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PRESSURE RESPONSIVE DEVICE

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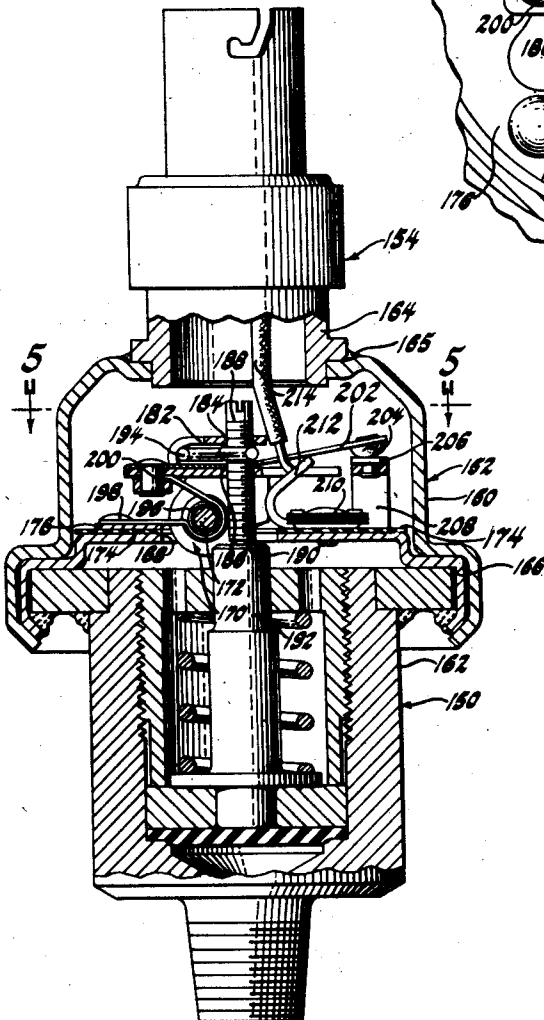


Fig. 4

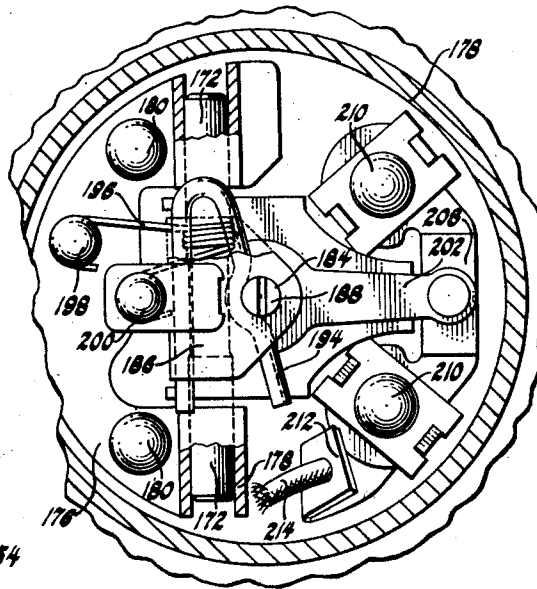


Fig. 5

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PRESSURE RESPONSIVE DEVICE

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4 Claims. (Cl. 200—83)

This invention relates to pressure responsive devices and more particularly to fluid pressure responsive switches and gauges for use in high pressure systems.

Fluid pressure gauges and switches must be quickly responsive to changes in pressure and must also be adequately sealed to prevent leakage of the fluid within the system. In order to accomplish such a device it is common practice to utilize a diaphragm as a pressure-responsive member, since by the use of a diaphragm a structure more adequately sealed against fluid leakage can be attained. However, the ordinary diaphragm type devices are not suitable for use in high pressure systems because of the inherent weakness and inability of the diaphragm to withstand the increased strain. On the other hand, the use of sliding piston type devices is undesirable because of the inadequate sealing means afforded.

It is an object of this invention to provide a fluid pressure responsive device which has improved means for fluid sealing to prevent leakage and which is particularly suited for operation in high pressure systems.

Another object is to provide a fluid pressure responsive device suited for use in high pressure systems which is durable, accurate and quickly responsive to fluid pressure changes.

