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Booth

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[54] **FOOT-OPERATED SPEED CONTROL FOR AIR-DRIVEN TOOL**

[76] Inventor: **Dwight A. Booth,** 3529 S.E. Crystal Springs Blvd., Portland, Oreg. 97202

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[51] **Int. Cl.** **A61c 1/10**

[58] **Field of Search** 32/DIG. 3, 28, 22; 251/122, 295, 35, 63

[56] **References Cited**

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Primary Examiner—Robert Peshock
Assistant Examiner—J. Q. Lever
Attorney, Agent, or Firm—Klarquist, Sparkman, Campbell, Leigh, Hall & Whinston

[57] **ABSTRACT**

A foot-operated speed control for an air-driven dental handpiece includes a solid control block having a central vertical cavity defining an upper piston chamber, a lower air inlet chamber, and a restricted passage between the two chambers. An air inlet passage extends from a surface inlet port through the control block into the inlet chamber, and an air outlet passage extends from the piston chamber through the control block to a surface outlet port. A piston portion of a one-piece piston-poppet projects from an upper opening of the piston chamber. A tapered stem portion of the piston-poppet extends downwardly and flares outwardly from the bottom of the piston into the restricted passage, with a lower end of the stem in sealing engagement with a wall of such passage when the piston is in an upper position. A foot-operated button exerts a downward pressure directly against the top of the piston sufficient to move the piston downwardly within its chamber, causing the lower, sealing end of the stem to move into the air inlet chamber so that the tapered portion of the stem at the lower end of the restricted passage provides a variable orifice permitting air to flow to the piston chamber and outlet passage. The effective size of the orifice increases with the downward movement of the piston to increase air pressure in the piston chamber and outlet passage. Piston chamber air pressure counterbalances applied foot pressure to determine the position of the piston-poppet and thus the outlet pressure.

