March 10, 1970 J. S. BALLANTINE 3,499,368

PNEUMATIC APPARATUS HAVING DETACHABLE MOUNTING MEANS

Filed Dec. 21, 1967 2 Sheets-Sheet 1

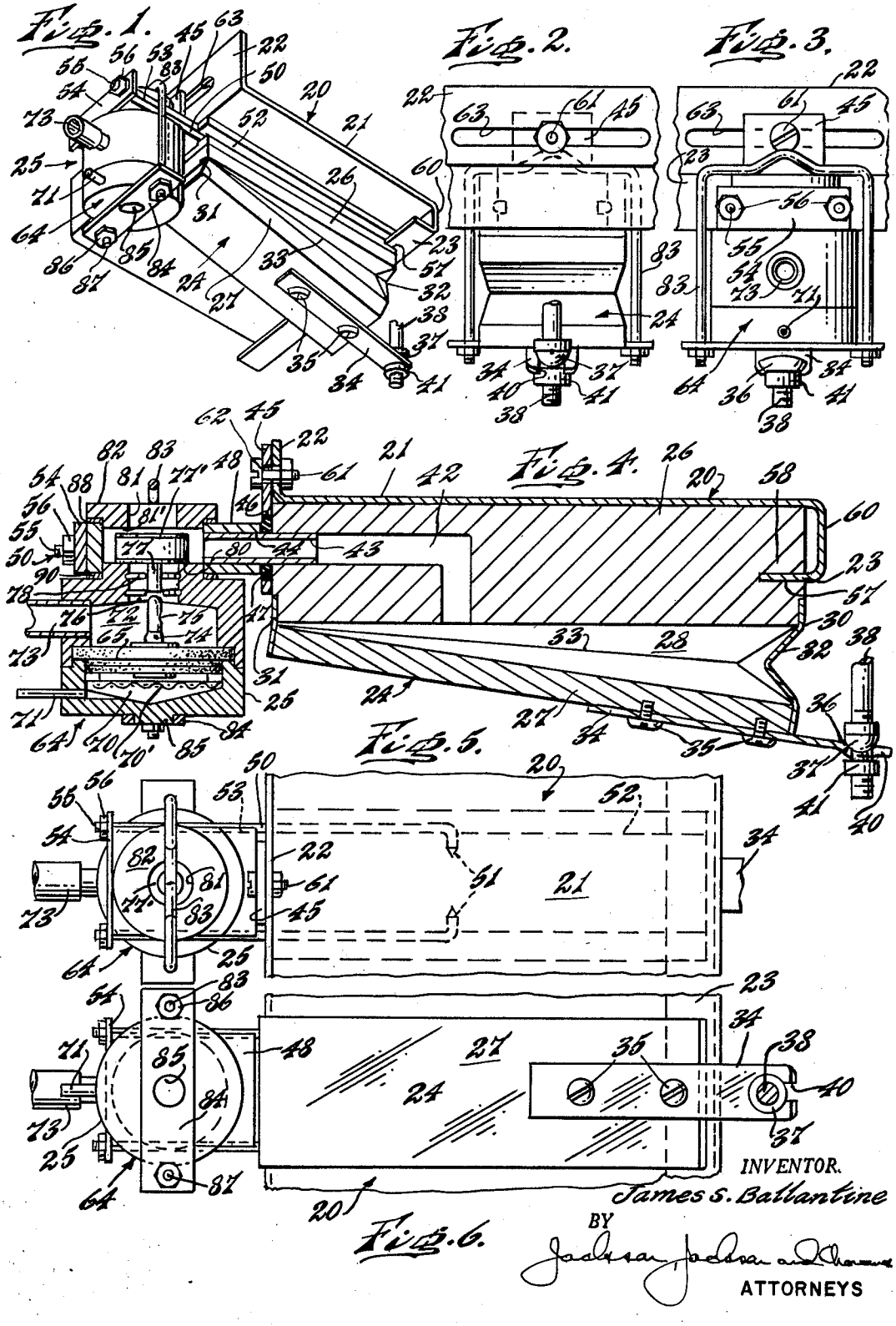

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Fig. 7.