These objects are accomplished in accordance with the invention by the provision of a structure utilizing a diaphragm and a piston of specific design, in combination, as a pressure-responsive member.

Other objects and advantages of the invention will appear more clearly from the following description of the preferred embodiments and from the drawings in which: Figure 1 shows a vertical sectional view of a gauge embodying the invention; Figure 2 is a view taken on the line 2—2 of Figure 1; Figure 3 is a side view with parts broken away of the top portion of the embodiment shown in Figure 1; Figure 4 is a side view in partial section of a switch embodying the invention; and Figure 5 is a view taken on the line 5—5 of Figure 4.

Referring to the drawings in detail, Figure 1 shows a fluid pressure gauge having a piston and diaphragm assembly 10, a variable electrical resistance unit 11 operative therewith and an electrical connector assembly 12.

The piston and diaphragm assembly 10 has a metal casing 14 which defines a cylindrical bore 16 provided with internal threads 18. The top of the casing is open and the bottom terminates in an externally threaded cylindrical extension 20 of reduced diameter. This extension has a longitudinally extending opening 22 therein, the lower portion of the opening being of increased diameter as shown at 24, and the upper end communicating with the bore 16 through a generally frusto conical portion 26. The top diameter of the generally frusto conical portion 26 is of slightly less diameter than that of the bore 16 so as to form an annular shoulder 28 on the interior wall of the casing.

Extending coaxially through the opening 22 and terminating within the generally frusto conical portion 26 is a restriction tube 30 sealed in position by the bushing 32,

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the bushing being secured within the portion of the opening of increased diameter 24. The tube 30 forms a passage to convey fluid to the pressure gauge and is positioned for alignment with an opening in the fluid pressure line when the gauge is connected by means of the external threads 34 provided on the extension 20.

A disk-shaped diaphragm 36 having a diameter the same as that of the bore 16 is positioned over the generally frusto conical portion 26 of the opening 22 so as to form a cavity 38. The edged portions of the diaphragm are pressed tightly against the shoulder 28 by a flat-sided metal ring 40 so as to form a fluid tight seal of the cavity 38. The diaphragm may be of any suitable flexible material such as natural or synthetic rubber, while the metal ring 40 is preferably made of bronze or other suitable bearing material.

A hollow cylindrical shaped retainer 42, provided with exterior threads 44 and a top wall 46, threadedly engages the interior of the casing 14 so as to force the metal ring 40 against the diaphragm 36 and compress its edge portions against the shoulder 28 to form a fluid tight seal therewith.

The interior wall of the retainer forms a cylinder 48 in which is located a reciprocable piston 50 with a head portion 52 extending into and in sliding contact with the sides of the centerbore of the ring 40. Immediately above the head portion 52 is an annular flange 54. The length of the head portion 52 is the same as the thickness of the ring 40 so that, when the lower face of the flange 54 abuts the top of the ring, the face 56 or the piston head will be flush with the lower face of the ring. Thus, the ring 40 serves not only to maintain the diaphragm in sealing engagement but also as a piston stop means.

Extending upwardly as shown, from the piston flange 54, is a piston shank portion 58, the upper end of which forms an extension 60 of reduced diameter. The extension 60 projects through and slidably engages the sides of a hole provided in the top wall 46 of the retainer 42. Upward movement of the piston 50 is limited by the annular shoulder 62 on the piston shank portion 58. In this manner the upward movement is restricted to that which will insure that the piston head 52 will remain in engagement with the central bore of the ring 40.

A helical compression spring 64 is positioned between the piston flange 54 and the retainer top wall 46 and maintains the piston flange against the ring 40 when no pressure is applied to the piston head.

Two holes, shown at 66, are provided in the retainer top wall 46 to permit use of a spanner wrench to tighten the retainer 42.

In order to avoid excessive diaphragm wear, the edges of the ring 40 adjacent its center bore and of the piston head are rounded as shown at 68 and 70 respectively. In this manner the diaphragm is precluded from excessive wear and also from being cut or pinched by what would otherwise be the relatively sharp adjacent edges of the ring bore and piston head.

