

Description

This invention relates to electro-pneumatic converters.

Electro-pneumatic converters utilise a motor which controls the operation of a pneumatic device. No known electro-pneumatic converter has a variable speed capacity as an integral portion of the device. Some manufacturers, in order to provide electro-pneumatic converters of different speeds, use various servo-motor/gear-box arrangements in their devices. This means that the manufacturer must supply a different converter model for a different speed. Each model is capable only of supplying a specific speed.

US Patent No. US—A—3 482 588 discloses an electro-pneumatic converter provided with a stepping motor and a pneumatic relay controlled by rotation of the motor. Pressure raising and lowering lines are selectively connected to a power source by relay switches. The pressure raising and lowering lines are connected to a transfer network which provides drive signals for the stepping motor on a plurality of output terminals such that rotation of the stepping motor is controlled by the drive signals.

According to the present invention there is provided an electro-pneumatic converter comprising:

- a reversible *dc* servo motor having a first terminal and a second terminal for receiving electrical power, and a shaft which is rotatable in two opposite directions;

- pneumatic means cooperable with the shaft for supplying gas at a pressure which is proportional to the rotation of the shaft;

- a pressure raising line;

- a pressure lowering line;

- an electric power supply having a common terminal and a power terminal at a voltage different from the common terminal; and

- switch means for selectively connecting the common terminal to one of the pressure raising and pressure lowering lines;

characterised by:

- a first resistor in the pressure raising line, the pressure raising line being connected to the first motor terminal;

- a second resistor in the pressure lowering line, the pressure lowering line being connected to the second motor terminal;

- a line terminal connected between the pressure raising and pressure lowering lines on a side of the first and second resistors opposite from the first and second motor terminals; and

- variable resistor means connected between the line terminal and the power terminal for applying a selected resistance between the power terminal and line terminal to drive the shaft of the motor in one direction when one of the pressure raising and pressure lowering lines is connected to the common terminal and in an opposite direction when the other of the pressure raising and pressure lowering lines is connected to the common terminal, the variable resistor means

providing the converter with a variable speed function.

The variable resistor means may be in the form of a multi-position switch or a plurality of switches each having one side connected to the power terminal and another side connected to one of a plurality of resistors which in turn are connected to the line terminal connecting the raising and lowering lines together. A variable resistor may instead be used as the variable resistor means.

A further resistor may be connected between the raising and lowering lines to accommodate surges in electricity supplied over the motor.

Preferred electro-pneumatic converters embodying the invention and described hereinbelow are simple in design, rugged in construction and economical to manufacture.

The preferred embodiment includes a resistive network which can be used in conjunction with the motor of the electro-pneumatic converter for changing the speed of the motor to change the speed of the electro-pneumatic converter. The resistive network may also be used to limit current and voltage supplied to the motor.

The invention will now be further described, by way of illustrative and non-limiting example, with reference to the accompanying drawings, in which:

Figure 1 is a block diagram showing a pneumatic positioning arrangement incorporating a variable speed electro-pneumatic converter embodying the invention;

Figure 2 is a schematic representation of a servo motor and resistive motor control arrangement utilised in the electro-pneumatic converter;

Figure 3 is a view similar to Figure 2 of another embodiment of the invention; and

Figure 4 is a diagrammatical representation of the motor and pneumatic means used in the electro-pneumatic converter.

The drawings show a variable speed electro-pneumatic converter 12 which can be utilised in a pneumatic positioning arrangement 10.

The pneumatic positioning arrangement 10 includes a basic positioner (known as a "Pneumatic Positioner") 14 which has a cam shaft output 16 for connection to a mechanical actuator. The positioner 14 is connected to a static supply line 18 for supplying the pneumatic positioning arrangement 10 with pressurised gas. The gas is generally air.

A position transmitter 20 includes a variable resistor or potentiometer 22 which has a slider that is mechanically connected to the shaft 16 over a schematically shown connection 24. By moving the slider of the potentiometer 22, the position transmitter 20 generates a signal on a 4 to 20 mA line 26 which is representative of the position of the shaft 16. The position transmitter 20 receives power over a +24 V *dc* line 28.