15 Claims, 3 Drawing Figures

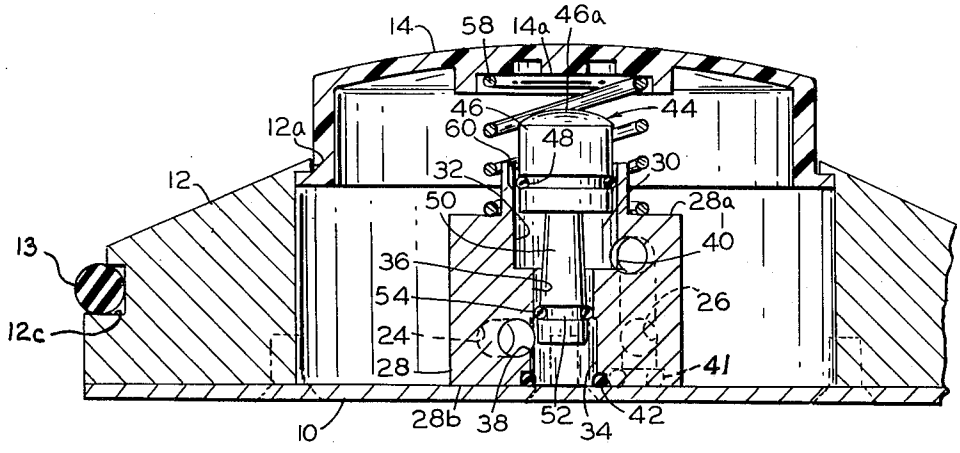


FIG. 1

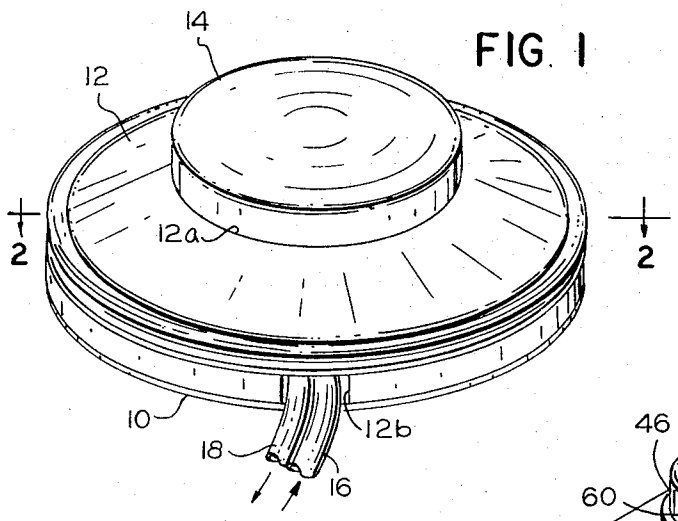


FIG. 3

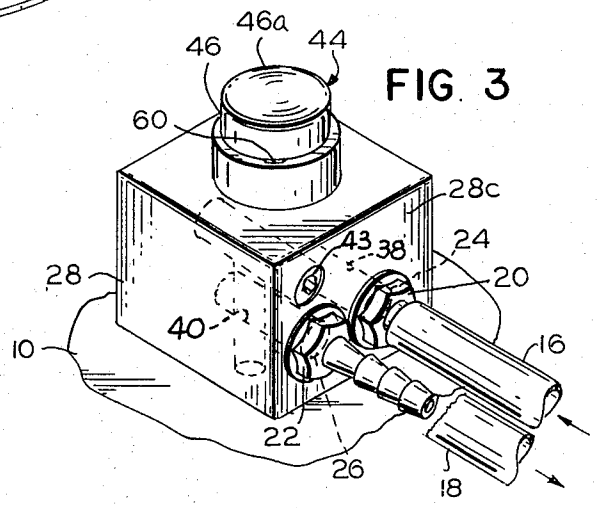
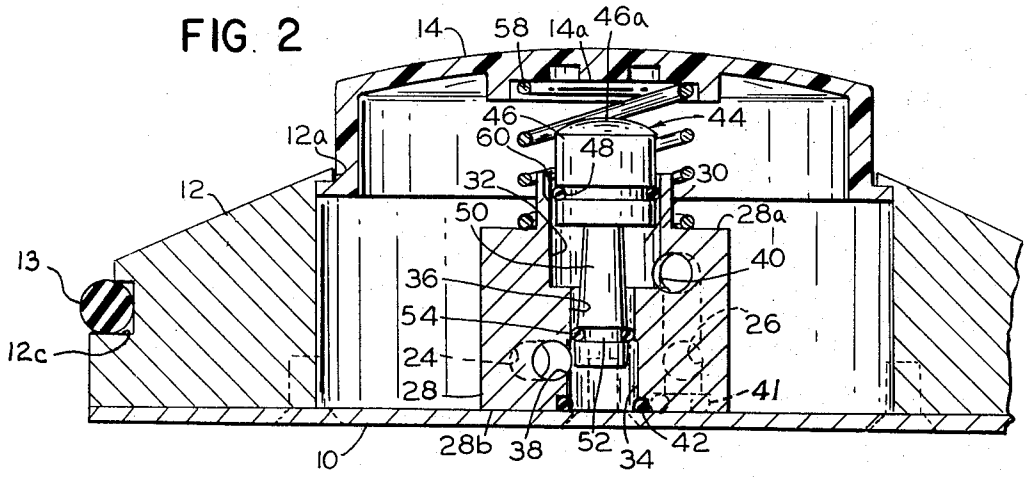


FIG. 2



FOOT-OPERATED SPEED CONTROL FOR AIR-DRIVEN TOOL

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a foot-operated speed control for an air-driven tool and particularly for an air-driven dental handpiece.

2. Description of the Prior Art

Conventional known foot-operated air pressure regulators for controlling the speed of air-driven tools usually employ a poppet or diaphragm-type valve and a system of multiple balance springs for controlling the position of the diaphragm of poppet and thus the outlet air pressure from the regulator. In one common type of foot control used for controlling the speed of a dental handpiece, there are, in addition to the foot control actuator, four separate springs, two with separate spring caps, a piston, a separate poppet actuated by a plunger on the piston, together with attendant O-ring seals, all telescoped within a single valve body. This results in a very complex interrelationship of a large number of separate parts to achieve what is essentially a single simple object of controlling the outlet air pressure from the device through a variable orifice.