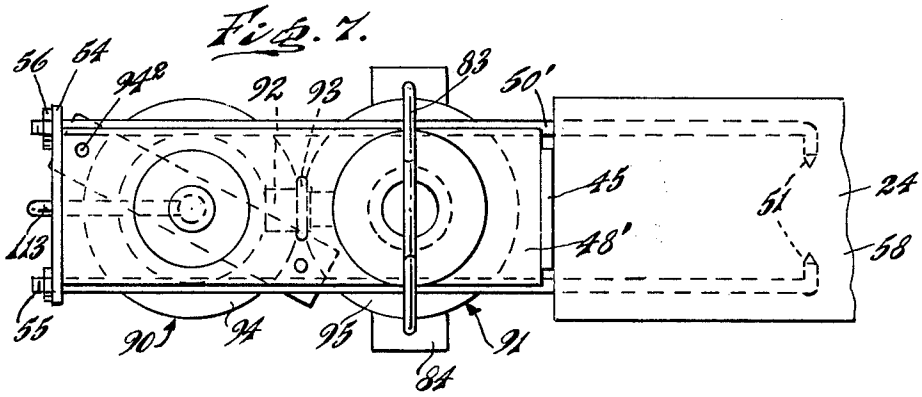


Fig. 8.

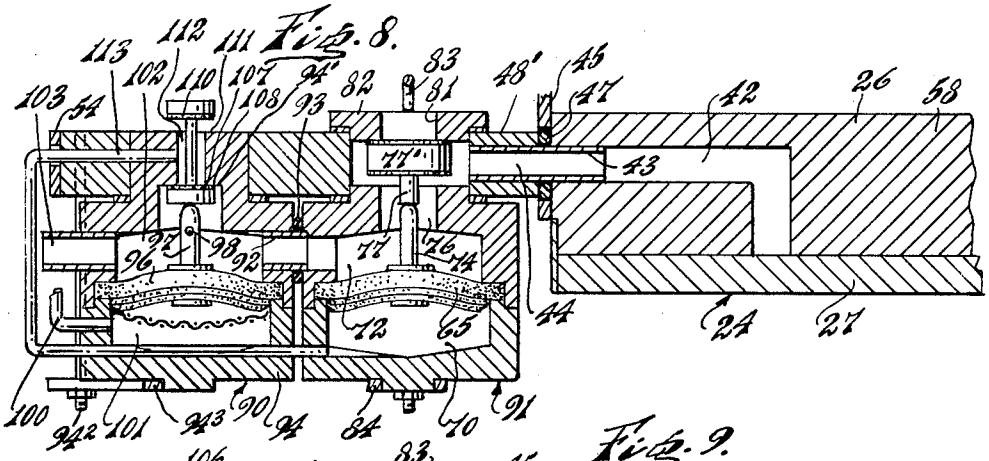
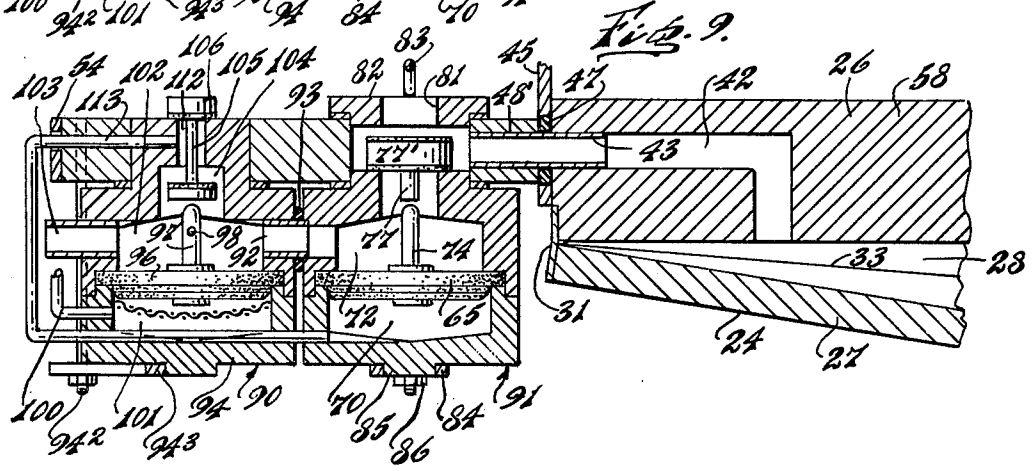