The electro-pneumatic converter 12, which is in the form of a motor-to-pneumatic converter (M/P converters), also receives pressurised gas over a line 30 connected to the pneumatic supply line 18,

as well as electrical power over +24 V *dc* line 32. The M/P converter 12 is also connected to a raise line 34 and a lower line 36 which are selectively connectable to a common terminal (see Figure 2). By connecting the raise line 34 to the common terminal, a motor of the converter 12 rotates in one direction to increase the pressure of gas leaving the converter 12 over a line 38. By connecting the lower line 36 to the common terminal, a shaft of the motor shaft rotates in an opposite direction to decrease the pressure on the line 38. The pressure on the line 38 is generally between 20.7 and 103.4 kPa (3 and 15 lbf/in² or PSI) and is proportional to the position of the motor in the converter 12 which in turn is proportional to the electrical signal supplied to the motor.

Referring now to Figure 4, the motor 40 of the electro-pneumatic converter 12 is in the form of a reversible *dc* servo motor. The shaft of the motor 40 is connected to a gear or gear reduction unit 42 which has an output shaft 44 connected to a cam 46. The cam 46 faces the orifice of a nozzle 48. The nozzle 48 is connected to a spring-biased bellows 50 having an input line 52 communicating with the interior of the bellows 50 as well as the interior of the nozzle 48. The line 38 for supplying a pneumatic gas at a controlled pressure is connected to the line 52. The lines 38 and 52 receive gas (generally air), at a constant low pressure of 151.7 kPa $\pm$ 13.8 kPa (22 lbf/in² $\pm$ 2 lbf/in²), from a regulator 54. The regulator 54 receives pressurised gas from a pump or other gas supply 56.

The rotational position of the shaft 44 as controlled by the gear or gear reduction unit 42 is ultimately controlled by the shaft of the motor 40. The shaft of the motor 40 turns in one direction or an opposite direction and at a selected speed which is determined by the electrical power supplied to terminals 58 and 60 of the motor.

Referring now to Figure 2, a resistive speed control arrangement for the motor 40 includes the raise line 34 which is in the form of a pressure raising line and the lower line 36 which is in the form of a pressure lowering line. The two lines 34, 36 are selectively connected by switch means 62 to a common terminal 64. The common terminal 64 is at a voltage (generally ground voltage) different from the power line 32.

The terminal 58 of the motor 40 is connected to the raise line 34 and the terminal 60 of the motor 40 is connected to the lower line 36.

A first resistor 66 is connected in the line 34 and a second resistor 68 is connected in the line 36. The resistors 66 and 68 might both, for example, be 1000 ohm resistors. A shunting resistor 70 which, for example, has a value of 56.2 ohms, is connected between the lines 34 and 36 and in parallel with the motor 40. The resistor 70 provides stabilisation of the voltage drop across the *dc* motor 40, which is necessary due to dynamic resistive changes which the motor experiences and which are caused by friction in the reduction gear unit 42.

A variable speed for the electro-pneumatic con-

verter 12, in general, and the motor 40, in particular, is achieved by providing variable resistor means 72. The resistor means 72 comprises four separate resistors 74 which are respectively connected to four switches in a four position dip switch 76. The other side of each switch is connected to the power line 32. By selecting one or more resistors 74 by closing one or more of the switches of the four position switch 76, a variety of voltage levels can be provided to a common terminal 78 connecting the resistors 66, 68 together.

The embodiment of Figure 3 is substantially the same as the embodiment of Figure 2, so that the same numerals are used to designate the same or similar parts. Additional explanation of these parts will not be provided. The embodiment of Figure 3 differs from the embodiment of Figure 2 in that the variable resistor means 72, instead of comprising a plurality of discrete resistors, comprises a single variable resistor 80 having a slider (or conversely a resistor) connected to the power line 32 and a resistor (or conversely the slider) connected to the common or line terminal 78.

The variable speed electro-pneumatic converter 12 operates as follows:

A selected resistance is first chosen for the variable resistor means 72 in Figure 2 or the variable resistance means (variable resistor) 80 in Figure 3. Then, if it is desired to raise the pressure on the line 38 in Figure 4, the raise line 34 is connected to the common terminal 64 by placing the switch means 62 in an appropriate position. Voltage and current is then supplied by the line 32, over the selected resistance of the resistor means 72 or 80, to the line terminal 78. Current then flows through the resistor 68, to the terminal 60, through the motor 40, to the terminal 58 and through the line 34 to the common terminal 64. This rotates the shaft of the motor 40 in one direction and at a selected speed to regulate the pressure on the line 38.

The shaft of the motor 40 is reversed by opening the connection between the line 34 and the common terminal 64 and closing the connection between the common terminal 64 and the line 36. The flow of current is then reversed in the *dc* servo motor 40 to reverse the rotation of its shaft.

