Aug. 13, 1963 | W. A. KATES | 3,100,620

ADJUSTABLE ORIFICE FOR USE IN DIFFERENTIAL PRESSURE APPARATUS

Filed Aug. 3, 1960

Fig. 1.

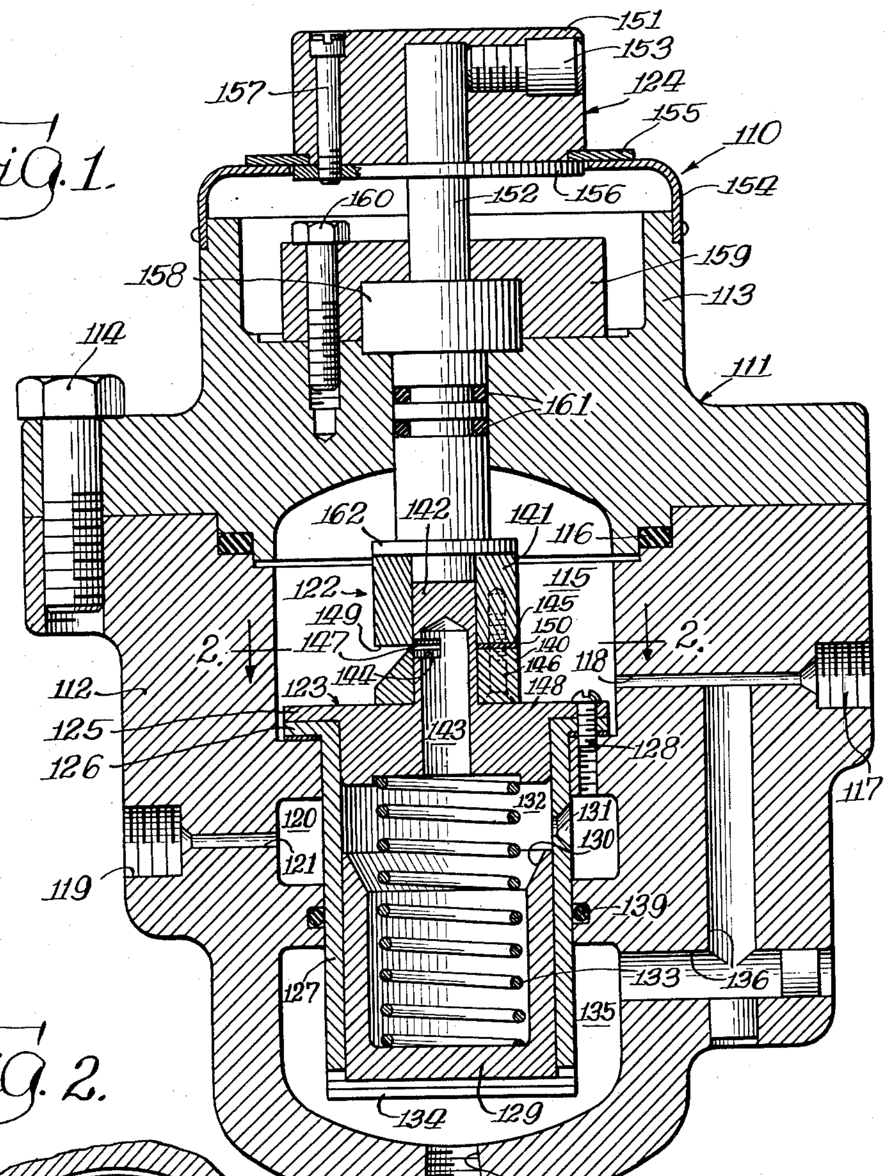
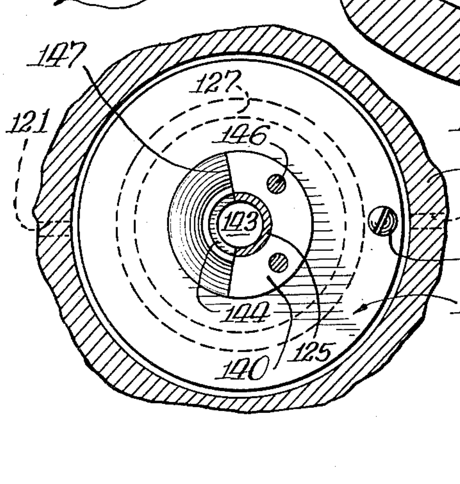


Fig. 2.