To assemble the diaphragm-piston assembly, the tube 30 and the bushing 32 may first be secured in the opening 22 and then the diaphragm 36 and the ring 40 positioned in the bore of the casing 14. After the piston 50 is placed in the ring 40, the helical compression spring 64 is placed on the piston flange 54 and the retainer 42 is screwed into the casing so as to compressibly force the diaphragm into sealing engagement with the shoulders 28.

It will be noted that the ring 40 serves as a separable end wall for the retainer 42. It is to be understood that the ring 40 could be made integral with the retainer 42 and the top wall 46 made separable to allow for assembly.

Mounted above the piston diaphragm assembly for cooperation therewith is a variable resistance unit en-

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closed in a cover 72 which consists of a cup-shaped housing 74 and a terminal support bushing 76 suitably secured as by flanges or by welding to the edges of a hole 73 cut in the top of the housing. As shown at 80 in Figure 1, the walls of the housing 74 adjacent its open end are flared outwardly and bent over a casing flange 82 so as to secure the housing to the casing 14. The flange 82 may be integral with the casing or may be welded or otherwise suitably secured thereto.

As shown in Figures 2 and 3 as well as in Figure 1, an arcuate shaped electrical resistance element 84 supported by a bracket 86 which has an arcuate portion 88 and leg portions 90 and 92 is secured within the housing by rivets 93 or by other suitable means. The resistance element 84, which consists of a suitable resistance wire coiled around an arcuately shaped flat strip of insulator material, is fastened to the bracket by means of rivets 94 and 95, and is electrically insulated therefrom by strips of insulating material 98 and 99. One end of the resistance wire is electrically connected to the rivet 96 which serves as a contact for the lead wire 100.

A sheet metal mounting plate 102, having parallel upstruck pivot shaft supporting members 103 and 104, is positioned in the bottom of the housing 74 and is secured thereto and to the piston diaphragm assembly by having its edge portions 105 bent over the casing flange 82 and clamped between the turned edge 80 of the housing and the flange 82. It will be noted that a soft metal 106, such as solder, is molded into the annular cavity under the casing flange 82 so as to assure a secure and sealed fit between the housing and the casing.

As can be seen in Figure 3, each of the parallel upstruck shaft supporting members 103 and 104 is provided with a recess 108 for the reception of a pivot shaft hereinafter described.

A contact supporting lever 110 having a generally inverted U-shape is provided with an integral cantilever arm 111 having riveted or otherwise suitably secured thereto a spring loaded contact arm 112 and is pivotally mounted on the supporting members 103 and 104 by means of a transversely extending shaft 114, the ends of which are fixedly secured within the recesses 108. The shaft 114 passes through a hole in each of the respective legs of the inverted U-shaped lever 110. The lever 110 is provided with a pair of insulator bushings 115 and 116 which serve as bearing surfaces for pivotal movement of the lever on the shaft 114.

The top of the lever 110 is inwardly and downwardly curled as shown at 118 and is provided with a centrally located and threaded aperture which is aligned with a similarly threaded aperture in the top of the lever to receive an angularly but generally vertically disposed calibrating screw 119. As can be seen most clearly in Figure 3, the top of the lever 110 is angularly disposed to the horizontal, as shown, so that the calibrating screw 119 can be disposed at a sufficient angle to allow for adjustment from above without interference from the bracket 86 and the resistance element 84. The adjusting screw 119 has a slotted top to allow for turning adjustment with an ordinary screwdriver and a rounded bottom portion 120 which abuts the end of the piston 50.

A hairpin friction spring 121 compressed between the curled head 118 and the calibrating screw 119 prevents unwanted turning of the screw by vibration, etc.

As can be seen in either Figure 1 or Figure 3, the pivot shaft supports 103 and 104 are suitably notched as shown at 122 and 123 to receive a generally U-shaped horizontally disposed shaft retainer spring 124. The spring 124 has vertically angled legs which ride over the ends of the shaft 114 and thereby maintain it in the recesses 108.

A torsion spring 126, which is anchored at one end to the mounting plate by a rivet 127 disposed around the shaft 114 and anchored at the other end to one of the dependent legs of the inverted U-shaped lever by

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a rivet 128, urges the lever to rotate clockwise, as shown, and thus maintains the rounded end 120 of the calibrating screw in abutting relationship with the piston 50. The spring 126 also serves as a ground connection for the lever 110.

