

Description

The present invention relates to a method of operating an on demand type ink jet head of the type which comprises a pressure chamber with an inlet which communicates with a supply of ink and an outlet which communicates with the atmosphere, and an electro-mechanical transducer which is arranged to alter the volume of the pressure chamber, comprising the steps of: applying an electrical signal to the electro-mechanical transducer so that the volume of the pressure chamber is increased whereby ink is drawn into the pressure chamber; and changing the said signal so that the volume of the pressure chamber is reduced whereby ink is propelled out of the said outlet.

The present invention also relates to a system employing a head of the said type.

A known method of driving an on demand type ink jet head is disclosed in U.S. Patent Specification No. 4,161,670. This head comprises a tubular drive element of polarised ceramic which contains printing ink and whose diameter is altered when a voltage is applied thereto. The tubular drive element thus forms a pressure chamber. In this known method a voltage of polarity opposite to that of the polarisation voltage of the piezo-electric ceramic element is applied to the element to deform, or maintain, the wall of the pressure chamber so that the volume of the pressure chamber is increased for a predetermined period of time after which the polarity of the voltage supplied to the piezo-electric element is reversed so that the volume of the pressure chamber is reduced and ink droplets are thereby jetted out of the tube. A voltage transducer is used to reverse the polarity of the voltage of the signal applied to the piezo-electric element, the secondary inductance of the voltage transducer forming an oscillatory circuit with a capacitance of the piezo-electric element. The resonance frequency of this oscillatory circuit is set equal to the mechanical resonance frequency of the column of ink in the drive tube and the duration of the primary current path applied to the voltage transducer is equal to half the period of the mechanical resonance frequency. In other words, the resonance frequency of the oscillatory circuit, constituted by the secondary inductance of the voltage converted and the capacitance of the piezo-electric element, is equivalent to the resonance frequency of the column of ink in the pressure chamber.

For implementing such a driving method, a separate voltage transducer and control circuit are required for each nozzle. Therefore, in the case of a multi-nozzle ink jet head the total cost of the assembly is high as it is necessary to provide as many voltage transducers and control circuits as there are nozzles.

In order to maximise the velocity at which ink droplets are propelled from an ink jet head whilst applying a relatively low voltage to the

piezo-electric element, the duration of the primary current pulse should not simply be set equal to half the period of the resonance frequency of the column of ink for the following reasons. The oscillation of the column of ink is a transient response to the primary current pulse applied to the voltage transducer in a system which is formed by the wall of the pressure chamber, the piezo-electric element and the ink, and accordingly, the oscillation is a damped oscillation involving a phase lag related to the driving waveform applied to the piezo-electric element. Therefore, the time instant at which the volume of the pressure chamber should be decreased by changing the voltage applied to the piezo-electric element should be selected to occur in synchronisation with the phase of the damped oscillation and the phase lag of the column of ink so as to maximise the velocity of the ink droplets. In other words, when the duration of the primary current pulse applied to the voltage transducer is equal to half the period of the resonant frequency of the column of ink, it should coincide with the optimum phase of the damped oscillation of the column of ink in the pressure chamber and the nozzle of the chamber, so that ink droplets can be propelled from the head by application of low voltage signals to the piezoelectric element. Experiments have confirmed that the duration of the current pulse referred to above should preferably be longer than half of the period of the natural frequency of the column of ink.

One advantage of decreasing the voltage required to jet ink from the head is that depolarisation of the piezoelectric element is reduced in circumstances where the voltage applied to the element has a polarity opposite to that of the polarisation voltage of the piezo-electric element.

The present invention therefore provides a method of operating an on demand type ink head of the type described above, in which the said signal is changed at a time when the amplitude of oscillation of a mechanical system formed by the electro-mechanical transducer, at least part of the pressure chamber, and ink within the pressure chamber is substantially at a maximum.

The method may comprise the steps of: applying the said signal to the electro-mechanical transducer so that the volume of the pressure chamber is increased whereby ink is drawn into the pressure chamber and changing the said signal by reducing its voltage so that ink is propelled out of the said outlet by means of elastic energy stored in the said mechanical system at the said maximum and, preferably, the power source is connected to the electro-mechanical transducer to establish the pressure chamber in a standby condition before the said signal which causes the volume of the pressure chamber to increase is applied to the electro-mechanical transducer.

Preferably the power source is connected to

the electro-mechanical transducer to establish the pressure chamber in a standby condition before the said signal which causes the volume of the pressure chamber to increase is applied to the electro-mechanical transducer.

Alternatively, the method may comprise the steps of: applying the said signal to the electro-mechanical transducer so that the volume of the pressure chamber is decreased; reducing the voltage of the said signal so that the volume of the pressure chamber is restored to its original condition and then increased by means of oscillation of the said mechanical system; and increasing the voltage of the said signal at the said time whereby ink drawn into the pressure chamber when the volume thereof was increased is propelled out of the said outlet.

The method may also comprise the steps of: applying the said signal to the electro-mechanical transducer so that the volume of the pressure chamber is decreased; reversing the polarity of the said signal so that the volume of the pressure chamber is restored to its original condition and is then increased; and again reversing the polarity of the said signal at the said time whereby ink drawn into the pressure chamber when the volume thereof was increased is propelled out of the said outlet. The said signal may be applied to the electro-mechanical transducer by signal supplying means which comprises: first transistor switch means connected in series with the electro-mechanical transducer; second transistor switch means connected in series with the electro-mechanical transducer; and driving means, for driving the first and second transistor switch means with opposite phases in response to an input signal.

The said signal may also be applied to the electro-mechanical transducer by a signal supply means which comprises a transistor drive circuit, the electro-mechanical transducer being connected in parallel with a resistor, the parallel arrangement being connected to the collector of an output transistor of the said circuit.

The present invention also provides an on demand type ink jet head system of the type described above in which the signal supply means is arranged, in use, to change the said signal at a time when the amplitude of oscillation of a mechanical system formed by the electro-mechanical transducer, at least part of the pressure chamber, and ink within the pressure chamber is substantially at a maximum.

The signal supply means may be arranged, in use, to apply the said signal to the electro-mechanical transducer so that the volume of the pressure chamber is increased whereby ink is drawn into the pressure chamber, and to then change the said signal by reducing its voltage so that ink is propelled out of the said outlet by means of elastic energy stored in the said mechanical system at the said maximum.

Alternatively, the signal supply means may

be arranged in use, to apply the said signal to the electromechanical transducer so that the volume of the pressure chamber is decreased, the voltage of the said signal is reduced so that the volume of the pressure chamber is restored to its original condition and then increased by means of oscillation of the said mechanical system, and to increase the voltage of the said signal at the said time whereby ink is drawn into the pressure chamber when the volume thereof was increased is propelled out of the said outlet.

The signal supply means may also be arranged, in use, to apply the said signal to the electro-mechanical transducer so that the volume of the pressure chamber is decreased, the polarity of the said signal is reversed so that the volume of the pressure chamber is restored to its original condition and is then increased, and to again reverse the polarity of the said signal at the said time whereby ink drawn into the pressure chamber when the volume thereof was increased is propelled out of the said outlet.