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ADJUSTABLE ORIFICE FOR USE IN DIFFERENTIAL PRESSURE APPARATUS

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This invention relates to a differential pressure responsive system and more particularly to apparatus providing a pressure differential creating orifice particularly adapted for use in such systems.

This application comprises a continuation-in-part of my copending application Serial No. 742,225, filed June 16, 1958, for a differential pressure system.

It is a general object of the present invention to produce a new and improved apparatus for use in pressure differential responsive systems.

It is a more specific object of the present invention to produce an improved adjustable orifice which may be utilized to create the pressure differential in systems of the type described in the preceding paragraph.

It is still another object of the invention to produce an improved adjustable orifice forming device of the character described wherein the orifice may take the form of an elongated slot, the length of which is adjustable, thereby to adjust the effective area of the orifice.

A further object of the invention is to provide an adjustable orifice forming device of the character described wherein orifices having extremely narrow widths may be provided with high accuracy.

It is a further object of the invention to provide such an adjustable orifice forming device having such high width accuracy which is extremely simple and economical of construction.

Other and further objects and advantages of the invention will be apparent from the following description and drawings, in which:

FIGURE 1 is a vertical section through an apparatus embodying the invention; and

FIG. 2 is a fragmentary transverse section taken substantially along the line 2—2 of FIG. 1.

While this invention is susceptible of embodiments in many different forms, there is shown in the drawings and will herein be described in detail a single embodiment, with the understanding that the present disclosure is to be considered as an exemplification of the principles of the invention and is not intended to limit the invention to the embodiment illustrated. The scope of the invention will be pointed out in the appended claims.

As shown in the drawing, the invention comprehends apparatus generally designated **110**, including a casing generally designated **111**, defined by a lower body **112**, and an upper bonnet **113** secured to the body by suitable means such as bolts **114** to define therebetween a chamber **115** sealed by means of an annular O-ring **116** disposed concentric of the chamber between the body and bonnet. The body is provided with an inlet **117** communicating with chamber **115** by means of a passage **118**, and is further provided with an outlet **119** communicating with an internal annular chamber **120** by means of a passage **121**. A pressure differential is provided between the inlet **117** and the outlet **119** by means of an adjustable orifice assembly generally designated **122** disposed in chamber **115**, and a flow regulating valve **123** associated with the adjustable orifice assembly for regulating the flow from the adjustable orifice assembly **122** and chamber **120**. Orifice assembly **122** may be adjusted by a manually operable means generally designated **124** to provide an accurately regulated pressure differential.

More specifically, the flow regulating valve **123** includes an orifice cylinder **125** secured to a flange **126** of a tubular

valve cylinder **127** by suitable means such as a screw **128**. Axially slidable within the lower portion of the valve cylinder is a cup-shaped valve piston **129** having a frusto-conical upper end **130** controlling an opening **131** communicating between annular chamber **120** and a chamber **132** defined by the orifice cylinder, the valve cylinder, and the valve piston. The valve piston is biased downwardly by a coil spring **133**, the downward movement of the piston being limited by a retainer **134** extending across the lower end of the valve cylinder **127**. Balancing of the flow regulating valve is effected by means of fluid pressure in a lower chamber **135** in which the lower half of the valve cylinder **127** and the valve piston **129** are disposed, the chamber **135** having communication with inlet passage **118** through an interconnecting passage **136**. A drain plug **137** is provided for controlledly closing a drain opening **138** in the bottom portion of the body **112** leading from chamber **135**. The valve cylinder is sealed to the body **112** by means of an O-ring **139** intermediate the chambers **120** and **135**.

Adjustable orifice assembly **122** includes a pair of annular orifice cylinders **140** and **141** coaxially rotatable on a cylindrical boss **142** upstanding from orifice cylinder **125**. The boss **142** is provided with the downwardly opening axial recess **143** communicating at its lower end with chamber **132** and communicating at its upper end with chamber **115** through an arcuate slot **144** extending through the wall of the boss approximately 160° about the axial recess **143**.