The use of mechanical balance springs in such controls also tends to isolate the foot from the outlet pressure of the control, and thus the foot is not sensitive to the speed of the controlled tool and the control tends to be insensitive to changes in applied foot pressure. The result is that the foot control of speed tends to be less precise than would be desirable in many applications.

The large number of parts in conventional foot-controlled pressure regulators require substantial assembly and service time, resulting in high initial and maintenance costs. Such prior controls are also more subject to malfunction than would be the case with a control having fewer parts and complexities.

Some prior foot controls also have the disadvantage of not being operable when pressure is applied to one particular portion of the foot actuator button or pedal.

SUMMARY OF THE INVENTION

Principal objects of the present invention are to provide a simplified foot control wih (1) a minimum number of separate operational parts, (2) great sensitivity to changes in applied foot pressures and therefore precise speed control, and (3) a foot-operated actuator operable when pressure is applied to any point on its foot-engaging surface.

At least some of the foregoing objects are achieved in the present invention through the elimination of all mechanical balance springs and the use of a single one-piece combination piston-poppet providing a variable orifice between the inlet air chamber and a piston chamber of the cavity.

A further feature of the invention helping to carry out the foregoing objects is the balancing of the piston-poppet within the cavity solely with air pressure acting at one side of the piston and foot pressure transmitted directly into the opposite side of the piston. The only essential moving parts are the foot actuator itself and the single-piece piston-poppet.

Another feature of the invention which provides a precise speed control is the design of the piston-poppet itself. The piston-poppet is characterized by a piston moving in sealed engagement with the walls of a piston chamber and a tapered stemlike poppet portion extending downwardly from the piston into a narrow passage between the piston chamber and an air inlet chamber to seal these chambers from one another when the piston is in its upper position. When the wide lower, sealing end of the tapered stem is pushed into the air inlet chamber by downward movement of the piston, the stem taper provides a variable orifice which increases in size as the piston moves progressively downward.

A further feature of the invention is the use of air pressure in the piston chamber when the poppet is open as an air spring to balance the foot pressure applied directly to the upper surface of the piston through the foot button, thus eliminating the need for any mechanical balance spring. Since the air pressure in the piston chamber and thus outlet air pressure increase with the size of the orifice provided by the tapered stem, the foot pressure required to maintain a given outlet air pressure and thus a given speed of the controlled tool varies directly with such pressure and speed, the operator is provided with a highly speed-sensitive control that can be directly sensed by the foot.

The foregoing and other objects, features and advantages of the present invention will become more apparent from the following detailed description which proceeds with reference to the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

In the drawing:

FIG. **1** is a perspective view of a foot control in accordance with the invention as viewed from above the control;

FIG. **2** is a sectional view through the control of FIG. **1**, taken approximately along the line **2—2** of FIG. **1**; and

FIG. **3** is a perspective view of the control block within the cover of the device as shown in FIG. **2**, with such cover removed.

DETAILED DESCRIPTION

With reference to the drawing, FIG. **1** discloses a foot control including a circular base plate **10** fastened to a cover or housing **12** having a central opening **12***a* through which a depressible foot-operated actuator button **14** projects. Cover **12** has an opening **12***b* in its rim through which a pair of flexible air tubes **16, 18** extends. Tube **16** extends from a source of air pressure, and tube **18** leads to an air-driven tool or to another control component for such a tool, such as a master on-off control unit, neither of which are shown. As shown in FIG. **2**, cover **12** is of largely solid construction to give the control considerable weight, thus reducing its mobility when placed on the floor. The rim of the cover is provided with an annular groove **12***c* which seats an elastomer bumper ring **13.**

Referring to FIG. **3**, tubes **16** and **18** are connected to suitable slip connectors **20, 22,** respectively, at inlet and outlet ports **24, 26** respectively, at one side surface **28***c* of a solid control block **28.** Block **28** is affixed to base plate **10** centrally within cover **12.**