Preferably the electro-mechanical transducer is a piezoelectric transducer and the polarity of the said signal when it causes the volume of the pressure chamber to be decreased is the same as that of the polarization voltage of the piezoelectric transducer.

The application of said electrical signal to said electro-mechanical conversion means may occur approximately when said damped oscillation reaches a maximum value thereof.

Alternatively the application of said electrical signal to said electro-mechanical conversion means may occur approximately at a time when the flow of air into said pressure chamber is at the maximum value thereof.

The said signal supplying means may comprise first transistor switch means connected across input terminals of said electro-mechanical conversion means; second transistor switch means coupled in series with said terminals of said electro-mechanical conversion means and a voltage source; and means for driving said first and second transistor switch means with opposite phases in response to an input pulse signal.

The said signal supplying means may comprise a transistor driver circuit with input terminals of said electro-mechanical conversion means coupled across a collector resistor of an output transistor.

The said signal supplying means may apply said electrical signal to said electro-mechanical conversion means approximately at a time when said damped oscillation reaches a maximum value thereof.

Alternatively, the said signal supplying means may apply said electrical signal to said electro-mechanical conversion means approximately at a time when the flow of air into the said pressure chamber is at a maximum value thereof.

Said electro-mechanical conversion means may comprise a piezo-electric transducer and the polarity of said electrical signal may be the same as that of the polarisation voltage of said piezo-electric transducer.

The present invention seeks to provide a method of operating an on-demand ink head in which the damped oscillation of the mechanical system formed by the piezo-electric element, the wall of the pressure chamber, and ink in the pressure chamber is utilized so that the ink jet head can be driven with a drive circuit of simple construction and low manufacturing costs, and so that a low drive voltage can be used to propel ink droplets out of the pressure chamber at the desired velocity.

The present invention will be described, merely by way of example, with reference to the accompanying drawings, in which:—

Figure 1 is a sectional side view of an ink jet head of the type to which the present is applied,

Figure 2 is a top view, part cut away, of the ink jet head of Figure 1,

Figure 3 is a circuit diagram showing a drive circuit for operating an ink jet head in accordance with the present invention,

Figure 4A is a timing diagram showing an input signal to the drive circuit of Figure 3,

Figure 4B is a timing diagram showing the waveform of a voltage across a piezo-electric element of an ink jet head such as that shown in Figures 1 and 2,

Figure 5A is a sectional side view showing the ink jet head shown in Figures 1 and 2 when ink has been drawn into a pressure chamber in accordance with one method of the present invention,

Figure 5B is a top view, part cut away, of the ink jet head of Figure 5A,

Figure 6 is a sectional side view of the ink jet head of Figure 5A whilst jetting ink droplets,

Figure 7A is a timing diagram showing a voltage across a piezo-electric element of an ink jet head such as that described above,

Figure 7B is a timing diagram showing the damped oscillation of a wall of a pressure chamber and a piezo-electric element in an ink jet head such as that described above,

Figure 7C is a timing diagram showing variations with time of the flow rate of air which is drawn in through the opening of the nozzle during the oscillation shown in Figure 7B,

Figure 7D is a diagram showing variations in velocity of ink droplets propelled from an ink jet head such as that described above with the variations of a pulse width T,

Figure 8 is another circuit diagram showing a drive circuit for operating an ink jet head in accordance with the present invention,

Figure 9A is a timing diagram showing an input signal to the drive circuit in Figure 8,

Figure 9B is a timing diagram showing the waveform of a voltage across a piezo-electric element in an ink jet head such as that described above,

Figure 10A is a sectional side view showing an ink jet head of the type described above when ink has been drawn into a pressure chamber in accordance with another method of the present invention,

Figure 10B is a top view, part cut away, of the ink jet head of Figure 10A,

Figure 11 is a sectional side view of the ink jet head shown in Figures 10A and 10B whilst jetting ink droplets,

Figure 12 is a schematic diagram of another embodiment of the driving circuit,

Figure 13 is a schematic diagram of another embodiment of the driving circuit, and

Figure 14 shows waveforms for explaining the operation of the circuit of Figure 13.

The ink jet head shown in Figures 1 and 2 comprises a pressure chamber 2 having a nozzle 3 and a supply port 4. These are formed by recesses in a substrate 1. Ink 6 from an ink container 7 is introduced to the pressure chamber 2 through an ink supply tube 8 and the supply port 4 which forms a narrow path to the pressure chamber 2. In the opening, or mouth, 3a of the nozzle 3, the surface tension of ink 6 balances with the negative pressure H between ink in the pressure chamber and ink in the container 7 so that ink does not leak or flow out of the nozzle 3. An electrode layer, or surface, 5a is formed on a wall 5 of the pressure chamber 2 by means of a vacuum evaporation technique or the like. A piezo-electric element 9, which acts as an electro-mechanical transducer, is bonded to the electrode layer 5a of the wall 5 in alignment with the pressure chamber 2 on the other side of the wall 5. Lead wires 10 are connected to the piezo-electric element 9 and the electrode layer 5a. The polarities of the lead wires 10 are selected so that the piezo-electric element 9 contracts to cause the wall 5 to cave-in in such a manner that the wall 5 becomes substantially concave, thereby decreasing the volume of the pressure chamber 2. That is, the voltage applied to the piezo-electric element 9 is of the same polarity as that of the polarization voltage of the piezo-electric element 9.

Figure 3 shows a drive circuit for supplying electrical pulses to the piezoelectric element 9. Figure 4A shows the waveform of an input signal 16 applied to the drive circuit. Before a time instant t_1 (see Figure 4B), a transistor 11 and a transistor 12 are rendered conductive (ON) as a result of which current flows in the direction of the arrow A to charge the piezo-electric element 9. The wall 5 of the pressure chamber 2 is, therefore, held in the concave position as shown in Figure 1. In this operation, the current flows through a charging resistor 13. The waveform of the voltage 19 applied to the piezo-electric element 9 is shown in Figure 4B. At the time instant t_1 , the input signal 16 rises, as shown by the reference numeral 17. In response thereto, a transistor 14 is rendered non-conductive (OFF) while a transistor 15 is rendered conductive (ON). As a result, the

charge stored in the piezo-electric element 9 flows as a current in the direction of the arrow B through the transistor 15 and the resistor 13. The waveform of the voltage 19 across the piezo-electric element 9 is shown in Figure 4B, and this voltage corresponds to the voltage between the circuit points indicated by reference numeral 24 in Figure 3. When the input signal 16 falls (as shown by the reference numeral 18), at a time t_2 , the transistors 14 and 15 are turned ON and OFF, and the transistors 11 and 12 are turned ON, causing an instantaneous current in the direction of the arrow A as a result of which the piezo-electric element 9 is charged. The voltage 24 across the piezo-electric element 9 thus becomes substantially equal to the source voltage 25.