The orifice cylinders **140** and **141** are spaced axially by an arcuate shim **145** extending approximately 200° around the boss **142** at the horizontal plane of the mid-portion of the slot **144**. The orifice cylinder **141** is secured to the lower orifice cylinder **140** with shim **145** thusly disposed therebetween by suitable means such as screw **146**, thereby arranging the orifice cylinders to define an arcuate slit **147** extending approximately 160° around the boss **142** between the opposite ends of the shim **145**. The lower orifice cylinder **140** bears downwardly against the upper surface **148** of orifice cylinder **125** and the axial length thereof is preselected to dispose the slit **147** at approximately the horizontal central plane of slot **144**. The lower surface **149** of the upper orifice cylinder **141** and the upper surface **150** of the lower orifice cylinder **140** are preferably made highly accurately planar, as by lapping, and the shim **145** is preferably formed of shim stock having a highly accurate preselected thickness, so that the width of the slit **147** may be controlled with a high degree of accuracy, including where the width is of extremely small magnitude, such as approximately .001 inch.

Adjustment of the rotational position of the adjustment orifice assembly **122** is effected by the adjustment means **124** which includes a manually operable knob **151** secured to a shaft **152** by suitable means such as set screw **153**. A plate **154** may be secured to the top of bonnet **113** for cooperation with a dial **155** secured to the knob **151** by a clamp ring **156** and a clamp screw **157** to indicate the condition of the valve.

Shaft **152** is mounted for free rotation in bonnet **113** by means of a ball thrust bearing **158** retained in association with the bonnet by a retainer **159** secured to the bonnet by a retainer clamp screw **160**. A pair of O-rings **161** is provided in the lower portion of the shaft for sealing the shaft rotatively to the bonnet. The lower end of the shaft is provided with an enlargement **162** connected to the upper orifice cylinder **141** for transmitting rotation thereto whereby the rotational position of the slit **147** is adjusted relative to the slot **144** to control the effective area of the flow passage between chamber **115** and recess **143** with an extremely high degree of accuracy.

The flow regulator apparatus **110** accurately controls the pressure differential between an inlet and outlet thereof. In apparatus **110**, fluid entering the inlet **117** passes into chamber **115** and, thence, through the adjustable flow passage defined by slit **147** and slot **144** to recess **143**. From recess **143** the fluid may pass through chamber **132** and outwardly through opening **131** and annular chamber **120** to the outlet **119**, as regulated by the valve member end **130**. The effective area of the flow passage defined by slit **147** and slot **144** is accurately controlled by the manipulation of handle **151** to provide an accurate control of the flow provided by apparatus **110** including at very small fluid flow rates.

In many installations where an orifice is used to create a pressure differential, which differential is utilized to measure or regulate flow, it is necessary to have straight clear runs of 10 to 30 diameters of pipe upstream and downstream from the orifice in order to get reliable measurements and eliminate errors arising from turbulent flow. By the provision of the inlet and outlet chambers in the device of the present invention, the turbulence of incoming and outgoing flow is in effect insulated from the orifice and absorbed therein so that long, straight runs on either side of the device are unnecessary.

It will be clear to those skilled in the art that the apparatus of the present invention can also be used as a flow meter. By adjusting the orifice to provide a predetermined pressure differential with a given fluid, the flow across the orifice will be uniform under all conditions.

In addition, it will be remembered that flow rate through an orifice is proportional to the square root of the differences in pressure existing upstream and downstream from the orifice. Flow rate meters are therefore essentially differential pressure gauges calibrated in gallons per minute. Since the scale of the normal pressure gauge is uniform in pressure, flow rate is proportionate to the square root of the pressure indications on the gauge with the result that flow rate scales are congested at the lower end and expanded at the higher end and the sensitivity of the device is correspondingly less at lower pressure differentials and greater as the pressure differential increases. By the use of the adjustable orifice of the present invention, the orifice size can be adjusted to meet the conditions of operation so that in effect, the optimum operating point on the pressure gauge scale can be shifted to any part of the scale simply by adjusting the orifice opening. Sensitivity will change correspondingly. Thus, in effect, the orifice can be "tuned" to this metering circuit.

It will, of course, be clear that by providing various configurations for the orifice slot varying responses to pressure differential or flow can be obtained. Thus, for example, the orifice can be designed to give what is known as a "suppressed zero." As understood, this term refers to an instrument constructed with the lower part of its range suppressed into a small portion of the total travel of an indicator or scale but a relatively widely spread scale can be obtained over the upper portion of the scale. If such a scale is desired, the orifice may be of relatively large size at one end and small at the other end so that equal degrees of rotation of the cover or closure member produces unequal differences in total slot area. For example, if the slot over the first 20 degrees of opening is double the width of that of the remaining 140 degrees, the scale calibration will be twice as great over the first 20 degrees as over the entire remaining 140 degrees and thus the accuracy of flow regulation is enhanced in the last portion.

