INFLATABLE FORMING DIAPHRAGM FOR HYDRAULIC PROCESS

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Fig. 6.

Fig. 9.

Fig. 10.

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Fig. 11

Fig. 12

Fig. 13

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This invention relates to hydraulic metal-forming presses of the diaphragm type and is particularly concerned with the means for actuating the diaphragm forming against the sheet metal arranged on form blocks confronting adjacent the diaphragm.

This application is a continuation-in-part of the copending application of O. A. Wheelon, Ser. 275,693 filed March 11, 1952, now U.S. Patent No. 2,771,850 entitled "High-Pressure Hydraulic Press." It is the consensus of those experienced in this art that one of the principal reasons heretofore for barring the universal adoption of this general type of press can be ascribed to the diaphragm material, particularly when the actuator is of the fluid-expandable bag type. Rupture of such actuators long before the terminus of their useful calculated life has been reached is a common occurrence. Such ruptures are due not so much to magnitude of the fluid pressure but to the initial elongation of the bag walls during the period when the bag is being fluid-discharged to its fullest extent in order to fully fill the working chamber of the press with the bag so as to assure even distribution of the fluid pressure on all portions of the forming diaphragm.

This invention provides a pressure-fluid energized power package of the expandable bag type which can be expanded repeatedly to conform to the full interior volume of the working chamber of a hydraulic diaphragm type press without any danger of the bag's rupturing. Notwithstanding this notable improvement in such actuators, the present power package is highly mechanically efficient and of the minimum cost, per unit of area, in fabrication.

Stated with more particularity the present power package essentially consists of an expandable pressure fluid cell comprising, first, an elongate mass of resilient elastomeric material, preferably in the shape of a flat, substantially hollow liquid tight container. An expanse of more rigid material, such as a more or less plane sheet of metal, is disposed in said mass intermediate said faces in substantially parallelism therewith, the edges of said expanse of rigid material terminating short of the adjacent edges of the elastomeric mass. One major face of said more rigid material is facewise united to that portion of the elastomeric mass that lies coextensively adjacent thereto, the opposite major face of the rigid material being free from that portion of the elastomeric mass that lies adjacent thereto. The peripheral portions of the material are so configured that in the mass and between the edges of said piece and the outer, side-faces and end-faces of the elastomeric mass, there are defined elastomeric portions so located, shaped and proportioned as to, first, distribute bag-rupture causing stresses over an elastomeric mass having a volume, radius of gyration and moment of inertia sufficient to prevent rupture of the bag in its initial "local elongation" phase of distortion in filling the working chamber of the press. Secondly, the mass, either with or without these novel improvements above location, shape and proportion, may be provided with an internal molecular structure and relative arrangement of the molecules to each other and to the transverse axis of the rigid mass as to result in these molecules being urged closely together upon bag distortion, thereby densifying the elastomeric material in that direction which causes the material to effectively resist tearing along planes extending from the respective edges of the rigid sheet to the adjacent outer faces of the bag, which tearing is that which is most frequent in occurrence.

Preferably, the substantially rigid liner or core member is so disposed in the mass that the major face thereof lies closer to the major face of the elastomeric mass than to the opposite major face thereof, so that to render the free, moving face portion thereof, thinner and more pliant than is the thicker opposite stationary portion or stratum which is employed to anchor the elastomer to the plate. In any event, however, means are provided for enabling fluid ingress and egress into the elastomeric container so as to enable it to act displacingly on the thinner stratum whereafter the fluid is withdrawn from the container and returned to its pressurized source. Preferably, the pressure fluid is fed and returned through the same single conduit means forming a part of the ingress and egress means. Other novel features that advance the utility of such actuators will be brought out hereinafter.

In the most specific aspect presently contemplated, the pressure-fluid energized power package essentially comprises an expanse of substantially rigid material having opposed major faces, the one major face being so surface-conditioned as to be substantially unengageable and free from the adjacent elastomeric means, the rigid material including a fluid aperture therethrough; an expanse of resilient elastomeric material disposed coextensively adjacent to at least said one face of said rigid material, the molecules of said elastomeric material being long-chain molecules connected by side links and having an initial mutual arrangement in said material such as to enable them, on longitudinal stretching of the elastomeric expanse, to undergo orientation into a plurality of substantially parallel, laterally spaced lines running transversely with respect to the adjacent rigid material and connected by said cross-links; means extending from the periphery of said mass at least partially over the opposite face of said rigid material so as to anchor said elastomeric material thereto; and pressure fluid ingress and egress means debouching onto that one of the inner faces of the elastomeric material that lies adjacent said one of the major faces of said rigid material so as to enable the pressure fluid to displace said inner face away from the rigid material and enable diaphragm actuating cycling of said cell. The invention also provides novel methods and apparatus for use in fabricating the improved pressure-fluid cell.