As will be evident from FIG. **2**, control block **28** includes a central vertical cavity indicated generally at **30** passing completely through the block from its upper surface **28***a* to its lower surface **28***b*. This cavity in-

cludes an enlarged upper piston chamber portion **32** and a lower air inlet chamber portion **34** connected by a restricted neck passage **26.** The air inlet port **24** leads into an air inlet passage **38** which opens into the lower air inlet chamber **34.** Similarly, outlet port **26** opens into an air outlet passage **40** which opens into a lower portion of the piston chamber **32.** Inlet passage **38** can be bored in a straight line at a slight horizontal angle directly into lower chamber **34** from inlet port **24.** However, outlet passage **40** requires three intersecting bores, including one vertical and two horizontal, as will be evident from FIGS. **2** and **3.** The vertical bore extends upwardly into block **28** from its bottom surface **28***b* and is sealed by an O-ring **41** at such surface. The upper horizontal bore extends into the block from side surface **28***c* and is closed by a cap **43** at such surface.

The lower end opening of cavity **30** is closed by base plate **10** and air-sealed by an O-ring seal **42.** However, the upper end opening of the cavity remains open to receive a one-piece combination piston-poppet member indicated generally at **44.** The piston-poppet includes a large piston portion **46** movable vertically within piston chamber **32** and has an upper surface **46**a normally projecting from the flanged upper end opening of such chamber at top surface **28**a of the control block. The piston is adapted to move in sealed engagement with the wall of the piston chamber and for this purpose is provided with an O-ring seal at **48.**

A stem-like poppet portion **50** of the piston-poppet extends downwardly from the bottom surface of piston **46** into restricted neck passage **36** between the piston and air inlet chambers. Stem **50** tapers or flares slightly outwardly from its intersection with the piston to a generally cylindrical lower sealing end portion **52** provided with an O-ring seal **54** to air-seal the upper and lower chambers from one another when O-ring **54** enters the lower end of neck passage **36.** This occurs, as shown in FIG. **2,** when the piston is in an upper position within its piston chamber.

However, downward movement of the piston through application of downward force to its upper surface shifts O-ring **54** on lower end **52** of the poppet stem **50** into air inlet chamber **34.** When this occurs, the inversely tapered stem **50** above such lower end permits air to flow from the inlet air chamber through neck passage **36** to the piston chamber, with the effective size of such passage or orifice varying with the position of the piston within its chamber. Thus the tapered stem provides a variable orifice at the neck passage and thus a variable pressure drop across the orifice. This then provides a variable pressure in the piston chamber and in the outlet passage **40** leading from such chamber.

Upper surface **46***a* of piston **46** is convexly curved. Foot button **14** has a central downward projection **14***a* on its undersurface which engages directly upper surface **46***a* of the piston when the button is depressed by the operator's foot. Although a coil spring **58** extends between a spring seat portion of the push botton's bottom surface and the top surface **28***a* of the control block, this spring serves no operational function. Instead it merely helps center-position the pedal with respect to the valve block and provides some resistance to downward pressure on the foot button when the air system is de-energized.

A small notch **60** provided at an upper inner wall portion of piston chamber **32** serves as an air bleed passage to depressurize the piston chamber and the outlet air passage when there is no foot pressure on button **14.** This feature prevents the air-driven turbine of the controlled tool from coasting after the foot button is released.

OPERATION

To operate the foot control, the air pressure system into which the control is connected is first energized. If the system is activated with the piston-poppet in its "up" or "off" position, it will remain in such position until button **14** is depressed. If, however, the air system is activated with the piston-poppet in an initial "down" or "on" position but with no foot pressure on button **14,** air entering the air inlet chamber **34** flows through neck passage **36** past tapered stem **50** to piston chamber **32,** where air pressure acting against the bottom surface of piston **46** pushes the piston upwardly until O-ring **54** on stem portion **52** closes neck passage **36,** cutting off air pressure to the air motor to be driven. This is the condition of the control as shown in FIG. **2.**

As the operator depresses foot button **14,** the upward pressure of spring **58** is easily overcome, and button contact portion **14**a engages convex surface **46***a* of the piston, no matter what part of button **14** is depressed. Thereafter, continued foot pressure on button **14** pushes piston-poppet **44** downwardly in its cavity **30,** closing bleed hole **60** in piston chamber **32,** and shifting stem end **52** with O-ring **54** down into inlet air chamber **34** to open neck passage **36** to air flow from lower chamber **34** to upper piston chamber **32.**