The mechanical operation which accompanies the above-described electrical operation will be described with reference to Figures 1, 5A, 5B and 6. As mentioned above, since the transistors 11 and 12 are conductive when the power source is connected to the circuit in Figure 3, the current flows in the direction of the arrow A and the piezo-electric element 9 begins to charge. When the charging is complete, the voltage 24 across the element 9 becomes substantially equal to the source voltage 25 and is held at this level. Therefore, the element 9 is held in the concave position so that the wall 5 of the pressure chamber 2 is also held in the concave state, as shown in Figure 1. At the time instant t_1 , the piezo-electric element 9 starts to discharge and it is restored to its original state by the elastic energy stored in the wall 5 and the element 9. During this operation, ink 6 from the ink container 7 is drawn in through the supply port 4 to the pressure chamber 2 and air is drawn in through the opening 3a in the nozzle 3. As a result of this, a state such as that shown in Figures 5A and 5B is reached.

The time instant t_2 is set so that it occurs when the amount of air (shown by reference numeral 20) drawn into the nozzle is approximately at a maximum. By applying the voltage across the piezo-electric element 9 again at the time instant t_2 , the piezo-electric element 9 is charged almost instantly and the element 9 is quickly deformed, as shown in Figure 6, so that ink 6 is propelled out of the opening 3a in the nozzle 3 in the form of ink droplets 21.

The manner in which the timing of the application of voltages to the piezo-electric element 9 are chosen will be described with reference to Figures 7a to 7d. If the pulse interval T between the time instants t_1 and t_2 is set to be relatively long, as indicated in Figure 7A, the wall 5 and the piezo-electric element 9 undergo damped oscillation 23 as indicated in Figure 7B. The damped oscillation 23 can be closely represented by the following expression:—

$$X = 1 - \beta e^{-nt} \sin(\omega t - \theta),$$

where X is the displacement of the wall 5 and

the piezo-electric element 9 in the direction indicated in Figure 5, $X = 0$ represents the displacement of the wall 5 and the element 9 when the pulse width T is infinitely long, i.e., when no voltage is applied to the piezo-electric element 9, and $X = -1$ represents the displacement thereof when a voltage is applied to the piezo-electric element 9, t represents time, with the time instant t_1 representing zero time or the reference time, and β , n, ω and θ are constants which are determined by the elastic coefficients and internal resistances of the wall 5 and the piezo-electric element 9, the fluid mass, or impedance, in the vicinity of the nozzle 3 and the supply port 4, and the surface tension of the ink in the opening 3a of the nozzle 3.

Although the wall 5 and the piezo-electric element 9 reach the position at which $X = 0$ during the time period from t_1 to t_2 in which the volume of the pressure chamber 2 is increased the wall 5 and the element 9 undergo damped oscillation with reference to the position at which $X = 0$ as shown in Figure 7B. The damped oscillation 23 is the transient resonance of a mechanical oscillation system formed by the piezo-electric element 9, the wall 5, and the ink in the pressure chamber 2 when a voltage having a waveform such as that shown in Figure 7A is applied to the piezo-electric element 9. The damped oscillation involves a time delay which is represented by the constant θ in the expression given above.

As the wall 5 and the piezo-electric element 9 undergo the damped oscillation 23 described above, ink in the vicinity of the nozzle 3 undergoes a similar oscillatory movement. This can be observed through the variations with time of the amount 20 of air drawn in through the opening 3a of the nozzle 3 as indicated in Figures 5A and 5B. The amount of air drawn-in undergoes a damped oscillation 22 as indicated in Figure 7C before the flow of air stops. At a time instant t_3 the amount of air drawn in is at a maximum and this substantially coincides with the time instant when the displacement X of the piezo-electric element 9 also reaches its maximum value 27 (see Figure 7B).

If the supply voltage 25 (see Figure 3) applied to the piezo-electric element 9 is set at a predetermined value while the pulse width T in Figure 7A is gradually reduced, a plot can be made of the corresponding variations in the velocity at which ink droplets are propelled from the nozzle 3. The velocity curve 26 obtained is shown in Figure 7D. As Figure 7D shows, if the pulse width T is long, no ink droplets 21 are propelled from the nozzle 3. However, if the pulse width T is set near the time period ($t_3 - t_0$), so that the time instant t_2 at which the piezo-electric element 9 is re-charged substantially coincides with the time instant t_3 , ink droplets 21 are propelled from the nozzle 3. The velocity of the ink droplets reaches a maximum when the pulse width T is set approximately, or slightly longer than, to the time period ($t_3 - t_0$).

If the supply voltage 25 (Figure 3), which is relatively low, is applied to the piezo-electric element 9 when the damped oscillation 23 of the wall 5 and the piezo-electric element is at the point 33, or point 34 where $X=0$, i.e. the pulse width T is shortened or increased, then the wall 5 and the piezo-electric element 9 are not returned to the position represented by $X=-1$ at a velocity which is sufficient to propel ink droplets from the nozzle 3. However, if the voltage is applied to the piezo-electric element 9 approximately at the time instant t_3 , then the transition represented by $X=-1$ is such that after the time instant t_3 the energy of the damped oscillation 23, which is causing the volume of the pressure chamber 2 to decrease, is added to the energy supplied by the piezo-electric element to return the wall 5 to the position represented by $X=-1$. Accordingly, the wall 5 and the piezo-electric element 9 move to the position represented by $X=-1$ at a higher velocity and ink droplets are propelled from the nozzle 3. The pulse width T is thus set in accordance with the period of the damped oscillation 23 which occurs when the ink 6 is drawn into the pressure chamber as described above so that ink droplets are jetted at a desired predetermined velocity by the application of a low voltage to the piezo-electric element 9. It should be noted that since there is no damped oscillation 23 at the time when the power source is initially connected, no ink droplets are jetted from the pressure chamber 2 even when the wall 5 is deformed so as to reduce the volume of the pressure chamber 2.

After ink droplets 21 have been jetted from the pressure chamber, the damped oscillation of the oscillation system composed of the wall 5, the piezo-electric element 9 and the ink 6 settles to the rest position because of the loss of ink from the nozzle 3 and the return of ink to the supply port 4. The next jetting of the ink droplets 21 is not, therefore, greatly affected by the damped oscillation of the previous jetting, so that the frequency response of the device is satisfactory.

As described above, a voltage having the same polarity as that of the polarization voltage of the piezo-electric element 9 is initially applied to the piezo-electric element 9 in response to which the wall 5 is held displaced in the concave position, thereby decreasing the volume of the pressure chamber 2. In this case, application of the voltage to the piezo-electric element 9 is suspended when a printing operation is required, so that the volume of the pressure chamber 2 is abruptly increased whereby ink is drawn into the pressure chamber 2. The voltage is then applied again approximately at the time when the damped oscillation of the oscillation system composed of the piezo-electric element 9, the wall 5, and the ink 6 reaches its peak value 27, which occurs when the flow rate of ink 6 is drawn-ink is also approximately at a maximum. Accordingly, the

droplets 21 can be jetted with a low voltage. The damped oscillation 23, being the transient response of the piezo-electric element 9, essentially involves a delay of time. Therefore, in order to ensure that the device operates efficiently, it is desirable that the pulse width T is set to end substantially at the time of occurrence of the maximum value 27 of the oscillation 23. Accordingly, even if the pulse width T is set equal to half of the period of the resonance frequency of the mechanical system formed by the piezo-electric element 9, the wall 5 and the ink 6, a satisfactory operation can be provided so long as the period T ends at a time when the amplitude of the oscillation of the mechanical system is substantially at a maximum because of the time delay involved.