The contact arm 112, which is made of a spring metal, has a center portion 130 struck out at an angle and riveted or otherwise suitably secured to the cantilever arm 111. The end of the arm is provided with a contact button 131 which is urged by the spring pressure of the arm 112 into contact with the resistor element 84.

The connector assembly comprises a terminal post 132 molded or otherwise suitably secured in a block of insulating material 134 and concentrically surrounded by a terminal connector socket 136 having an outwardly extending flange 137 which abuts the insulator block 134. The interior bore of the terminal support bushing 76, which is suitably secured to the housing 74 as by a pair of outwardly extending flanges 138 and 139 or by soldering, welding or riveting, is provided with a groove 140 which carries a washer 141 of insulating material, the insulating block 134, and the flange 137 of the socket member. This assembly is accomplished by placing the washer, insulator block and socket flange within the bore of the support bushing and the spinning over the top edge of the bushing so as to securely clamp the assembly in position. The lead wire 100, one end of which is electrically connected to the terminal 132 and the other end of which is electrically connected to the rivet 96 and insulated from the bracket 86 by means of a strip of insulating material 142, is provided with a flexible insulator sleeve 143 adjacent the junction of the terminal support bushing with the housing for additional protection.

The operation of the fluid pressure gauge is as follows:

Oil from the fluid pressure system enters through the tube 30 into the cavity 38 and exerts pressure on the diaphragm 36. The center portion of the diaphragm, which abuts the piston head face 56, urges the piston upwardly, as shown, against the pressure of the compression spring 64, while the other portions of the diaphragm are forced against the face of the metal ring 40, thus creating a sealing action. Upward motion of the piston 50 is transmitted to the calibrating screw 119 which causes the lever 110 to pivot on the shaft 114 against the pressure of the torsion spring 126. The rotation of the lever moves the contact button 131 across the resistance element, thus changing the current flow through the electrical circuit in proportion to the pressure exerted on the diaphragm.

The pressure range within which the gauge will operate is of course determined by the strength of the compression spring 64 used. Because of the relatively small diameter of the piston head face 56, a gauge highly suitable for use in measuring very high fluid pressures may be attained. In one particular embodiment, for example, I have used a spring that allows a piston movement of $\frac{1}{16}$ " for every 3000 lbs. of pressure.

It is to be understood, of course, that other ratios of piston movement to fluid pressure may be attained by the use of a different compression spring strength or by the use of a piston having a different piston head diameter.

The unit is calibrated to zero position by turning adjustment of the calibrating screw 119 prior to the installation of the electrical connector assembly 12. To adjust for the amount of travel per unit pressure applied, the adjusting screw 119 is rocked by the use of a suitable tubular tool to bend the upper portion of the lever 110 at the narrow section 149 on either side of the calibrating screw. This operation will change the distance between the bottom 120 of the screw 119 in relation to the shaft 114 to increase or decrease the leverage of lever 110. This in turn determines the amount of travel of the contact button 131 over the resistance ele-

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ment 84 per unit pressure applied. In a particular embodiment, for example I have calibrated the unit to register from zero to 30 ohms resistance for from zero to 3000 lbs. pressure.

Once having been calibrated, the continued accuracy of the gauge is assured by the provision of the hairpin spring 121 which prevents unauthorized movement of the calibrating screw.

Figures 4 and 5 show a fluid pressure operated switch embodying the present invention and consisting of a piston diaphragm assembly 150, an electric switch assembly 152, and a connector assembly 154.

The piston diaphragm assembly 150 is essentially identical with that shown by Figure 1. Likewise, the housing 160, the means for securing the housing to the casing 162, and the connector assembly 154, are essentially the same as those shown by Figure 1 and previously described in conjunction therewith. In the particular embodiment of the invention shown by Figure 4, the terminal support bushing 164 is secured to the housing 160 by means of a weld 165 rather than by the flange arrangement shown in Figure 1.