Orifices may also be constructed with dual or triple ranges. This may be accomplished by having two or more slots in the orifice cylinder, circumferentially parallel, but displaced axially one from the other. The housing may then be constructed of sufficient length so that the orifice adjusting sleeve may be positioned axially so as to unmask one, two, or more slots. Thus, there will be an orifice of double or triple range.

Other and further variations and adaptations of the invention herein disclosed to fit a variety of situations and conditions will be readily apparent to persons qualified in the art to which the invention pertains.

I claim:

1. In a differential pressure apparatus, means defining an adjustable orifice comprising: a cylindrical member having an axial flow passage opening through an end portion thereof, and an arcuate slot extending circumferentially approximately 160° about said cylindrical member and communicating inwardly with said flow passage; an assembly including a first annular member rotatable coaxially about said cylindrical member and having a planar transaxial end surface aligned with said slot, a second annular member rotatable coaxially about said cylindrical member and having a planar transaxial end surface juxtaposed to and confronting said first annular member end surface, an arcuate, flat spacer between said surfaces extending circumferentially approximately 200° and having an accurately predetermined axial width, and means retaining said annular member end surfaces in engagement with the opposite surfaces of said spacer to define between said end surfaces an arcuate slit extending approximately 160° from the opposite ends of the arcuate spacer in alignment with said cylindrical member slot; and means for rotatably adjusting said assembly relative to said cylindrical member to vary the amount of circumferential alignment of said slit with said slot.

2. In a differential pressure apparatus, means defining an adjustable orifice comprising: a cylindrical member having a flow passage opening through an end portion thereof, and an arcuate slot extending circumferentially partially about said cylindrical member and communicating inwardly with said flow passage; an assembly including a first annular member rotatable coaxially about said cylindrical member and having a planar transaxial end surface, a second annular member rotatable coaxially about said cylindrical member and having a planar transaxial end surface juxtaposed to and confronting said first annular member end surface, an arcuate, flat spacer between said surfaces and having an accurately predetermined axial width, and means retaining said annular member end surface in engagement with the opposite surfaces of said spacer to define between said end surfaces an arcuate slit having a circumferential extent approximately equal to the circumferential extent of said slot, and extending between the opposite ends of the arcuate spacer in alignment with said cylindrical member slot; and means for rotatably adjusting said assembly relative to said cylindrical member to vary the amount of circumferential alignment of said slit with said slot.

3. In a differential pressure apparatus, means defining an adjustable orifice comprising: a cylindrical member having a flow passage opening through a portion thereof, and an arcuate slot extending circumferentially partially about said cylindrical member and communicating inwardly with said flow passage; an assembly including a first annular member rotatable coaxially about said cylindrical member and having a planar transaxial end surface, a second annular member rotatable coaxially about said cylindrical member and having a planar transaxial end surface juxtaposed to and confronting said first annular member end surface, an arcuate, flat spacer between said surfaces and having an accurately predetermined axial width, and a screw extending through one annular member and said spacer, and threaded to the other annular member for retaining said annular member end surfaces in non-rotative engagement with the opposite surfaces of said spacer to define between said end surfaces an arcuate slit extending between the opposite ends of the arcuate spacer in alignment with said cylindrical member slot; and means for rotatably adjusting said assembly relative to said cylindrical member to vary the

amount of circumferential alignment of said slit with said slot.

4. In a differential pressure apparatus, means defining an adjustable orifice comprising: a cylindrical member having an axial, cylindrical recess opening through one end thereof, and an arcuate slot extending circumferentially about said cylindrical member and communicating inwardly with said recess adjacent the inner end thereof; an assembly including a first annular member rotatable coaxially about said cylindrical member and having a planar transaxial end surface aligned with said slot, a second annular member rotatable coaxially about said cylindrical member and having a planar transaxial end surface juxtaposed to and confronting said first annular member end surface, an arcuate, flat spacer between said surfaces and having an accurately predetermined axial width smaller than the axial width of the slot, and means retaining said annular member end surfaces in engagement with the opposite surfaces of said spacer to define between said second surfaces an arcuate slit extending between the opposite ends of the arcuate spacer in alignment with said cylindrical member slot; and means for rotatably adjusting said assembly relative to said cylindrical member to vary the amount of circumferential alignment of said slit with said slot.

5. The orifice means of claim 4 wherein the slot and slit have substantially equal circumferential extents about the axis of the recess.

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