With the method described above, which uses the properties of the damped oscillation 23, it is possible to drive the ink jet head highly efficiently. Since the polarity of the voltage to be applied to the piezo-electric element 9 is the same as that of the polarization voltage of the piezo-electric element 9, depolarisation of the element is avoided. Furthermore, since the voltage applied to the element 9 is always of the same polarity, the drive circuit can be considerably simplified and, thus, is not expensive to make. As described above, the ink jet head can be driven in a highly efficient manner by simply selecting a suitable pulse width T . Therefore, even if the oscillation system composed of the piezo-electric element, the wall 5, and the ink 6 is varied, and the time period at which the damped oscillation 23 has its peak value 27 is varied, it is still possible to efficiently drive the element by appropriately altering the pulse width T . This is an important advantage of the present invention over a device using a voltage converter which requires a complicated procedure for changing the primary winding and the secondary winding of the voltage converter in order to allow for such variations.

In the method described above, the piezo-electric element 9 is initially deformed so that the volume of the pressure chamber 2 is decreased and it is then returned to its original state to draw in ink, after which the volume is again decreased in order to propel the ink out of the head. However, it is also possible to operate the head in such a manner in which, when printing is required, the element 9 is initially deformed so as to increase the volume of the pressure chamber by applying a predetermined voltage, namely, a voltage having the opposite polarity to that of the polarization voltage of the element 9, in order to draw in ink and, when the ink is to be jetted, the voltage is removed in synchronization with the damped oscillation of the vibration system to allow the volume of the pressure chamber to rapidly decrease. In such a method, the element 9 may be connected directly across the collector-emitter circuit of the transistor 15, as shown in Figure 8. Figure 8 shows a circuit which is similar to that shown in

Figure 3, but the polarities of the input signal 16 and, thus the voltage 19, are reversed. The operation of the circuit in Figure 8 will be clear to those skilled in the art.

Figure 8 shows a drive circuit for supplying electrical pulses to the piezo-electric 9. Figures 9A and 9B show the waveforms of an input signal 16' applied to the drive circuit, and of a voltage 19' (corresponding to the voltage between the circuit points indicated by reference numeral 24 in Figure 8) across the piezo-electric element 9. At the time instant t_1 , a transistor 11 and a transistor 12 are rendered conductive (ON) at the time of fall 17' of the input signal 16', as a result of which current flows in the direction of the arrow A to charge the piezo-electric element 9. In this operation, the current flows through a charging resistor 13. The waveform of the voltage 19' applied to the piezo-electric element 9 is shown in Figure 9B. At the time instant t_2 , the input signal 16' rises, as shown by the reference numeral 18'. In response to this, a transistor 14 is rendered non-conductive (OFF) while a transistor 15 is rendered conductive (ON). As a result, the charge stored in the piezo-electric element 9 flows as a current in the direction of the arrow B through the transistor 15.

The mechanical operation which accompanies the above-described electrical operation will be described with reference to Figures 10A and 10B. At the time instant t_1 , the piezo-electric element 9 starts to charge and is deformed. Since the piezo-electric element 9 is bonded to the wall 5, the deformation of the element 9 raises the wall 5 in such a manner that the wall 5 becomes substantially conical thereby increasing the volume of the pressure chamber 2, as shown in Figure 10A. During this operation, ink 6 from the ink container 7 is drawn in through the supply port 4 while air is drawn in through the opening 3a in the nozzle 3 as a result of which a state such as that shown in Figures 10A and 10B is reached. If the time instant t_2 is set so that it occurs approximately when the amount of air drawn-in (20) is at a maximum and the charge stored in the piezo-electric element 9 is discharged almost instantly, the wall 5 and the element 9 will be quickly restored to the position shown in Figure 11 by the elastic energy which is stored in the wall 5 and the element 9. As a result, ink 6 will be propelled from the opening 3a in the nozzle 3 in the form of ink droplets 21.

In the method described above the energy consumption is small since the piezo-electric element is not supplied with voltage at any time other than the time when ink is jetted, during the interval T. In addition, even when the electric power is on, it is safe to touch the piezo-electric element, for example when exchanging a recording sheet when printing is stopped, since the piezo-electric element is not supplied with voltage.

Although the method described above may

suffer from depolarization problems, this method still has the advantages that the driving voltage of the piezo-electric element is always of the same polarity, so that the driving circuit can be of simple construction, and that the ink jet head can be operated in an efficient manner by making use of the damped oscillation of the mechanical system.

Figure 12 shows another embodiment of a circuit which may be used to drive an ink jet head by a method according to the present invention. Before the time instant t_1 , a transistor 30 and a transistor 31 are rendered conductive (ON) and non-conductive (OFF), respectively, as a result of which the voltage 32 across the piezo-electric element 9 becomes substantially equal to the source voltage 25. During the pulse interval T between the time instants t_1 and t_2 , the transistors 30 and 31 are turned ON and OFF respectively. As a result of this the charge stored in the piezo-electric element 9 flows as a current in the direction of the arrow B through the resistor 13. When the input signal 16 falls, the transistor 30 and the transistor 31 are respectively rendered conductive (ON) and non-conductive (OFF) again, as a result of which the piezo-electric element 9 is charged.

At times other than the time during the interval T, the electric power consumed by the resistor 13 is very low. The circuit shown in Figure 9 is of more simple construction than that shown in Figure 3.

Figure 13 shows another embodiment of a drive circuit for the piezo-electric element 9. This circuit may be used when the element is to be driven with a very low voltage. Although the operation of the circuit in Figure 9 will be clear for those skilled in the art, it will be briefly described with reference to Figure 14 which shows waveforms at various points in the circuit.

A switch 51 is turned ON by an application of a suitable signal to a control terminal 52 to allow a source voltage V to be applied across a circuit D, which comprises transistors Tr_1 , Tr_2 , Tr_3 and Tr_4 , resistors 53 and 54 and the piezo-electric element 9. The transistors Tr_1 and Tr_2 are connected in series through the resistor 53, and the transistors Tr_3 and Tr_4 are connected in series through the resistor 54. The piezo-electric element 9 is connected between points E and F.

A suitable control signal generator 57 which produces a bi-directional biasing signal according to a printing demand is provided. An output of the generator 57 is directly connected to bases of the transistors Tr_1 and Tr_4 , and through an inverter 56 to bases of the transistors Tr_2 and Tr_3 so that when the transistors Tr_1 and Tr_4 are turned ON the transistors Tr_2 and Tr_3 are turned OFF, or vice versa.