Fig. 9.



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PNEUMATIC APPARATUS HAVING DETACHABLE MOUNTING MEANS

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U.S. Cl. 91—418 2 Claims

ABSTRACT OF THE DISCLOSURE

The invention relates to pneumatic apparatus having detachable mounting means including differential diaphragm devices such as differential valves and pilot operated differential valves. The differential diaphragm valve device is positioned at the front of the pneumatic apparatus, and the pneumatic apparatus is engaged and supported by a groove or slot which surrounds a tongue on a support, the opposite end of the pneumatic apparatus being supported by securing a bracket to a slotted or perforated flange on the support.

The present invention relates to pneumatic apparatus having detachable mounting means, including differential diaphragm devices for programmed control of machinery, including stack assemblies for player pianos and organs.

A purpose of the invention is to mount a differential diaphragm device in combination with a pneumatic device in adjustable position on a support.

A further purpose is to support one end of a differential diaphragm device by a longitudinally extending tongue engaging a slot, and to hold the device at the other end or near the other end by a bracket cooperating with the flange and provided with a slot or perforations.

A further purpose is to provide a differential valve assembly with a valve housing or a plurality of valve housings at the front and a bellows-like device behind it, mounting the bellows-like device so that it is slidable laterally in the support to an adjustable position, and can be clamped in the proper adjusted position.

A further purpose is to permit ready replacement of a defective differential valve assembly by simply disconnecting it from the push rod or other output mechanism, detaching the connection between the bracket and the flange of the support at the front end, detaching the pneumatic connection and sliding the assembly forward to release the groove or slot from the tongue or other interlock at the back.

A further purpose is to locate the tongue with respect to the slot so that the portion of the device which is between the tongue and the support is crowded or tightly gripped between the tongue and the support to guard against any play or freedom transversely.

A further purpose is to provide an improved combined pilot and secondary valve for easy mounting on a support as part of a stack assembly.

Further purposes appear in the specification and in the claims.

In the drawings I have chosen to illustrate a few only of the numerous embodiments in which my invention may appear, selecting the forms shown from the standpoints of convenience in illustration, satisfactory operation and clear demonstration of the principles involved.

FIGURE 1 is a perspective of a preferred form of diaphragm device of the invention.

FIGURE 2 is a rear elevation of the device of FIGURE 1.

FIGURE 3 is a front elevation of the device of FIGURE 1.

FIGURE 4 is a central longitudinal section of the device of FIGURE 1.

FIGURE 5 is a top plan view of the device of FIGURE 1.

FIGURE 6 is a bottom plan view of the device of FIGURE 1.

FIGURE 7 is a fragmentary top plan view of a stack assembly including a pneumatic and a pilot operated differential pressure valve or pneumatic amplifier mounted according to the invention.

FIGURE 8 is a fragmentary central section of the pneumatic and the pilot operated valve of FIGURE 7 in actuated position.

FIGURE 9 is a view similar to FIGURE 8 showing the valve in inactive position.

Describing in illustration but not in limitation, and referring to the drawings:

The present invention is applicable to a wide variety of programmed control devices which may be employed for operating machinery such as testing machines, or machine tools, for operating electrical devices such as electric signs, or for manipulating what may be generally called output mechanism to operate a player piano or an organ. Many other types of mechanism involving programmed control can be controlled by the device of the invention.