The switch assembly 152 consists of a sheet metal mounting plate 166 which is secured to the housing 160 and to the casing 162 as described in conjunction with Figure 1 and which has a generally centrally located opening 168 for reception of a contact supporting lever 170. The contact supporting lever 170 has a generally inverted U-shape, each of the downwardly extending legs of which is provided with a hole for the reception of a shaft 172. A pair of bushings, one located in each of the aforementioned holes, rotatably secure the lever 170 to the shaft 172. The ends of the shaft 172 abut the surface of an insulator sheet 174 which lies over the top of the mounting plate 166 and which has an opening aligned with that in the mounting plate. A shaft mounting bracket 176, having a generally half-moon shape and having transversely extending upwardly pressed channels 178 in each end thereof, maintains the shaft in fixed position, the inner surfaces of the channels 178 being positioned over the top of the ends of the shaft 172. A series of rivets 180 secures the mounting plate 166 and the shaft mounting bracket 176 together, the insulator sheet 174 being pressed therebetween. The contact supporting lever has an upwardly and inwardly curled portion 182, the end of which is provided with a threaded hole 184 which is aligned with a similar threaded hole in the horizontal top portion 186 of the lever to receive a vertically disposed calibrating screw 188. The screw has a slotted top to allow for turning adjustment with a screwdriver and a rounded bottom portion 190 which abuts the end of the piston 192. A hairpin-friction spring 194 compressed between the calibrating screw 188 and the curled portion 182 of the lever prevents undesired turning of the screw once the device is calibrated.

A torsion spring 196 anchored at one end to the mounting plate 176 as shown at 198 has a central portion wrapped around the shaft 172 and is anchored at the other end to the top of the lever by means of the rivet 200. The torsion spring 196 urges the lever to rotate clockwise as shown and thus maintains the rounded end 190 of the calibrating screw 188 against the end of the piston 192. The spring 196 also serves as a ground connection for the lever 170.

Attached to the top of the lever 170 by the rivet 200 is a contact supporting arm 202 made of a spring metal and provided with a contact button 204 which is vertically aligned with a contact tip 206 secured to the top of a contact support bridge 208. The contact support bridge 208 which is electrically insulated from the housing by the insulator sheet 174 and which is secured by means of the insulated rivets 210, has an upwardly turned portion 212 at one end thereof to which the conductor

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wire 214 leading from the connector assembly 154 is brazed or otherwise suitably secured.

As was described in conjunction with Figures 1 to 3, the instrument is calibrated to zero by adjustment of the calibrating screw prior to securing the connector assembly 154.

The operation of the piston diaphragm assembly is identical to that previously described.

The piston 192, as actuated by the fluid pressure, urges the calibrating screw 188 upwardly as shown, thus causing the lever 170 to rotate on the shaft 172 against the pressure of the torsion spring 196. The spring loaded contact button 204 which is carried by the lever 170 is thus caused, upon application of a predetermined amount of fluid pressure to the instrument, to break the electrical contact with the tip 206 and open the circuit.

The switch is particularly suitable for use in high fluid pressure systems. As was true of the gauge previously described, the exact amount of piston movement per unit fluid pressure exerted on the diaphragm will depend upon the strength of the compression spring and on the diameter of the piston head. For use in high pressure systems I prefer to use a switch mechanism such as will cause a break in the electrical contact after about $\frac{1}{32}$ " of piston movement.

The devices of this invention have all the advantages which can be attained by the use of a diaphragm as a pressure responsive member. The greatest of these advantages is the prevention of fluid leakage. At the same time, the device is particularly suitable for use in high pressure systems and thus avoids the disadvantages of conventional type diaphragm gauges or switches.

It is to be understood that, although the invention has been described with specific reference to particular embodiments thereof, it is not to be so limited since changes and alterations therein may be made which are within the full intended scope of this invention as defined by the appended claims.