When the switch 51 is closed by an application of the signal a (Figure 14) to the control terminal 52, the voltage source 50 is connected in circuit to apply the source voltage V

across the circuit D, as shown by waveform *b* in Figure 14.

In this condition, when a print demand occurs, the generator 57 is actuated to produce positive and negative outputs as shown by waveform *c* in Figure 14. Assuming that during a period T_1 , in which there is no printing, the polarity of the output of the generator 57 is such that the transistors Tr_2 and Tr_3 are turned ON, a current flows through the transistor Tr_3 , the piezo-electric element 9 and the transistor Tr_2 , so that the voltage at points E and F are as shown by waveforms *d* and *e*, respectively, causing the piezo-electric element 9 to be deformed in one direction. When a printing demand occurs, the polarity of the output generator 57 is reversed for a period T_2 and the voltages at points E and F become V and O, respectively, causing the element 9 to be deformed in the other direction. The amounts by which the element 9 is deformed is thus doubled, as shown by waveform *f* in Figure 14 and this means that the source voltage may be smaller than that used in the methods described above.

Furthermore, in this method the ink jet head is driven in a highly efficient manner merely by suitably selecting the pulse width T. Accordingly, even when the oscillation system composed of the piezo-electric element 9, the wall 5 and the ink 6 varies, and hence the position of the maximum valve 27 of the damped oscillation 23 is changed, the ink jet head can still be driven efficiently by adjusting the pulse width T. If, on the other hand, a voltage transducer were used, it would be necessary to change the connections of the primary and secondary windings. This would undoubtedly be intricate and troublesome.

Claims

1. A method of operating an on-demand type ink jet head, which comprises a pressure chamber (2) with an inlet (4) which communicates with a supply of ink (6) and an outlet (3) which communicates with the atmosphere, and an electro-mechanical transducer (9) which is arranged to alter the volume of the pressure chamber (2), comprising the steps of: applying an electrical signal to the electro-mechanical transducer (9) so that the volume of the pressure chamber (2) is increased whereby ink is drawn into the pressure chamber (2), and changing the said signal so that the volume of the pressure chamber (2) is reduced whereby ink (6) is propelled out of the said outlet (3), characterised in that the said signal is changed at a time when the amplitude of oscillation of a mechanical system formed by the electro-mechanical transducer (9), at least part of the pressure chamber (5), and ink (6) within the pressure chamber (2) is substantially at a maximum.

2. A method as claimed in claim 1 characterised by comprising the steps of: applying the

said signal to the electro-mechanical transducer (9) so that the volume of the pressure chamber (2) is increased whereby ink (6) is drawn into the pressure chamber (2), and changing the said signal by reducing its voltage so that ink (6) is propelled out of the said outlet (3) by means of elastic energy stored in the said mechanical system (9, 5, 6) at the said maximum.

3. A method as claimed in claim 2 characterised in that a power source is connected to the electro-mechanical transducer (9) to establish the pressure chamber (2) in a standby condition before the said signal which causes the volume of the pressure chamber (2) to increase is applied to the electro-mechanical transducer (9).

4. A method as claimed in claim 1 characterised by comprising the steps of: applying the said signal to the electro-mechanical transducer (9) so that the volume of the pressure chamber (2) is decreased; reducing the voltage of the said signal so that the volume of the pressure chamber (2) is restored to its original condition and then increased by means of oscillation of the said mechanical system (9, 5, 6); and increasing the voltage of the said signal at the said time whereby ink (6) drawn into the pressure chamber (2) when the volume thereof was increased is propelled out of the said outlet (2).

5. A method as claimed in claim 1 characterised by comprising the steps of: applying the said signal to the electro-mechanical transducer (9) so that the volume of the pressure chamber (2) is decreased; reversing the polarity of the said signal so that the volume of the pressure chamber (2) is restored to its original condition and is then increased; and again reversing the polarity of the said signal at the said time whereby ink (6) drawn into the pressure chamber (2) when the volume thereof was increased is propelled out of the said outlet (3).

6. A method as claimed in claim 5 characterised in that the said signal is applied to the electro-mechanical transducer (9) by signal supplying means which comprises: first transistor switch means (Tr_2 , Tr_3) connected in series with the electro-mechanical transducer (9); second transistor switch means (Tr_1 , Tr_4) connected in series with the electro-mechanical transducer (9); and driving means (56, 57), for driving the first and second transistor switch means (Tr_1 , Tr_2 , Tr_3 , Tr_4) with opposite phases in response to an input signal.

7. A method as claimed in any preceding claims characterised in that the said signal is applied to the electro-mechanical transducer (9) by signal supply means which comprises a transistor drive circuit, the electro-mechanical transducer (9) being connected in parallel with a resistor (13), the parallel arrangement (9, 13) being connected to the collector of an output transistor (31) of the said circuit.

across the circuit D, as shown by waveform *b* in Figure 14.

In this condition, when a print demand occurs, the generator 57 is actuated to produce positive and negative outputs as shown by waveform *c* in Figure 14. Assuming that during a period T_1 , in which there is no printing, the polarity of the output of the generator 57 is such that the transistors Tr_2 and Tr_3 are turned ON, a current flows through the transistor Tr_3 , the piezo-electric element 9 and the transistor Tr_2 , so that the voltage at points E and F are as shown by waveforms *d* and *e*, respectively, causing the piezo-electric element 9 to be deformed in one direction. When a printing demand occurs, the polarity of the output generator 57 is reversed for a period T_2 and the voltages at points E and F become V and O, respectively, causing the element 9 to be deformed in the other direction. The amounts by which the element 9 is deformed is thus doubled, as shown by waveform *f* in Figure 14 and this means that the source voltage may be smaller than that used in the methods described above.

Furthermore, in this method the ink jet head is driven in a highly efficient manner merely by suitably selecting the pulse width T. Accordingly, even when the oscillation system composed of the piezo-electric element 9, the wall 5 and the ink 6 varies, and hence the position of the maximum valve 27 of the damped oscillation 23 is changed, the ink jet head can still be driven efficiently by adjusting the pulse width T. If, on the other hand, a voltage transducer were used, it would be necessary to change the connections of the primary and secondary windings. This would undoubtedly be intricate and troublesome.

Claims

1. A method of operating an on-demand type ink jet head, which comprises a pressure chamber (2) with an inlet (4) which communicates with a supply of ink (6) and an outlet (3) which communicates with the atmosphere, and an electro-mechanical transducer (9) which is arranged to alter the volume of the pressure chamber (2), comprising the steps of: applying an electrical signal to the electro-mechanical transducer (9) so that the volume of the pressure chamber (2) is increased whereby ink is drawn into the pressure chamber (2), and changing the said signal so that the volume of the pressure chamber (2) is reduced whereby ink (6) is propelled out of the said outlet (3), characterised in that the said signal is changed at a time when the amplitude of oscillation of a mechanical system formed by the electro-mechanical transducer (9), at least part of the pressure chamber (5), and ink (6) within the pressure chamber (2) is substantially at a maximum.