In a further embodiment of the invention, rather than regulating the voltage in the variable resistor means 72 or 80, the power supply of the line 32 can be regulated.

The pressure on the line 38 as shown in Figure 4 is regulated in accordance with a rotational position of the cam 46 which is determined by the shaft 44 of the reduction gear unit 42. Gas supplied by the regulator 54 to the line 52 inflates the bellows 50 against the biasing of its spring to move the nozzle 48 towards the top of the cam 46. A state of dynamic equilibrium will be achieved at some point during the approach of the nozzle 48 to the top of the cam 46. This will establish a back pressure in the bellows 50 which will determine the pressure on the line 38. By changing the

position of the cam 46, the pressure on the line 38 is changed in proportion to the electrical power which was supplied to the motor 40 by its terminals 58, 60.

A first important advantage of the electro-pneumatic converter 12 resides in cost savings which result from the elimination of having to purchase and/or stock a variety of servo motor/gearing mechanisms and converter models for providing different desired speeds. With the resistive network of Figures 2 or 3, only one servo motor/gearing mechanism is needed. The cost of buying and stocking resistors is minimal compared to that required for servo motors.

A second advantage is that the speed is field adjustable. It is no longer necessary to order different converters for providing different speeds where the required speed is different from the speed originally specified on the converter.

Claims

1. An electro-pneumatic converter (12) comprising:

a reversible *dc* servo motor (40) having a first terminal (58) and a second terminal (60) for receiving electrical power, and a shaft which is rotatable in two opposite directions;

pneumatic means cooperable with the shaft for supplying gas at a pressure which is proportional to the rotation of the shaft;

a pressure raising line (34);

a pressure lowering line (36);

an electric power supply having a common terminal (64) and a power terminal (32) at a voltage different from the common terminal; and

switch means (62) for selectively connecting the common terminal (64) to one of the pressure raising and pressure lowering lines (34, 36);

characterised by:

a first resistor (66) in the pressure raising line (34), the pressure raising line (34) being connected to the first motor terminal (58);

a second resistor (68) in the pressure lowering line (36), the pressure lowering line (36) being connected to the second motor terminal (60);

a line terminal (78) connected between the pressure raising and pressure lowering lines (34, 36) on a side of the first and second resistors (66, 68) opposite from the first and second motor terminals (58, 60); and

variable resistor means (72; 80) connected between the line terminal (78) and the power terminal (32) for applying a selected resistance between the power terminal and line terminal to drive the shaft of the motor (40) in one direction when one of the pressure raising and pressure lowering lines (34, 36) is connected to the common terminal (64) and in an opposite direction when the other of the pressure raising and pressure lowering lines (34, 36) is connected to the common terminal (64), the variable resistor means (72; 80) providing the converter (12) with a variable speed function.

2. A converter according to claim 1, including a

shunt resistor (70) connected between the pressure raising and pressure lowering lines (34, 36) on a side of the first and second resistors (66, 68) adjacent the first and second motor terminals (58, 60) and across the motor (40).

3. A converter according to claim 1 or claim 2, wherein the pneumatic means comprises a reduction gear (42) connected to the shaft of the motor (40) and having a gear shaft (44), a cam (46) connected to the gear shaft (44), a nozzle (48) mounted proximate to the cam (46) and movable towards and away from the gear shaft (44), a bellows (50) connected to the nozzle (48) for moving the nozzle, a gas pressure supply (54, 56) connected to the bellows (50) for supplying a selected constant pressure to the bellows, and a pressure supply line (38) connected to the bellows for supplying gas at a selected pressure whereby gas supplied through the nozzle (48) is selectively restricted by the cam (46) to regulate a position of the bellows (50) and produce a back pressure in the bellows.

4. A converter according to claim 1, claim 2 or claim 3, wherein the variable resistor means (72) comprises a plurality of discrete resistors (74) each having one side connected to the line terminal (78) and an opposite side, and a separate switch (76) connected to each opposite side of each discrete resistor (74), each switch being connected to the power terminal (32).

5. A converter according to claim 1, claim 2 or claim 3, wherein the variable resistor means (80) comprises a variable resistor (80) connected between the power terminal (32) and the line terminal (78).