I claim:

1. A fluid pressure responsive device comprising a cylinder, a flat-sided ring at one end of said cylinder, said ring having a centrally located cylindrical bore therethrough, a reciprocable piston in said cylinder having a cylindrical head portion of reduced diameter extending into said cylindrical bore and a flange for contacting the inside face of said metal ring, said head portion having a diameter approximately equal to the diameter of said bore and a length approximately equal to and not exceeding the thickness of said ring, a spring in said cylinder for urging said flange against said ring, a flat diaphragm of rubber-like material having a small centrally located part of its interior surface abutting said piston head portion and the remainder of its interior surface backed up by and in sealing engagement with said ring, the adjacent edges of said ring and said head being rounded to prevent diaphragm wear, and means for conducting fluid against the outside surface of said diaphragm, said means including a pressure chamber having one wall formed by the outside surface of said diaphragm, the area of said outside surface forming said wall being substantially greater than the cross-sectional area of the head portion of said piston.

2. A fluid pressure responsive device comprising a cylinder, a flat-sided ring at one end of said cylinder, said ring having a centrally located cylindrical bore therethrough, a reciprocable piston in said cylinder having a cylindrical head portion of reduced diameter extending into said cylindrical bore and a flange for contacting the inside face of said metal ring, said head portion having a diameter approximately equal to the diameter of said bore and a length approximately equal to and not exceeding the thickness of said ring, a spring in said cylinder for urging said flange against said ring, a flat diaphragm of rubber-like material having a small centrally located part of its interior surface abutting

said piston head portion and the remainder of its interior surface backed up by and in sealing engagement with said ring, the adjacent edges of said ring and said head being rounded to prevent diaphragm wear, means actuated by said piston movement for controlling the flow in an electrical circuit, and means for conducting fluid against the outside surface of said diaphragm, said last-mentioned means including a pressure chamber having one wall formed by the outside surface of said diaphragm, the area of said outside surface forming said wall being substantially greater than the cross-sectional area of the head portion of said piston.

3. A fluid pressure responsive device comprising a cylinder, a flat-sided ring at one end of said cylinder, said ring having a centrally located cylindrical bore therethrough, a reciprocable piston in said cylinder having a cylindrical head portion of reduced diameter extending into said cylindrical bore and a flange for contacting the inside face of said metal ring, said head portion having a diameter approximately equal to the diameter of said bore and a length approximately equal to and not exceeding the thickness of said ring, a spring in said cylinder for urging said flange against said ring, a flat diaphragm of rubber-like material having a small centrally located part of its interior surface abutting said piston head portion and the remainder of its interior surface backed up by and in sealing engagement with said ring, the adjacent edges of said ring and said head being rounded to prevent diaphragm wear, means for conducting fluid against the outside surface of said diaphragm, said means including a pressure chamber having one wall formed by the outside surface of said diaphragm, the area of said outside surface forming said wall being substantially greater than the cross-sectional area of the head portion of said piston, and a mechanism actuated by the movement of said piston for controlling the current flow through an electric circuit, said mechanism comprising a rockable lever having a calibrating screw passing therethrough and into contact with said piston for actuation of said screw and said lever thereby, and a contact arm having one end fixed to said lever for movement therewith, the other end of said arm being provided with a contact button for opening and closing an electric circuit.

4. A fluid pressure responsive device comprising a

cylinder, a flat-sided ring at one end of said cylinder, said ring having a centrally located cylindrical bore therethrough, a reciprocable piston in said cylinder having a cylindrical head portion of reduced diameter extending into said cylindrical bore and a flange for contacting the inside face of said metal ring, said head portion having a diameter approximately equal to the diameter of said bore and a length approximately equal to and not exceeding the thickness of said ring, a spring in said cylinder for urging said flange against said ring, a flat diaphragm of rubber-like material having a small centrally located part of its interior surface abutting said piston head portion and the remainder of its interior surface backed up by and in sealing engagement with said ring, the adjacent edges of said ring and said head being rounded to prevent diaphragm wear, means for conducting fluid against the outside surface of said diaphragm, said means including a pressure chamber having one wall formed by the outside surface of said diaphragm, the area of said outside surface forming said wall being substantially greater than the cross-sectional area of the head portion of said piston, and a mechanism actuated by the movement of said piston for controlling the current flow through an electric circuit, said mechanism comprising a rockable lever having a calibrating screw passing therethrough, and into contact with said piston for actuation of said screw and said lever thereby, and a contact arm having one end fixed to said lever for movement therewith and another end in engagement with an electrical resistance coil.

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