In all of such devices, difficulty in functioning has occurred which has necessitated replacement or repair of individual differential diaphragm devices. Also from time to time it is desirable to obtain most effective operation to be able to adjust differential diaphragm devices laterally so that they can effectively align with the output mechanism.

In the prior art differential diaphragm devices have been assembled and mounted by adhesives or by bolts which are not readily accessible. Once mounted, such devices have been difficult to remove and when replaced it has been troublesome to realign with an output mechanism such as a push rod.

One of the improvements in the invention is that the differential diaphragm assembly, consisting of a pneumatic and a differential pressure valve, or a plurality of cooperating differential pressure valves, are readily removed in toto and readily replaced.

A further advantage of the device of the invention is that when replaced or during replacement lateral shifting of position is readily accomplished.

The differential valve of the invention in its simplest form is not a part of the present invention, being described and claimed in my copending application Ser. No. 682,403, filed Nov. 13, 1967 for Programmed Control Device. This is incorporated herein by reference.

Referring particularly to the drawings, I there show in the preferred form of FIGURES 1 to 6 a support **20** which is conveniently a plate **21** having a flange **22** at the front and a reverse bend at the back providing a tongue **23** directed toward the front. It will be evident that the support can extend horizontally as in a player piano where it extends from side to side, or may extend in any other desired direction to meet the requirements of a particular piece of machinery.

The differential diaphragm device in the simplest form consists of a pneumatic operating device **24** which in the case of a player piano is commonly called a pneumatic and which is anchored to the support, and a differential valve **25** supported on the pneumatic operating device **24** and desirably projecting forward from it, as shown.

The pneumatic output device or pneumatic **24** comprises a body **26** which is in spaced relation from a moving bellows plate **27** to provide a chamber **28** between them, the body **26** and the plate **27** being flexibly connected by pneumatically leakage-tight bellows cloth **30** which forms a hinge **31** conveniently at the forward end and which is pleated at the opposite end **32** and at the sides at **33** so that the pneumatic can move the plate **27**

from its retracted position, as shown in FIGURE 4, to collapse it to its operating position as shown in FIGURE 8. Secured on the bellows plate **27** is a metallic extension **34** secured to the bellows plate **27** as by screws **35** and at its rearward end the extension **34** has a ball socket **36** which receives a ball **37** on a push rod **38**, the push rod passing through an opening or slot **40** in the extension **34** and held against unintentional separation by a nut **41** threaded on the push rod **38**.

The pneumatic **24** has an internal passage **42** through the body **26** which at one end receives nipple **43** of an exhaust port **44** from the differential diaphragm valve **25**. A bracket **45** is clamped between the pneumatic body **26** and the valve **25** and has an annular opening **46** around and in spaced relation to the nipple **43**, the thickness of the metal of the bracket **45** being adequate to control the compression of an elastomer backing ring **47**, limit the compression of the backing ring **47**, such as an elastomeric O-ring, by valve housing **48** as it is urged against the bracket **45** by strongback **50** anchored in the body at the ends at **51** (FIGURE 5) and extending through slots **52** at the sides of the pneumatic body and through slots **53** at the sides of the valve housing **48** to pass through openings in a clamping plate **54** at the front. Threaded ends **55** of the strongback receive nuts **56** which tighten the clamping plate and the valve housing against the forward side of the bracket and center the bracket with respect to the packing to compress the packing or O-ring **47**, between the nipple at the inside the bracket **45** at the outside, the pneumatic body **26** at the rear and the valve housing **48** at the front, as best seen in FIGURE 4.