As foot pressure on button **14** continues to shift piston-poppet **44** downwardly, the effective size of the orifice defined by stem **50** and its passage **36** increases because of the reverse taper of the stem. As the effective size of the orifice increases, the pressure drop across the orifice decreases, and thus the pressure in the piston chamber and the outlet passage **40** therefrom increases, causing a corresponding increase in the speed of the air-driven motor connected to tube **18.**

At the same time, as stem **50** moves downwardly to increase the effective size of neck passage **36,** the upward pressure acting on the bottom of piston **46** increases, requiring a corresponding opposing foot pressure to maintain a given position of the piston-poppet and thus a given speed. Any increase in speed desired requires a corresponding increase in applied foot pressure sufficient to overcome the resisting air pressure acting on the bottom of the piston. In this sense foot pressure and counteracting air pressure replace the usual mechanical balance springs of conventional foot controls and make the present foot-operated speed control directly variable with variations in applied foot pressure. Conversely the control button, and thus the operator's foot, become "speed sensitive."

A decrease in foot pressure causes the previously balanced air pressure acting upwardly on piston **46** to shift the piston-poppet upwardly, whereby the tapered stem reduces the effective size of the orifice or opening at the bottom of neck passage **36,** consequently reducing air pressure in the piston chamber and outlet passage until such air pressure again is in balance with the applied foot pressure. Release of all pressure on the foot button causes the air pressure in piston chamber to push the piston-poppet upwardly until it returns to its upper, FIG. **2** position sealing closed the neck passage.

In this "closed" position of the piston-poppet, residual air pressure in the piston chamber and outlet passage is bled to atmosphere through bleed hole **60,** preventing the air-driven motor from coasting.

Having illustrated and described what is presently a preferred embodiment of the invention, it should be apparent to persons skilled in the art that such embodiment can be modified in arrangement and detail without departing from the spirit and scope of the invention. I claim as my invention all embodiments and their equivalents that come within the true spirit and scope of the following claims.

I claim:

1. A foot control for controlling the speed of an air-driven motor, said control comprising:

a control block,

means defining a cavity extending into said block from an upper surface opening thereof,

said cavity including an upper piston chamber, a lower inlet air chamber and a narrow neck passage means interconnecting said chambers;

means defining an inlet air passage extending through said block into said inlet air chamber from an inlet air port at a surface portion of said block;

means defining an outlet air passage extending from a portion of said cavity above said inlet chamber through said block to an outlet air port at a surface portion of said block;

and means defining a one-piece combination piston-poppet means movable within said cavity, including a piston portion movable within said piston chamber in sealed engagement with the walls of said chamber and a narrower stem portion extending downwardly from said piston portion into said neck passage and having a maximum diameter less than the diameter of said piston portion;

said stem portion including sealing means operable to close said neck passage means when said piston is in an upper position within said piston chamber;

said stem portion including said sealing means being movable downwardly into said inlet air chamber solely under foot pressure to open said neck passage means upon downward movement of said piston under foot pressure from said upper position and being movable upwardly solely under air pressure acting in opposition to said foot pressure to close said neck passage.

2. A control according to claim **1** including a foot pressure operated piston actuator means separate from and movable relative to said piston portion and having a contact portion adapted to engage directly an upper surface of said piston portion upon application of foot pressure to said actuator means.

3. Apparatus according to claim **2** wherein said piston portion has a convexly curved upper surface engageable by said contact portion to enable downward movement of said piston through application of foot pressure to any surface area on an upper surface of said actuator means.

4. Apparatus according to claim **3** wherein said actuator means comprises a depressible actuator button and said contact portion projects downwardly toward said piston from a central undersurface portion of said button, said button being mounted for limited universal movement in alignment with said piston portion, whereby foot pressure applied to any upper surface portion of said button causes said contact portion to engage and depress said piston portion.

5. A control according to claim **1** wherein said stem portion includes a tapered portion tapering outwardly in a downward direction along said stem portion from said piston portion to said sealing means, said tapered stem portion providing a gradually variable orifice at the opening of said neck passage means into said inlet air chamber upon downward movement of said piston within said piston chamber.