Patentansprüche

1. Elektropneumatischer Signalumformer (12) umfassend: eine reversiblen Gleichstrom-Servomotor (40) mit einem ersten Anschluß (58) und einem zweiten Anschluß (60) zur elektrischen Stromaufnahme und einer Welle, die in zwei entgegengesetzte Richtungen drehbar ist; pneumatische Mittel, die mit der Welle zusammenwirken, zum Zuführen von Gas bei einem Druck der proportional der Drehung der Welle ist; eine Druckerhöhungsleitung (34); eine Druckerniedrigungsleitung (36); eine elektrische Stromversorgung mit einem gemeinsamen Anschluß (64) und einem Stromanschluß (32) mit einer Spannung unterschiedlich zu der des gemeinsamen Anschlusses; und Schaltmittel (62) zum selektiven Verbinden des gemeinsamen Anschlusses (64) mit entweder der Druckerhöhungsleitung (34) oder der Druckerniedrigungsleitung (36); gekennzeichnet durch: einen ersten Widerstand (66) in der Druckerhöhungsleitung (34), wobei die Druckerhöhungsleitung (34) mit dem ersten Motoranschluß (58) verbunden ist; einen zweiten Widerstand (68) in der Druckerniedrigungsleitung (36), wobei die Druckerniedrigungsleitung (36) mit dem zweiten Motoranschluß (60) verbunden ist; einen Leitungsanschluß (78), der zwischen der Drucker-

position of the cam 46, the pressure on the line 38 is changed in proportion to the electrical power which was supplied to the motor 40 by its terminals 58, 60.

A first important advantage of the electro-pneumatic converter 12 resides in cost savings which result from the elimination of having to purchase and/or stock a variety of servo motor/gearing mechanisms and converter models for providing different desired speeds. With the resistive network of Figures 2 or 3, only one servo motor/gearing mechanism is needed. The cost of buying and stocking resistors is minimal compared to that required for servo motors.

A second advantage is that the speed is field adjustable. It is no longer necessary to order different converters for providing different speeds where the required speed is different from the speed originally specified on the converter.

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1. An electro-pneumatic converter (12) comprising:

a reversible *dc* servo motor (40) having a first terminal (58) and a second terminal (60) for receiving electrical power, and a shaft which is rotatable in two opposite directions;

pneumatic means cooperable with the shaft for supplying gas at a pressure which is proportional to the rotation of the shaft;

a pressure raising line (34);

a pressure lowering line (36);

an electric power supply having a common terminal (64) and a power terminal (32) at a voltage different from the common terminal; and

switch means (62) for selectively connecting the common terminal (64) to one of the pressure raising and pressure lowering lines (34, 36);

characterised by:

a first resistor (66) in the pressure raising line (34), the pressure raising line (34) being connected to the first motor terminal (58);

a second resistor (68) in the pressure lowering line (36), the pressure lowering line (36) being connected to the second motor terminal (60);

a line terminal (78) connected between the pressure raising and pressure lowering lines (34, 36) on a side of the first and second resistors (66, 68) opposite from the first and second motor terminals (58, 60); and

variable resistor means (72; 80) connected between the line terminal (78) and the power terminal (32) for applying a selected resistance between the power terminal and line terminal to drive the shaft of the motor (40) in one direction when one of the pressure raising and pressure lowering lines (34, 36) is connected to the common terminal (64) and in an opposite direction when the other of the pressure raising and pressure lowering lines (34, 36) is connected to the common terminal (64), the variable resistor means (72; 80) providing the converter (12) with a variable speed function.

2. A converter according to claim 1, including a

shunt resistor (70) connected between the pressure raising and pressure lowering lines (34, 36) on a side of the first and second resistors (66, 68) adjacent the first and second motor terminals (58, 60) and across the motor (40).

3. A converter according to claim 1 or claim 2, wherein the pneumatic means comprises a reduction gear (42) connected to the shaft of the motor (40) and having a gear shaft (44), a cam (46) connected to the gear shaft (44), a nozzle (48) mounted proximate to the cam (46) and movable towards and away from the gear shaft (44), a bellows (50) connected to the nozzle (48) for moving the nozzle, a gas pressure supply (54, 56) connected to the bellows (50) for supplying a selected constant pressure to the bellows, and a pressure supply line (38) connected to the bellows for supplying gas at a selected pressure whereby gas supplied through the nozzle (48) is selectively restricted by the cam (46) to regulate a position of the bellows (50) and produce a back pressure in the bellows.

4. A converter according to claim 1, claim 2 or claim 3, wherein the variable resistor means (72) comprises a plurality of discrete resistors (74) each having one side connected to the line terminal (78) and an opposite side, and a separate switch (76) connected to each opposite side of each discrete resistor (74), each switch being connected to the power terminal (32).