2. A method as claimed in claim 1 characterised by comprising the steps of: applying the

said signal to the electro-mechanical transducer (9) so that the volume of the pressure chamber (2) is increased whereby ink (6) is drawn into the pressure chamber (2), and changing the said signal by reducing its voltage so that ink (6) is propelled out of the said outlet (3) by means of elastic energy stored in the said mechanical system (9, 5, 6) at the said maximum.

3. A method as claimed in claim 2 characterised in that a power source is connected to the electro-mechanical transducer (9) to establish the pressure chamber (2) in a standby condition before the said signal which causes the volume of the pressure chamber (2) to increase is applied to the electro-mechanical transducer (9).

4. A method as claimed in claim 1 characterised by comprising the steps of: applying the said signal to the electro-mechanical transducer (9) so that the volume of the pressure chamber (2) is decreased; reducing the voltage of the said signal so that the volume of the pressure chamber (2) is restored to its original condition and then increased by means of oscillation of the said mechanical system (9, 5, 6); and increasing the voltage of the said signal at the said time whereby ink (6) drawn into the pressure chamber (2) when the volume thereof was increased is propelled out of the said outlet (2).

5. A method as claimed in claim 1 characterised by comprising the steps of: applying the said signal to the electro-mechanical transducer (9) so that the volume of the pressure chamber (2) is decreased; reversing the polarity of the said signal so that the volume of the pressure chamber (2) is restored to its original condition and is then increased; and again reversing the polarity of the said signal at the said time whereby ink (6) drawn into the pressure chamber (2) when the volume thereof was increased is propelled out of the said outlet (3).

6. A method as claimed in claim 5 characterised in that the said signal is applied to the electro-mechanical transducer (9) by signal supplying means which comprises: first transistor switch means (Tr_2 , Tr_3) connected in series with the electro-mechanical transducer (9); second transistor switch means (Tr_1 , Tr_4) connected in series with the electro-mechanical transducer (9); and driving means (56, 57), for driving the first and second transistor switch means (Tr_1 , Tr_2 , Tr_3 , Tr_4) with opposite phases in response to an input signal.

7. A method as claimed in any preceding claims characterised in that the said signal is applied to the electro-mechanical transducer (9) by signal supply means which comprises a transistor drive circuit, the electro-mechanical transducer (9) being connected in parallel with a resistor (13), the parallel arrangement (9, 13) being connected to the collector of an output transistor (31) of the said circuit.



8. An on demand type ink jet head system comprising: an ink jet head having a pressure chamber (2) with an inlet (4) which communicates with a supply of ink (6) and an outlet (3) which communicates with the atmosphere; an electro-mechanical transducer (9) which is arranged to be able to alter the volume of the pressure chamber (2); and means for supplying an electrical signal to the electro-mechanical transducer (9), the signal supplying means being arranged, in use, to apply an electrical signal to the electro-mechanical transducer (9) so that the volume of the pressure chamber (2) is increased whereby ink (6) is drawn into the pressure chamber (2), and to change the said signal so that the volume of the pressure chamber (2) is reduced whereby ink (6) is propelled out of the said outlet (3), characterised in that the said signal supplying means is arranged, in use, to change the said signal at a time when the amplitude of oscillation of a mechanical system formed by the electro-mechanical transducer (9) at least part of the pressure chamber (5), and ink (6) within the pressure chamber (2) is substantially at a maximum.

9. A system as claimed in claim 8 characterised in that the signal supplying means is arranged, in use, to apply the said signal to the electro-mechanical transducer (9) so that the volume of the pressure chamber (2) is increased whereby ink (6) is drawn into the pressure chamber (2), and to then change the said signal by reducing its voltage so that ink (6) is propelled out of the said outlet (3) by means of elastic energy stored in the said mechanical system (9, 5, 6) at the said maximum.

10. A system as claimed in claim 8 characterised in that the signal supplying means is arranged, in use, to apply the said signal to the electro-mechanical transducer (9) so that the volume of the pressure chamber (2) is decreased, the voltage of the said signal is reduced so that the volume of the pressure chamber (2) is restored to its original condition and then increased by means of oscillation of the said mechanical system (9, 5, 6), and the voltage of the said signal is increased at the said time whereby ink (6) is drawn into the pressure chamber (2) when the volume thereof was increased is propelled out of the said outlet (3).

11. A system as claimed in claim 8 characterised in that the signal supply means is arranged, in use, to apply the said signal to the electro-mechanical transducer (9) so that the volume of the pressure chamber (2) is decreased, the polarity of the said signal is reversed so that the volume of the pressure chamber (2) is restored to its original condition and is then increased, and the polarity of the said signal is again reversed at the said time whereby ink (6) drawn into the pressure chamber (2) when the volume thereof was increased is propelled out of the said outlet (3).

12. A system as claimed in any of claims 8 to 11 characterised in that the electro-mechanical

transducer (9) is a piezo-electric transducer (9) and that the polarity of the said signal when it causes the volume of the pressure chamber (2) to be decreased is the same as that of the polarization voltage of the piezoelectric transducer (9).

Revendications

1. Procédé de commande d'une tête d'impression à la demande par projection d'encre, qui comprend une chambre sous pression (2) ayant une entrée (4) qui communique avec une réserve d'encre (6) et une sortie (3) qui communique avec l'atmosphère, et un transducteur électromécanique (9) disposé afin qu'il modifie le volume de la chambre sous pression (2), comprenant les étapes d'application d'un signal électrique au transducteur électromécanique (9) de manière que le volume de la chambre sous pression (2) augmente si bien que de l'encre est aspirée dans la chambre sous pression (2), et de modification dudit signal de manière que le volume de la chambre sous pression (2) soit réduit et que de l'encre (6) soit projetée par la sortie (3), caractérisé en ce que ledit signal est modifié à un moment auquel l'amplitude d'oscillation d'un système mécanique formé par le transducteur électromécanique (9), une partie au moins de la chambre sous pression (5) et l'encre (6) se trouvant dans la chambre sous pression (2) est sensiblement à un maximum.

2. Procédé selon la revendication 1, caractérisé en ce qu'il comprend les étapes d'application dudit signal au transducteur électromécanique (9) de manière que le volume de la chambre sous pression (2) soit augmenté si bien que l'encre (6) est aspirée dans la chambre sous pression (2), et de modification dudit signal par réduction de sa tension afin que l'encre (6) soit projetée par la sortie (3) sous l'action d'énergie d'élasticité emmagasinée dans le système mécanique (9, 5, 6) audit maximum.

3. Procédé selon la revendication 2, caractérisé en ce qu'une source d'énergie est connectée au transducteur électromécanique (9) afin que la chambre sous pression (2) soit mise en condition d'attente avant que ledit signal qui provoque une augmentation du volume de la chambre sous pression (2) ne soit appliqué au transducteur électromécanique (9).