Briefly, the simplest method now contemplated comprises taking a mass of elastomeric material which includes an aperture; taking an elongate expanse of substantially rigid material which includes a substantially central aperture therein and has two opposite major surfaces, the one of which is conditioned to effectively resist adherence of substantially all elastomers thereto, the opposite face being adapted either frictionally or cementiously to engage the adjacent elastomeric material; arranging said elastomeric mass envelopingly around said expanse of rigid material with the two apertures in registry; arranging the unit in a heat-and-pressure type mold or similar; applying heat and compressive pressure to said material sufficiently to form said mass to said predetermined shape and, concurrently, if desired, to cause said "adapted" surface if in this instance it is bare of cementitious material, to adhere to the adjacent elastomeric material while leaving the opposite surface of said rigid expanse free from the elastomeric material; and thereafter removing the substantially finished article from the matrix.

The invention also comprehends a specific development of this basic method in which the fabrication procedure is initiated by taking a mass of elastomeric material, also containing the aforementioned central aperture, but in
which there are long-chain elastomer molecules, with the long-chains laterally connected by side links. In this mass of elastomeric material the molecules have an initial relative arrangement such that when the material is stretched, the long-chain molecules undergo orientation into a plurality of substantially parallel lines extending transversely of the elongate elastomeric sheet. These lines are somewhat separated laterally and are united only by side-links. When the elastomer is applied outwardly on the peripheral edges of the bag these lines approach each other more closely and densify and strengthen the elastomer at these edges so that they effectively resist tearing or other ruptures.

The next step consists in taking an elongate expanse of substantially rigid material, lesser in area than that of the elastomeric mass and having a central aperture and arranging said elastomeric mass around the rigid material in such a manner as to envelope the latter and so dispose said molecules that when the elastomer is stretched they will orient themselves in parallelism transversely across the elongate expanse of rigid material, with the two aforementioned apertures in registry.

The one major surface of the expanse of rigid material is so surface-conditioned as to enable it to be adhered to the adjacent portion of the elastomeric material, where as the opposite surface of said rigid expanse is so surface-conditioned as to enable it to effectively resist adhesion to the face-wise adjacent elastomeric material and to remain free, and outwardly displaceable, therefrom.

The process continues with the step of arranging the aforesaid unit in a heat-and-pressure type mold or matrix and applying heat and compressive pressure to the same sufficiently to form the elastomer into a fluid-tight container of a predetermined configuration while causing said admissible surface on the rigid material to adhere to the adjacent portion of the elastomeric mass while permitting the opposite portion of said mass to remain free of the rigid material; and thereafter removing the substantially finished article from the zone of operations.

The presently preferred apparatus for heat and pressure molding the pressure-fluid cell comprises a pair of substantially rigid plane members, such as a pair of steel plates, arranged in mutual parallelism and maintained spaced vertically by a pair of transversely spaced side rails disposed between the plates. The side rails are concaved on their inner faces to the desired shape of the edges of the finished bag and are intersected rectangularly at each of the opposite ends of the mold by one of a pair of spaced end bars. The rails and end bars are mortised remotely into recesses formed superadjacent thereto into the inner face of the upper plate and this plate is spaced a small distance above these members by plugs and lugs extending upwardly from the rigid plane member or core plate, so that when the elastomer-envelope core-plate is placed properly in the mold, the upper plate, thereby spaced from the side rails and end bars, can be compressed in the heated ram-type press, downwardly so as to shape and unite the elastomer into the predetermined configuration of envelope fluid-tightly enveloping the core-plate. Vents are provided at suitable points in the upper plate of the mold and the side rails and end bars are provided with air traps for preventing gases, originating in the bottom of the mold from bubbling through the elastomer and forming "blisters" or "blow-holes" in the elastomer.