The pneumatic at its rear has a slot or groove **57** which extends laterally and is so located as to tightly grip the portion **58** of the pneumatic body in the reverse bend **60** of the support so that the rear end of the support is gripped tight by the plate **20** at one side and by the tongue **23** against moving in reaction to the push rod **38**. The pneumatic is forced into this position and held in this position by engagement of the bracket **45** with the front of the flange **22** on the support, the pneumatic and the differential diaphragm valve assembly being adjusted laterally along the tongue and held in adjusted position by tightening bolt **61** extending through an opening **62** in the bracket **45** and extending through a lateral slot or one of a series of perforations **63**, the slot running a considerable distance along the flange **22**, the distance normally being sufficient to cover the span of several different pneumatics but being shortened in FIGURE 1 for illustration purposes.

While the construction and operation of the differential diaphragm valve in the form shown in FIGURES 1 to 6 does not comprise the subject matter of the present application, it will be understood that the differential diaphragm valve in one embodiment, as shown in FIGURE 4, may consist of a diaphragm housing **64** which has, extending across it and suitably sealed at the outer circumference to it, a diaphragm **65**, suitably of an elastomeric material such as synthetic rubber. The diaphragm at the radial inside desirably has a piston portion and annularly around this a series of annular convolutions which in cross section are curved and merge at the radial inner and outer edges by curved portions, there being a rim which is sealed in the housing. At one side of the diaphragm there is a pressure control chamber **70** connected by a pressure control tube **71** with a tracker bar orifice, as well known, the orifice being adapted to be closed by a paper or other strip or selectively opened by a perforation therein. At the other side of the diaphragm there is a plenum chamber **72** connected by a plenum connection **73** with a suitable source of control pressure, desirably a vacuum pump. Through the center of the diaphragm extends a hollow tappet **74**, closed at the end, and which has a side wall bleed opening **75** which permits a leakage of control pressure between the plenum chamber and the control pressure chamber. As well known in the art, the cross sectional area of the bleed opening **75** is substantially smaller than the area of the tracker bar orifice and in the preferred embodiment the area of the tracker bar orifice may be three or four times the area of the bleed opening.

At the end of the plenum chamber **72** remote from the diaphragm there is a plenum port **76** and coaxial with the tappet in the plenum port there extends a valve stem **77** of a valve **77'**, the tappet and the valve stem being guided to maintain alignment by spiders **78**. The valve has suitable cushion seating material at opposite surfaces and at the position shown in FIGURE 4 engages and annularly seals on an annular plenum valve seat **80** which is around the plenum port **76**. Coaxial with the plenum port **76** and opposed to it there is an atmospheric port **81** provided in an end closure **82** of the valve housing, the end closure, the valve housing and the parts of the diaphragm housing being held together by a strongback **83** suitably spaced from the atmospheric port **81** to avoid air noise, and urging a locking plate **84** which is positioned centrally by a boss **85** against the diaphragm housing by nuts **86** threaded on the threaded ends **87** of the strongback **83**. The various housing parts are sealed by packing rings **88** and **90**.

Thus it will be evident that the differential diaphragm valve proper is positioned on the front of the pneumatic by one strongback so that it can readily be removed from the pneumatic and the differential diaphragm valve itself is readily disassembled by releasing another strongback.

In operation of the device shown in FIGURES 1 to 6, once the support is put in position, and the tracker bar is properly located, the stack assembly is positioned by engaging the tongue **23** in the groove or slot **57** and in adjusting each pneumatic laterally, and then tightening the bolt **61** at a proper position in the slot or perforation **63**. The push rods are properly located in the extensions **34** to the pneumatics and fastened in position. Plenum tubes are connected to the plenum connections **73**. Tracker bar tubes are interconnected to the control pressure connections **71** and to the correct tracker bar opening.

In operation of the device, a paper or other strip covers the particular tracker bar opening, vacuum is in the control pressure chamber **70** on both sides of a strainer **70'**, having been derived from the bleed opening **75**. Since the diaphragm is in inactive position, the valve **77'** is closed on the plenum valve seat **80** and the interior chamber **28** of the pneumatic is open through exhaust port **44** to the atmosphere at atmospheric port **81**.