4. Procédé selon la revendication 1, caractérisé en ce qu'il comprend les étapes d'application dudit signal au transducteur électromécanique (9) de manière que le volume de la chambre sous pression (2) diminue, de réduction de la tension dudit signal de manière que le volume de la chambre sous pression (2) reprenne son état d'origine puis augmente sous l'action de l'oscillation dudit système mécanique (9, 5, 6), et d'augmentation de la tension dudit signal audit moment si bien que l'encre (6) aspirée dans la chambre sous pression (2) lorsque son volume a augmenté est



chassée par la sortie (2).

5. Procédé selon la revendication 1, caractérisé en ce qu'il comprend les étapes d'application dudit signal au transducteur électromécanique (9) afin que le volume de la chambre sous pression (2) diminue, d'inversion de la polarité dudit signal afin que le volume de la chambre sous pression (2) reprenne son état d'origine puis augmente, puis d'inversion à nouveau de la polarité dudit signal audit moment afin que l'encre (6) aspirée dans la chambre sous pression (2) lorsque son volume a augmenté soit projetée par ladite sortie (3).

6. Procédé selon la revendication 5, caractérisé en ce que ledit signal est appliqué au transducteur électromécanique (9) par un dispositif de transmission de signaux qui comporte un premier dispositif de commutation à transistors (Tr2, Tr3) monté en série avec le transducteur électromécanique (9), un second dispositif de commutation à transistors (Tr1, Tr4) monté en série avec le transducteur électromécanique (9), et un dispositif de pilotage (56, 57) destiné à piloter le premier et le second dispositif à transistors (Tr1, Tr2, Tr3, Tr4) avec des phases opposées en fonction d'un signal d'entrée.

7. Procédé selon l'une quelconque des revendications précédentes, caractérisé en ce que ledit signal est appliqué au transducteur électromécanique (9) par un dispositif de transmission de signaux qui comporte un circuit de pilotage à transistor, le transducteur électromécanique (9) étant monté en parallèle avec une résistance (13), l'arrangement parallèle (9, 13) étant connecté au collecteur du transistor de sortie (31) dudit circuit.

8. Appareil à tête d'impression à la demande par projection d'encre, comprenant une tête d'impression par projection d'encre ayant une chambre sous pression (2) qui a une entrée (4) qui communique avec une réserve d'encre (6) et une sortie (3) qui communique avec l'atmosphère, un transducteur électromécanique (9) disposé afin qu'il puisse modifier le volume de la chambre sous pression (2), et un dispositif destiné à transmettre un signal électrique au transducteur électromécanique (9), les dispositif de transmission de signaux étant disposé de manière que, lors du fonctionnement, il applique un signal électrique au transducteur électromécanique (9) d'une manière telle que le volume de la chambre sous pression (2) augmente et que de l'encre (6) soit aspirée dans la chambre sous pression (2), et qu'il modifie ledit signal de manière que le volume de la chambre sous pression (2) soit réduit et que de l'encre (6) soit projetée par ladite sortie (3), caractérisé en ce que ledit dispositif de transmission de signaux est disposé de manière que, lors du fonctionnement, il modifie ledit signal à un moment auquel l'amplitude d'oscillation du système mécanique formé par le transducteur électromécanique (9), une partie au moins de la chambre sous pression (5) et l'encre (6) qui se

trouve dans la chambre sous pression (2) soit sensiblement à un maximum.

9. Appareil selon la revendication 8, caractérisé en ce que le dispositif de transmission de signaux est disposé de manière que, lors du fonctionnement, il applique ledit signal au transducteur électromécanique (9) d'une manière telle que le volume de la chambre sous pression (2) augmente et que de l'encre (6) soit aspirée dans la chambre sous pression (2), et il modifie ledit signal par réduction de sa tension d'une manière telle que l'encre (6) est chassée par la sortie (3) sous l'action de l'énergie d'élasticité emmagasinée dans le système mécanique (9, 5, 6) audit maximum.

10. Appareil selon la revendication 8, caractérisé en ce que le dispositif de transmission de signaux est disposé de manière que, lors du fonctionnement, il applique ledit signal au transducteur électromécanique (9) d'une manière telle que le volume de la chambre sous pression (2) diminue, la tension dudit signal est réduite de manière que le volume de la chambre sous pression (2) soit remis à son état d'origine et augmente du fait de l'oscillation du système mécanique (9, 5, 6), et la tension dudit signal est augmentée audit moment, si bien que de l'encre (6) aspirée dans la chambre sous pression (2) lorsque son volume a augmenté, est chassée par ladite sortie (3).

11. Appareil selon la revendication 8, caractérisé en ce que le dispositif de transmission de signaux est disposé de manière que, lors du fonctionnement, il applique ledit signal au transducteur électromécanique (9) d'une manière telle que le volume de la chambre sous pression (2) diminue, la polarité dudit signal soit inversée de manière que le volume de la chambre sous pression (2) reprenne son état d'origine puis augmente, et la polarité dudit signal soit à nouveau inversée audit moment si bien que de l'encre (6) aspirée dans la chambre sous pression (2) lorsque son volume a augmenté est chassée par ladite sortie (3).

12. Appareil selon l'une quelconque des revendications 8 à 11, caractérisé en ce que le transducteur électromécanique (9) est un transducteur piézoélectrique (9) et en ce que la polarité dudit signal, lorsqu'il provoque la réduction du volume de la chambre sous pression (2), est la même que celle de la tension de polarisation du transducteur piézoélectrique (9).

Patentansprüche

1. Verfahren zum Betreiben eines Bedarfsfarbspritzkopfes, der eine Druckkammer (2) mit einem Einlaß (4), welcher mit einer Farbzufuhr (6) in Verbindung steht, und einen elektromechanischen Wandler (9) besitzt, welcher für die Änderung des Volumens der Druckkammer (2) vorgesehen ist, bestehend aus den Verfahrensschritten: Aufgeben eines elektrischen Signals auf den elektromechanischen Wandler (9), so daß das Volumen der Druckkammer (2)



vergrößert wird, wodurch Farbe in die Druckkammer (2) eingesaugt wird; und Änderung des Signals, so daß das Volumen der Druckkammer (2) verringert wird, wodurch Farbe (6) aus dem Auslaß (3) ausgestoßen wird, dadurch gekennzeichnet, daß das Signal zu einem Zeitpunkt geändert wird, wenn die Schwingungsamplitude eines mechanischen Systems, das von dem elektromechanischen Wandler (9), wenigstens einen Teil der Druckkammer (5) und der Farbe (6) innerhalb der Druckkammer (2) gebildet wird, sich im wesentlichen auf einem Maximum befindet.

2. Verfahren nach Anspruch 1, gekennzeichnet durch die Verfahrensschritte: Aufbringen des Signals auf den elektromechanischen Wandler (9), so daß das Volumen der Druckkammer (2) erhöht wird, wodurch Farbe (6) in die Druckkammer (2) eingesaugt wird; und Änderung des Signals durch Verringerung seiner Spannung, so daß Farbe (6) aus dem Auslaß (3) mit Hilfe der in dem mechanischen System (9, 5, 6) bei dem Maximum gespeicherten Energie ausgestoßen wird.