5. A converter according to claim 1, claim 2 or claim 3, wherein the variable resistor means (80) comprises a variable resistor (80) connected between the power terminal (32) and the line terminal (78).

Patentansprüche

1. Elektropneumatischer Signalumformer (12) umfassend: eine reversiblen Gleichstrom-Servomotor (40) mit einem ersten Anschluß (58) und einem zweiten Anschluß (60) zur elektrischen Stromaufnahme und einer Welle, die in zwei entgegengesetzte Richtungen drehbar ist; pneumatische Mittel, die mit der Welle zusammenwirken, zum Zuführen von Gas bei einem Druck der proportional der Drehung der Welle ist; eine Druckerhöhungsleitung (34); eine Druckerniedrigungsleitung (36); eine elektrische Stromversorgung mit einem gemeinsamen Anschluß (64) und einem Stromanschluß (32) mit einer Spannung unterschiedlich zu der des gemeinsamen Anschlusses; und Schaltmittel (62) zum selektiven Verbinden des gemeinsamen Anschlusses (64) mit entweder der Druckerhöhungsleitung (34) oder der Druckerniedrigungsleitung (36); gekennzeichnet durch: einen ersten Widerstand (66) in der Druckerhöhungsleitung (34), wobei die Druckerhöhungsleitung (34) mit dem ersten Motoranschluß (58) verbunden ist; einen zweiten Widerstand (68) in der Druckerniedrigungsleitung (36), wobei die Druckerniedrigungsleitung (36) mit dem zweiten Motoranschluß (60) verbunden ist; einen Leitungsanschluß (78), der zwischen der Drucker-



höhungs- (34) und der Druckerniedrigungsleitung (36) auf einer Seite des ersten und zweiten Widerstands (66, 68) entgegengesetzt zum ersten und zweiten Motoranschluß (58, 60) verbunden ist; und variable Widerstandsmittel (72, 80), die zwischen dem Leitungsanschluß (78) und dem Stromanschluß (32) verbunden sind, um einen ausgewählten Widerstand zwischen dem Stromanschluß und dem Leitungsanschluß anzulegen, um die Welle des Motors (40) in einer Richtung anzutreiben, sobald die Druckerhöhungs- oder die Druckerniedrigungsleitung (34, 36) mit dem gemeinsamen Anschluß (64) verbunden wird, und in entgegengesetzter Richtung, sobald die andere der Druckerhöhungs- und Druckerniedrigungsleitungen (34, 36) mit dem gemeinsamen Anschluß verbunden wird, wobei die variablen Widerstandsmittel (72; 80) den Signalumformer (12) mit einer variablen Geschwindigkeitsfunktion versehen.

2. Signalumformer nach Anspruch 1, umfassend einen Überbrückungswiderstand (70), der zwischen den Druckerhöhungs- und Drucker-niedrigungsleitungen (34, 36) auf einer Seite der ersten und zweiten Widerstände (66, 68) benachbart zum ersten und zweiten Motoranschluß (58, 60) und über den Motor (40) verbunden ist.

3. Signalumformer nach Anspruch 1 oder 2, wobei die pneumatischen Mittel ein Untersetzungsgetriebe (42), das mit der Welle des Motors (40) verbunden ist und eine Getriebewelle (44) hat, einen Nocken (46), der mit der Getriebewelle (44) verbunden ist, eine Düse (48), die benachbart zum Nocken (46) befestigt und auf die Getriebewelle (44) hin- und von dieser weg-bewegbar ist, einen mit der Düse (48) verbundenen Faltenbalg (50) zum Bewegen der Düse (48), eine Gasdruckzufuhr (54, 56), die mit dem Faltenbalg (50) verbunden ist, um einen ausgewählten konstanten Druck dem Faltenbalg zuzuführen, und eine Druckzuführleitung (38) aufweist, die mit dem Faltenbalg verbunden ist, um Gas bei einem ausgewählten Druck zuzuführen, wobei das durch die Düse (48) zugeführte Gas mittels des Nockens (46) selektiv beschränkt wird, um eine Stellung des Faltenbalgs (50) einzuregulieren und einen Staudruck im Faltenbalg zu bilden.

4. Signalumformer nach Anspruch 1, Anspruch 2 oder Anspruch 3, wobei die variablen Widerstandsmittel (72) eine Vielzahl von diskreten Widerständen (74) aufweisen, von denen jeder eine mit dem Leitungsanschluß (78) verbundene erste Seite und eine gegenüberliegende Seite hat, und einen separaten Schalter (76), der mit jeder gegenüberliegenden Seite jedes diskreten Widerstands (74) verbunden ist, wobei jeder Schalter mit dem Stromanschluß (32) verbunden ist.