The outer upper edge of each side rail is bevelled to define an outlet for air and for heat-produced gases. This outlet is connected, by means of a channel defined between the spaced upper surface of the rail and the superadjacent surface of the upper mold plate, with vents traversing the G-sectional side rails. These vents and their locations and configurations induce the air, gases and excess flash elastomer emanating from the lower portion of the mold and seeking an exit under pressure, to travel around the longitudinal edges of the matrix to the top wall thereof and out these vents. Thus, this excess elastomer is brought around the edges of the envelope and assures the presence in the end and side walls of the final cell of a sufficient mass of elastomer to prevent rupture of this elastomer in this, the crucial, region of the envelope.

Preferably, in order to adhere the one surface of the core-plate to the elastomer and to more accurately shape the elastomer to the matrix surfaces, the ram head and the platen of the press employed are heated while acting pressurally upon the mold, as by passing steam through suitable channels in the ram head and platens. The mold's movable die-type parts then absorb sufficient heat from the ram head and platens to effect the necessary amount of plasticizing of the elastomer. On the upper surface of the mold, a plurality of elongate pressure-distributing rods or battens is placed transversely of the mold to cooperate with the ram-head and distribute the molding pressure uniformly over the top of the mold.

Only to render the invention concepts more concrete, certain ones of the many presently contemplated physical embodiments of the foregoing is illustrated in the accompanying drawings and are described in conjunction with the present detailed description hereinafter in conjunction with these drawings.

In said drawings, FIGURE 1 is a perspective view, partly in section, of one of the novel fluid-pressure cells combined with a diaphragm to form a metal-working unit insertable into a hydraulic press confronting adjacent the work-bearing platens therein;

FIGURE 2 is a fragmentary longitudinal section of this form of the cell itself, showing means in the liner or core plate for enabling connection of the cell to the two-way pressure-fluid conduit;

FIGURE 3 is a similar view of another form of the cell,

FIGURE 4 is a perspective view of still another form of the cell, showing the orientation of the elastomer molecules with respect to each other and to the reinforcing member of the cell for preventing tearing of the bag in the crucial plane extending from the edges of the reinforcing member to the respective adjacent end and side walls of the bag;

FIGURE 5 is a fragmentary longitudinal section taken along line 5-5 of FIGURE 4 to show a mode of disengagingly engaging the fluid conduit with the cell;

FIGURE 6 is a fragmentary perspective of the last-mentioned form, showing the liner or core plate as provided with bulb-edges;

FIGURE 7 is a fragmentary longitudinal section of still another species of cell;

FIGURE 8 is a top plan view of the now preferred form of mold for fabricating the cell;

FIGURE 9 is a fragmentary transverse section of the mold;

FIGURE 10 is a fragmentary longitudinal section of the mold;

FIGURE 11 is a fragmentary side sectional view of a form of the cell incorporating a modified core plate;

FIGURE 12 is a fragmentary side sectional view of the cell having still another form of core plate; and

FIGURE 13 is an enlarged cross sectional view of the filler component in the assembly shown in FIG. 1.

The pressure-fluid cell is illustrated in FIGURES 1 and 2 comprises, first, a flat, rectangular planform envelope or fluid-tight container 10 the walls of which are of uniform thickness throughout. This envelope is composed of some such resilient elastomer as neoprene in all cases where the hydraulic fluid employed for distending the envelope is one of the common natural petroleum hydrocarbons and not one of the synthetic heavy hydrocarbon hydraulic fluids. In the latter case, it is preferable to employ one of the butyl-rubbers as the material constituting the envelope in order to preclude damage to the envelope by the fluid. If constrained to do so by a war-
time national shortage of neoprene, certain other synthetic resilient elastomers may be employed in lieu of neoprene in cases where a natural petroleum hydrocarbon is employed as the hydraulic fluid. Among these elastomers may be mentioned butadiene; Buna-N; and Buna-S (a copolymer of butadiene and styrene also known as "GR-S"). Although the ones last mentioned are not in every respect as suitable for the present purposes as neoprene, not having its resistance to shearing, tearing and other stresses, and the like, certain hydraulic fluids, they will suffice if no neoprene is available.

In any event, this envelope includes a substantially central aperture 11 in its upper stratum 12. Disposed substantially centrally of the mass is a substantially rigid planar member 13. This member 13 is not only a structural component of the fluid-cell but is also a translated functional component of the molding apparatus that has been employed in fabricating this cell, having initially served as the core-plate in the mold and being bodily transferred from the mold with the rest of the cell upon completion.