3. Verfahren nach Anspruch 2, dadurch gekennzeichnet, daß eine Stromquelle mit dem elektromechanischen Wandler (9) verbunden wird, um die Druckkammer (2) in einen Bereitschaftszustand zu bringen, ehe das Signal, das den Ausstieg des Volumens der Druckkammer (2) veranlaßt, auf den elektromechanischen Wandler (9) aufgegeben wird.

4. Verfahren nach Anspruch 1, gekennzeichnet durch die Verfahrensschritte: Aufbringen des Signals auf den elektromechanischen Wandler (9), so daß das Volumen der Druckkammer (2) verringert wird; Verringerung der Spannung des Signals, so daß das Volumen in der Druckkammer (2) in seinen ursprünglichen Zustand zurückgebracht und dann mittels der Schwingung des mechanischen Systems (9, 5, 6) vergrößert wird; und Erhöhen der Spannung des Signals zu diesem Zeitpunkt, wodurch Farbe (6), die in die Druckkammer (2) bei Erhöhung des Volumens derselben eingesaugt worden ist, aus dem Auslaß (3) ausgestoßen wird.

5. Verfahren nach Anspruch 1, gekennzeichnet durch die Verfahrensschritte: Aufbringen des Signals auf den elektromechanischen Wandler (9), so daß das Volumen der Druckkammer (2) verringert wird; Umkehren der Polarität des Signals, so daß das Volumen der Druckkammer (2) in seinen ursprünglichen Zustand zurückgebracht und dann erhöht wird; und wiederum Umkehren der Polarität des Signals zu diesem Zeitpunkt, wodurch Farbe (6), in die Druckkammer (2) bei Erhöhung des Volumens desselben eingesaugt worden ist, aus dem Auslaß (3) ausgestoßen wird.

6. Verfahren nach Anspruch 5, dadurch gekennzeichnet, daß das Signal auf den elektromechanischen Wandler (9) durch eine Signalführeinrichtung aufgegeben wird, bestehend aus einer ersten Transistorschalteneinrichtung (Tr2, Tr3), die in Reihe mit dem elektromechanischen Wandler (9) geschaltet ist; einer zweiten Transistorschalteneinrichtung (Tr1, Tr4),

die in Reihe mit dem elektromechanischen Wandler (9) geschlossen ist; und einer Ansteuereinrichtung (56, 57), um die erste und die zweite Transistorschalteneinrichtung (Tr1, Tr2, Tr3, Tr4) mit entgegengesetzten Phasen in Abhängigkeit von einem Eingangssignal anzusteuern.

7. Verfahren nach einem vorangehenden Anspruch, dadurch gekennzeichnet, daß das besagte Signal auf den elektromechanischen Wandler (9) mittels einer Signalführeinrichtung aufgegeben wird, die eine Transistorsteuereinrichtung aufweist, wobei der elektromechanische Wandler (9) parallel zu einem Widerstand (13) geschaltet ist, wobei die parallele Anordnung (9, 13) an den Kollektor eines Ausgangstransistors (31 der Schaltung) angeschlossen ist.

8. Bedarfsfarbspritzkopfsystem, bestehend aus einem Farbspritzkopf, der eine Druckkammer (2) mit einem Einlaß (4), der mit einer Farbzufuhr (6) in Verbindung steht, und einem Auslaß (3) besitzt, der mit der Atmosphäre kommuniziert; einem elektromechanischen Wandler (9), welcher für die Änderung des Volumens der Druckkammer (2) vorgesehen ist; und aus einer Einrichtung zum Zuführen eines elektrischen Signals auf den elektromechanischen Wandler (9), wobei die Signalführeinrichtung so vorgesehen ist, daß sie bei Benützung ein elektrisches Signal auf den elektromechanischen Wandler (9) aufgibt, so daß das Volumen der Druckkammer (2) erhöht wird, wodurch Farbe (6) in die Druckkammer (2) eingesaugt wird, und daß sie dieses Signal ändert, so daß das Volumen der Druckkammer (2) verringert wird, wodurch Farbe (6) aus dem Auslaß (3) ausgestoßen wird, dadurch gekennzeichnet, daß die Signalführeinrichtung beim Gebrauch zur Änderung dieses Signals zu einem Zeitpunkt vorgesehen ist, zu dem sich die Amplitude der Schwingung eines mechanischen Systems, das aus dem elektromechanischen Wandler (9), wenigstens einem Teil der Druckkammer (5) und der Farbe (6) innerhalb der Druckkammer (2) gebildet wird, im wesentlichen auf einem Maximum befindet.

9. System nach Anspruch 8, dadurch gekennzeichnet, daß die Signalführeinrichtung bei Gebrauch für die Aufgabe des Signals auf den elektromechanischen Wandler (9) derart vorgesehen ist, daß das Volumen der Druckkammer (2) erhöht wird, wodurch Farbe (6) in die Druckkammer (2) eingesaugt wird, und daß dann dieses Signal durch Verringerung seiner Spannung derart geändert wird, daß Farbe (6) aus dem Auslaß (3) mittels der in dem mechanischen System (9, 5, 6) gespeicherten Energie bei diesem Maximum ausgestoßen wird.

10. System nach Anspruch 8, dadurch gekennzeichnet, daß die Signalführeinrichtung beim Gebrauch zum Aufgeben dieses Signals auf den elektromechanischen Wandler (9) derart vorgesehen ist, daß das Volumen der



Druckkammer (2) verringert wird, daß die Spannung dieses Signals derart verringert wird, daß das Volumen der Druckkammer (2) in seinen ursprünglichen Zustand zurückgebracht und dann mittels der Schwingung des mechanischen Systems (9, 5, 6) erhöht wird, und daß die Spannung des Signals zu diesem Zeitpunkt erhöht wird, wodurch Farbe (6), die in die Druckkammer (2) bei Erhöhen des Volumens desselben eingesaugt worden ist, aus dem Auslaß (3) ausgestoßen wird.

11. System nach Anspruch 8, dadurch gekennzeichnet, daß die Signalszuführeinrichtung beim Gebrauch zum Aufgeben dieses Signals auf den elektromechanischen Wandler (9) in der Art vorgesehen ist, daß das Volumen der Druckkammer (2) verringert wird, daß die Polarität dieses Signals umgekehrt wird, so daß das

Volumen der Druckkammer (2) in seinen ursprünglichen Zustand zurückgebracht und dann erhöht wird, und daß die Polarität des Signals wiederum zu dem besagten Zeitpunkt umgekehrt wird, wodurch Farbe (6), die in die Druckkammer (2) bei Erhöhen des Volumens desselben eingesaugt worden ist, aus dem Auslaß (3) ausgestoßen wird.

12. System nach einem der Ansprüche 8 bis 11, dadurch gekennzeichnet, daß der elektromechanische Wandler (9) ein piezo-elektrischer Wandler (9) ist, und daß die Polarität des besagten Signals, wenn es die Verringerung des Volumens der Druckkammer (2) veranlaßt, dieselbe wie die der Polarisationsspannung des piezo-elektrischen Wandlers (9) ist.