When a perforation on the paper or other strip opens the orifice opening in the tracker bar, air at atmospheric pressure is admitted through the tracker bar orifice and enters control pressure chamber **70**. Since bleed opening **75** is ineffective to admit vacuum at the same rate that the atmospheric air is entering, since it is much smaller than the tracker bar orifice, the diaphragm expands or raises in FIGURE 4, conveniently permitting a slight lost motion of the tappet, and then the tappet **74** strikes the valve stem **77** and closes the valve **77** on atmospheric port **81** around a valve seat **81'**. In this position, vacuum from the plenum chamber **72** enters the chamber **28** of pneumatic **24** and the bellows collapses, pushing the push rod **38** upward to effectuate any desired motion, such as operating a valve or switch or striking a key or actuating an organ pipe, as desired.

In the alternate form of the invention shown in FIGURES 7 to 9, a primary valve **90** is connected to the front of the stack, and this is secured to a secondary valve **91** which is connected to the pneumatic as previously discussed. In this case a valve housing **48'** resembling the valve housing previously described has been lengthened to not only form a valve housing for the secondary differential diaphragm valve but also to assist in mounting the primary differential diaphragm valve,

and a lengthened strongback **50'** extends through grooves in the side of the valve housing **48'** and clamps the structure together by urging a clamping plate **54** against the valve housing **48'** and to tightly clamp the bracket **45** in place and also tighten a packing ring **47** around nipple **43**, as previously described.

A primary valve housing **94** has a tubular portion **94'** which is anchored in a recess of the valve housing **48'** and held in place by a strongback **94²** anchored in the valve housing **48'** and suitably clamping a clamping plate **94³** by nuts as previously described.

Primary valve housing **94** has extending across it and sealed in it an elastomeric diaphragm **96** which has extending through the axis a hollow tappet **97**, suitably an eyelet. The tappet **97** has a closed end but has at the side a bleed opening **98** which is regulated so that its area is considerably smaller than a tracker bar orifice to which it is connected by control pressure connection **100**, the area of the tracker bar opening being suitably three or four times the area of the bleed. A control pressure chamber **101** is located in the housing on one side of the diaphragm and a plenum chamber **102** is connected to plenum connection **103** suitably from a source of vacuum or other differential pressure.

The plenum chamber **102** has at the axis in prolongation of the tappet a valve chamber **104** which in a reduced diameter portion receives the stem **105** of a valve **106**, the stem extending down into alignment with the tappet and held in alignment by a spider, not shown. In inactive position of the diaphragm there is preferably a slight clearance between the tappet and the valve, but in active position the tappet preferably delivers a hammer blow to the valve.

The valve has in the plenum chamber **102** a valve element **107** which in closed position seals on an annular plenum seat **108** and at the other end has a valve element **110** which in one position seals on an annular atmospheric seat **111** around an atmospheric port **112**. The interior of plenum port **104** (around the valve stem) connects by an output pneumatic connection **113** with the control pressure chamber **70** of secondary valve **91** to be described.

Secondary valve **91** is the same in construction as the differential diaphragm valve previously described in connection with FIGURES 1 to 6 except that tappet **74** has no bleed opening. It receives plenum (vacuum) through plenum connection **92** sealed by gasket **93** to plenum chamber **102** of the primary valve.

In operation, when the strip of paper or the like closes the tracker bar opening, then pressure from the control pressure chamber **101** in the primary valve **90** is equalized through bleed opening **98** and the diaphragm is in inactive position. Atmospheric port **112** is closed as in FIGURE 9 and vacuum from the plenum chamber **102** of the primary valve enters through connection **113** to the control pressure chamber **70** of secondary valve **91**. Since the other side of the diaphragm **65** in secondary valve **91** is also under the same vacuum, the diaphragm **65** of the secondary valve **91** is inactive and the plenum port **76** of the secondary valve is closed, the atmospheric port **81** is open and the pneumatic is in inactive position.