In the finished cell, member 13 performs plural functions: it serves as a spreader, base and "liner" for the elastomeric material, reinforcing the upper stratum thereof and serving as the fulcruing base for the outward distension of the lower elastomeric stratum and, of course, divides the elastomeric "membrane" horizontally into two regions, a fixed region 12 and a movable or expandable portion constituted by the stratum 14.

To accomplish these and other ends, the member 13 is preferably composed of some rigid but non-brittle and tough light metal alloy such as Aclad. The lower face, A, of member 13 is rendered so smooth and planeal, as by burnishing, that neoprene and the like cannot adhere to it and the stratum 14 hence is free and independent of the lower face of member 13. The upper major surface B of member 13 is provided, to each side of aperture 11 with a plurality of transversely extending, longitudinally spaced ruggosities or ribs 15 with which the elastomer is interengaged by heat and pressure in the mold. To further prevent separation, a suitable cementitious material may be applied to the surface B, if desired, but such is not absolutely essential in this instance. Controlly of member 13 there is provided an aperture 16 coaxial with aperture 11 in the upper stratum of the elastomeric mass.

The side edges 17 and end edges 18 of the rigid planar member 13 are provided transversely of the member for quite a distance back into the body of the sheet 13 so as to provide a bulbus periphery on the sheet 13. The form of cell depicted in FIG. 11 includes substantially the same form and features of components as the cell of FIG. 2 with the exception of the geometry of the bulbous periphery of sheet 17. A close comparison of these FIGS. 2 and 11 will reveal that the bulb on the periphery of the FIG. 2 cell is formed by the outward taper of lower face A merging with the rounded plate edge, the upper face B being planar, whereas in the bulb in FIG. 11 both upper and lower faces A and B are tapered to respectively form upper and lower projections constituting a symmetrical bulb.

By these means, the uniformly thick walls of the envelope and particularly the lower stratum 14 and about one half of the arc of the curved edges of the envelope can be made to withstand distention elongations and press-body and work reactions without too much danger of rupture thereof. In fact, the portion of the envelope referred to above can be expanded away from the plate 13 to completely fill the working chamber of the press and force the diaphragm formingly around the form blocks on the platen without these portions undergoing any appreciable deformation. After the local working chamber has been filled, and the diaphragm has been workingly actuated, by the distention of the envelope by, say, the first 500 pounds per square inch component of the total fluid head without substantial danger of envelope rupture, further increase of hydraulic pressure merely forces the bag walls into tighter contact with the diaphragm proper and forces the diaphragm more effectively against the metal work, clamps or form blocks so as to complete the bending thereof around sharp corners or undercut surfaces on the form blocks, still without much liability of the envelope's rupturing. Thus, the fluid-cell incorporates no fluid-pressure limit.

The bulbous or transversely enlarged peripheral edges of plate 13 are particularly efficacious in the achievement of this result. These formations increase the radius of curvature of the envelope at all points of the lower free arced portion of the stratum 14 and especially along a plane extending from the bulbus periphery to the exterior surface of the rubber envelope to such an extent as to distribute the tearing stresses over such an area as to preclude tearing.

This species of the present cell is shown in FIGURE 1 as associated in a manner more specifically described in my aforesaid co-pending application, with a forming diaphragm 19 which is secured by means of a clamp group 20 to the upper half of a hemi-cylindrical press-body, not shown. Group 20 comprises a pair of side clamps 21 and a pair of end-edge clamps 22. The side clamps 21 consist of grooved elongate members adapted to seize between them the bent edge 23 of the bulbus periphery means, not shown, being employed to fasten the clamps 21 to the press body. The end-edge clamps 22 are similarly configured with the adjacent beaded end-edge of the diaphragm, but are resiliently mounted to the press-body by means of flanges or skirts 24 in each of which there is formed a plurality of spring-ears 25 through which bolts or the like, not shown, are passed to secure the end clamps resiliently to the press body so as to allow the fluid-cell to urge the end portions of the diaphragm sealingly against the end-gates of the work-bearing platens in the press, as described in my aforesaid application.