6. A control according to claim **5** wherein said stem portion tapers gradually outwardly in a downward direction from said piston portion and terminates at a lower sealing end portion of smaller diameter than said neck passage means and carrying said sealing means for sealed engagement with the interior wall of said neck passage means.

7. Apparatus according to claim **1** wherein said cavity extends vertically through said block from said upper surface opening to a bottom surface opening thereof, a base plate mounting said block and means sealing said bottom surface opening against said base plate, a housing enclosing the sides of said block and fixed to said base plate, a single large depressible foot button separate from and of substantially larger diameter than said piston portion centered within and closing an upper opening of said housing and including contact means extending downwardly from a central lower surface portion of said button for engaging an upper surface of said piston portion and moving said piston portion downwardly upon application of a downward foot pressure to said button.

8. A control according to claim **1** wherein said piston and stem are relatively sized and shaped such that air back pressure within said piston chamber exerts a differential pressure acting upwardly against bottom surface portions of said piston sufficient to move said piston-poppet means upwardly to close said neck passage means in the absence of foot-applied downward force acting against the upper surface of said piston portion.

9. A control according to claim **1** including piston-poppet moving means operable to move said piston-poppet means downwardly and upwardly within said cavity to open and close said neck passage, said moving means comprising solely a rigid depressible footoperated actuator means in direct engagement with an upper surface portion of said piston portion for effecting downward movement of said piston-poppet means upon application of foot pressure to said actuator means, and air pressure acting upwardly against bottom surface portions of said piston-poppet means for effecting upward movement of said piston-poppet means.

10. A control according to claim **2** wherein the foot pressure applied to said actuator means required to effect downward movement of said piston-poppet means within said cavity varies directly with and is solely a function of the air pressure in said piston chamber.

11. A manually operated fluid valve comprising:

a valve block including a valve cavity extending inwardly of said block from a surface opening therein,

a movable valve member movable axially within said cavity solely by manual pressure in a valve-opening direction and solely by fluid pressure in the opposite valve-closing direction, whereby said valve is

characterized by the absence of springs for effecting movement of said valve member,

said movable valve member including a valve piston movable axially within a first cavity section and including piston sealing means in fluid sealing engagement with the walls of said first cavity section to prevent escape of fluid from said surface opening,

said movable valve member including a valve stem extending axially from a bottom surface portion of said piston within a second cavity section and including stem sealing means in fluid sealing engagement with the walls of said second cavity section and spaced axially from said piston sealing means,

said stem sealing means being movable out of fluid sealing engagement upon movement of said piston under manual pressure in a valve-opening direction,

a fluid inlet port in said block opening into said cavity upstream of said stem sealing means when said stem is in sealing engagement with said second cavity section,

a fluid outlet port in said block opening into said cavity between said piston sealing means and said stem sealing means, whereby movement of said piston under manual pressure in a valve opening direction enables fluid flow from said inlet port into said valve cavity and past said stem sealing means into said outlet port,

said stem and piston being sized such that fluid back pressure from said outlet port acting between said piston sealing means and said stem sealing means creates a variable differential pressure proportional to said back pressure acting upwardly against said piston in opposition to said manually applied pressure and tending to move said valve member in a valve closing direction so that manual pressure is required to open said valve.

12. A valve according to claim **11** wherein said piston and said stem comprise a one-piece said valve member.

13. A valve according to claim **11** wherein said second cavity section is of smaller diameter than said first cavity section and said inlet port is in a third cavity section of larger diameter than said second cavity section, said stem sealing means being movable from sealing engagement with the walls of said second cavity section into said third cavity section to enable fluid flow past said stem sealing means upon movement of said piston in a valve-opening direction under manual pressure.

14. A valve according to claim **11** wherein said piston is of larger diameter than the largest-diameter portion of said stem and has a larger bottom surface area against which back pressure acts than any opposed upper surface portion of said stem.

15. A valve according to claim **11** wherein said stem tapers gradually and progressively outwardly in an axial direction from its intersection with the bottom of said piston to said stem sealing means to provide a variable orifice within said cavity upon variable movement of said valve member.

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