exhaust outlet **1**, and the air accumulated in tank **17** during the time of

$$0<t<\frac{1}{2f}$$

is also exhausted through exhaust outlet **19** from air exhaust outlet **20**. Exhaust outlet **19** and air exhaust outlet **20** being small in exhausting resistance, the air accumulated in tank **17** will be exhausted instantaneously. Therefore, the internal pressure P_T in tank **17** becomes nearly zero ($P\cong 0$) during the time of

$$\frac{1}{2f}<t<\frac{1}{f}$$

Accordingly, the variation of the internal pressure P_T to the time can be charted as FIG. 3.

Supposing the primary pressure at channel **13** where the air flows (represented by Q_3) from supply inlet **11** passes through restriction valve **16** (having resistance R_4) into tank **17** to be P_1, the secondary pressure thereof will be P_T which is the internal pressure of tank **17**, and the relation between the primary pressure P_1 and the secondary pressure P_T can be expressed as follows:

$$Q3=\frac{1}{R_4}\sqrt{P_1-P_T}$$

$$P_1=P_T+(Q_3R_4)^2 \qquad (2)$$

The internal pressure P_T of tank **17** varies in saw waveform as shown in FIG. 3, so it will be seen that the primary pressure P_1 at the channel **13** also varies in saw waveform. However, by having the primary pressure P_1 passed through restriction valve **14** with a large resistance, the ripple of the primary pressure will be absorbed by restriction valve **14** and therefore a mean value P_1 means of the primary pressure P_1 will be supplied to a load connected to connection gate **15**. The mean value P_1 mean can be expressed as follows:

$$P_1\ \text{mean}=\frac{1}{\frac{1}{f}}\int_0^{\frac{1}{f}}P_1dt$$

$$=\frac{1}{\frac{1}{f}}\int_0^{\frac{1}{f}}\left\{P_T+(Q_3R_1)^2\right\}dt$$

$$=\frac{Q_1+Q_2+Q_3}{8Cf}+(Q_3R_4)^2f \qquad (3)$$

As illustrated above, the input pulse having frequency f is converted into P_1 mean in analogue, and the relation therebetween can be expressed by the Equation 3 above.

Wherein, if Q_1 and Q_2 are small in value and C and R_4 are large in value, P_1 means results in the following Equation 4 and if Q_1 and Q_2 are large in value and C and R_4 are small in value, P_1 means results in the following Equation 5:

$$P_1 \text{ mean} \fallingdotseq (Q_2 R_4)^2 f \quad (4)$$

$$P_1 \text{ mean} \fallingdotseq \frac{Q_1+Q_2+Q_3}{8Cf} \quad (5)$$

In accordance with the present invention, a D-A converter is provided with has little mechanical and electrical operating parts, performs D-A conversion operation easily and precisely only using of the stream operation of a fluid and operates in quiet and almost no accident for a long period maintaining the accuracy.

What I claim is:

1. A fluid operated digital to analogue converter comprising, a tank means including a first inlet means for receiving a first fluid stream, a second inlet means for receiving a second fluid stream and an exhaust means, a fluid amplifying means connected to said first tank inlet means and biased for diverting said first fluid stream therefrom, said tank exhaust means including a normally opened switching means through which said second fluid stream normally exhausts, said second tank inlet means passing through first and second restriction means prior to entry into said tank, load connection means located between said first and second restriction means, and means for applying an input in the form of a pulsed fluid stream commonly to said fluid amplifying means and said switching means, whereby an input pulse from said pulsed fluid stream diverts said first fluid stream into said tank means and operably closes said normally opened switching means within said tank exhaust means for increasing the pressure within said tank means and applying said pressure to said load connection means as an analogue output representation of said pulsed fluid stream input.

2. A fluid operated digital to analogue converter comprising, a tank including a first inlet for receiving a first fluid stream, a second inlet for receiving a second fluid stream, and an exhaust outlet, a fluid amplifier connected to said first tank inlet and biased for diverting said first fluid stream therefrom, a restrictive valve located within said connection between said fluid amplifier and said tank, a normally opened, spring biased, switching valve located within said tank exhaust outlet, means commonly connecting said fluid amplifier and said normally opened switching valve operative to apply a pulsed fluid stream input thereto for diverting said first fluid stream into said tank and for closing said switching valve, said second tank inlet passing through first and second restrictive valve means prior to entry into said tank, load connection means loacted between said first and second restrictive valve means, and a final restrictive valve located within said load connection means for forming a load channel therebetween, whereby an input pulse from said pulsed fluid stream diverts said first fluid stream into said tank and closes said switching valve thereby increasing the pressure within said tank and consequently increasing the pressure within said load channel for providing an output pressure increase through said load final restrictive valve as an analogue representation of said pulsed fluid stream input.

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