When the tracker bar orifice receives air from the atmosphere through a perforation through the paper or other strip (FIGURE 8), then control pressure chamber **101** of primary valve **90** is subjected to air pressure against the diaphragm **96** and this diaphragm deflects and seats valve element **107** on plenum seat **108**, admitting atmosphere through atmospheric port **112** to control pressure connection **113** and to the control pressure chamber of secondary valve **91**. This deflects the diaphragm **65** of the secondary valve **91** and closes secondary valve **77'** to atmosphere, admitting reduced pressure from the plenum chamber **72** to the interior **33** of the bellows of the pneumatic, and the atmospheric air collapses the bellows of the pneumatic and operates the device.

It will be evident that the combination of the primary valve and the secondary valve as described gives a more powerful operating device and assures more output energy from the pneumatic. In effect, since there is no bleed in the secondary valve which diminishes the operating pressure, the differential pressure valves in FIGURES 8 and 9 act like a pneumatic amplifier.

An important aspect of the invention is in a pilot valve of the type under discussion to locate the primary and secondary valves in sequence on the front of the pneumatic or other operating device, so that the whole stack assembly can be removed as a unit by the mounting previously discussed.

Another important feature of the invention is that the primary valve has a bleed opening located in the side wall of the tubular tappet so as to protect against lodgement of dirt in the bleed opening and also the bleed is through the center of the diaphragm, so that the danger is prevented of expanding the diaphragm more on one side than on the other so that the tappet could be cocked.

It will be evident that the relation between the tongue on the mounting and the slot on the pneumatic can be reversed, so that the tongue can be provided on the pneumatic and the slot on the mounting if desired. It will also be evident that an equavalent interlocking relationship between the tongue and the slot can be achieved in some other way, as for example by pin engagement in an opening, or by other suitable interconnection which is removable by motion forward of the support and is adjustable by motion laterally of the support.

It will also be evident that resilient engagement can be provided between the support and the pneumatic at the rear, as by providing a resilient material such as a cushion material on one of the parts which is to receive an interlocking element such as a pin on another part or by providing a spring or other engaging feature which will relatively closely maintain the position of the support and the pneumatic.

In view of my invention and disclosure, variations and modifications to meet individual whim or particular need will doubtless become evident to others skilled in the art to obtain all or part of the benefits of my invention without copying the structure shown, and I, therefore, claim all such insofar as they fall within the reasonable spirit and scope of my claims.

Having thus described my invention what I claim as new and desire to secure by Letters Patent is:

1. In a pneumatic apparatus having detachable mounting means, a support extending laterally, having a body portion which is generally flat, having at one edge a first interlock which permits relative adjustment laterally and having at the other edge an anchorage which extends laterally, a pneumatic device engaging the generally flat portion of the support, having at one end a second interlock which cooperatively engages the first interlock and provides lateral adjustment and having at the other end a bracket which engages the anchorage, the first and second interlocks comprising a laterally extending tongue and laterally extending slot in engagement with one another, the pneumatic device including a bellows which contains one interlock, the bellows having a hinge adjacent the bracket and the portion of the bellows between the interlocks and the flat surface of the support filling the space by a pressure fit, the anchorage comprising a flange on the support extending away from the generally flat surface and engaging the bracket, a differential diaphragm valve controlling the pneumatic beyond the anchorage, support and pneumatic device, fastening means permitting lateral adjustment which engages and clamps the bracket to the anchorage in laterally adjustable relation and fixes the position of the pneumatic device both laterally of the support and also crosswise, and said differential diaphragm valve being secured from the pneumatic device at a position beyond the anchorage, support and pneumatic device.

2. An apparatus of claim 1 having a second differential diaphragm valve secured from the pneumatic device at a position beyond the anchorage, one of said first and second valves being a primary valve and the other a secondary valve both controlling the pneumatic device.

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