5. Signalumformer nach Anspruch 1, Anspruch 2 oder Anspruch 3, wobei die variablen Widerstandsmittel (80) einen variablen Widerstand (80) aufweisen, der zwischen dem Stromanschluß (32) und dem Leitungsanschluß (78) verbunden ist.

Revendications

1. Un convertisseur électropneumatique (12) comprenant: un servomoteur à courant continu réversible (40) ayant une première borne (58) et une seconde borne (60) destinées à recevoir de l'énergie électrique, et un arbre qui peut tourner dans deux sens opposés; des moyens pneumatiques qui peuvent coopérer avec l'arbre pour fournir un gaz à une pression qui est proportionnelle à la rotation de l'arbre; une ligne d'élévation de pression (34); une ligne de diminution de pression (36); une alimentation électrique ayant une borne commune (64) et une borne d'alimentation électrique (32) à une tension différente de celle de la borne commune; et des moyens de commutation (62) destinés à connecter sélectivement la borne commune (64) à l'une des lignes d'élévation de pression et de diminution de pression (34, 36); caractérisé par: une première résistance (66) dans la ligne d'élévation de pression (34), cette ligne d'élévation de pression (34) étant connectée à la première borne du moteur (58); une seconde résistance (68) dans la ligne de diminution de pression (36), cette ligne de diminution de pression (36) étant connectée à la seconde borne du moteur (60); une borne de lignes (78) connectée entre les lignes d'élévation de pression et de diminution de pression (34, 36), d'un côté des première et seconde résistances (66, 68) qui est opposé aux première et seconde bornes du moteur (58, 60); et des moyens à résistance variable (72; 80) connectés entre la borne de lignes (78) et la borne d'alimentation électrique (32), pour appliquer une résistance sélectionnée entre la borne d'alimentation électrique et la borne de lignes, afin d'entraîner l'arbre du moteur (40) dans un sens lorsque l'une des lignes d'élévation de pression et de diminution de pression (34, 36) est connectée à la borne commune (64), et dans un sens opposé lorsque l'autre ligne parmi les lignes d'élévation de pression et de diminution de pression (34, 36) est connectée à la borne commune (64), les moyens à résistance variable (72; 80) permettant au convertisseur (12) de disposer d'une fonction de vitesse variable.

2. Un convertisseur selon la revendication 1, comprenant une résistance shunt (70) connectée entre les lignes d'élévation de pression et de diminution de pression (34, 36) d'un côté des première et seconde résistances (66, 68) qui est adjacent aux première et seconde bornes du moteur (58, 60), et en parallèle sur le moteur (40).

3. Un convertisseur selon la revendication 1 ou la revendication 2, dans lequel les moyens pneumatiques comprennent un engrenage réducteur (42) connecté à l'arbre du moteur (40) et comportant un arbre d'engrenage (44), une came (46) connectée à l'arbre d'engrenage (44), une buse (48) montée à proximité de la came (46) et mobile de façon à pouvoir s'approcher et s'éloigner de l'arbre d'engrenage (44), un soufflet (50) accouplé à la buse (48) pour la déplacer, une source de gaz sous pression (54, 46) branchée au soufflet (50) pour fournir au soufflet une pression



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constante sélectionnée, et une ligne d'alimentation en gaz sous pression (36) branchée au soufflet pour fournir un gaz sous une pression sélectionnée, grâce à quoi le gaz qui est délivré à travers la buse (48) est restreint sélectivement par la came (46), pour réguler la position du soufflet (50) et produire une contre-pression dans le soufflet.

4. Un convertisseur selon la revendication 1, la revendication 2 ou la revendication 3, dans lequel les moyens à résistance variable (72) comprennent un ensemble de résistances discrètes (74)

ayant chacune un côté connecté à la borne de lignes (78) et un côté opposé, et un interrupteur séparé (76) connecté à chaque côté opposé de chaque résistance discrète (74), chaque interrupteur étant connecté à la borne d'alimentation électrique (32).

5. Un convertisseur selon la revendication 1, la revendication 2 ou la revendication 3, dans lequel les moyens à résistance variable (80) comprennent une résistance variable (80) connectée entre la borne d'alimentation électrique (32) et la borne de lignes (78).

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