The diaphragm is upwardly domed in order to assure its clearing the path of the platen group lying below it and since the cell is normally planar on its lower surface, it is preferable to employ space-filler means 26 between the upper surface of the end-edges of the diaphragm and the upper surface of the side-edges of the diaphragm, to provide for efficient transmission of the hydraulic and expansive forces and the power generated by the cell to all portions of the upper surface of the diaphragm. These filler means may consist of a single piece of suitable plastic material or of two side pieces and two sides pieces. In either case, in cross-section, as more clearly shown in FIG. 13, they are generally of a double-hook shape, or are double re-curved, the shorter hook curving over the upper surface of the cell and the longer hook extending between the lower surface of the cell and the upper, domed surface of the diaphragm. Thus, the substantially planar displacement downwardly of the lower surface of the cell is transmitted substantially equally in intensity to every square inch of the upper surface of the diaphragm despite the domed nature of the latter, resulting in the domed diaphragm applying forming forces to the work substantially just as well as at its edges as in its center. The upper and lower faces of the filler 26 are provided with a plurality of longitudinally extending, laterally spaced grooves 26 which serve the purpose of laterally contracting when the filler 26 is compressed by the pad in order that the remainder of the grooves air originally trapped therein thereby to set up an air tight or vacuum seal between the pad bag and filler.

When pressure fluid is applied to the cell of FIGURES 1 and 2 through conduit means, not shown, but connected into the local working chamber. After the forcing plate, the lower wall or stratum 14 is urged downwardly as well as substantially half the cross-sectional "arc" of the envelope at the edges of the rein-
forcing plate. The pressure fluid in the bag urges the plate to which the upper wall is fixed, tightly against the upper inside of the fluid-pressure vessel. Thus, since the conduit may be of such rigidity and be so connected to the plate as to, in effect, suspend the bag therefrom in cantilever-fashion, no discrete means need be provided for anchoring the bag in place, such as fastening means extending between the bag and the press body.

The pressure activated diaphragm actuating cell disclosed in FIGURES 3 and 12 are generically the same as that previously described in that they incorporate "core" means 27 having its upper surface attached to the upper wall 28 of the envelope for reinforcing same and for carrying this upper wall with it against the abutment (not shown) provided by the upper interior surface of the press body when the pressure fluid expands the bag, as well as for dividing the elastomeric mass into two zones, a stationary one and a movable one. These cells also include means, not shown, for supplying and removing pressure fluid from the bag that are substantially identical with those described in connection with FIGURES 1 and 2.

However, in order to prevent tearing of the envelope at the edges thereof, that is, along the crucial plane extending from the side edges and end edges of the reinforcing plate, provision is made, in the adjacent lateral faces of the bag, of reinforcing plate 27 is employed that has a uniform thickness from edge to edge thereof, or, throughout its entire extent. Instead of disposing this plate medially of the thickness of the elastomeric mass as is preferred in the species illustrated in FIGURES 1 and 2, the stratum is inserted into the bottom surface of the envelope than to the top surface and lies in parallelism with both surfaces of the envelope. The stratum 32 is thus rendered readily displaceable and distendible outwardly while retaining the necessary amount of thickness and the stratum 28 lying between the plate and the sides of the press body, when attached to the upper surface of the plate throughout the mutually contacting areas of plate and elastomer, hence provides a substantial amount of resistance to the tension exerted on the upper portion of the bag by the expansion of the bottom and side walls, this resistance being met by a peripheral marginal portion of the upper stratum anchored over a relatively great area of elastomer lying inwardly of this margin and attached securely to the upper face of the plate 27. In order to distribute the flexing stresses at the side and end faces of the bag through a bulk sufficient to prevent tearing, the stratum provides a plurality of spaced and adapted for coaction with the envelope. To these and other ends, all the edges of the outer edge of the lower stratum, as shown in FIGURES 3 and 4 curved upwardly the top surface of the envelope. Each upper edge portion of the interior face of the plate includes a planar portion 20 and a hooked, or recurved portion 20A. The lower stratum 32, is, in cross-section, substantially planar and of uniform thickness for most of its extent but at a point 30 lying directly below the beginning of the upper portion 20, the thickness of this stratum passes from uniformity through a transition area 30A in which the thickness gradually increases to a maximum flexural plane 30C and thence proceeds in a fair curve that maintains a uniform lateral dimension through portion 30B over the top of the hook. Thence the elastomer forms the upper stratum 28 which may gradually thin down towards the center of the stratum. The elastomeric mass 30A between the planar portion 20 and the radially adjacent exterior surface of the bag is the first portion to undergo outward distention and transfers forces to the portion 30B lying between the hook and the exterior surface of the bag and attached rigidly to the hook 30A which cause maximum flexure along plane 30C. The portions 30A and 30B have respective radii of gyration and moments of inertia so chosen with respect to the modulus of elasticity of the elastomer that the flexural stresses along plane 30C and other stresses elsewhere at no time can cause flexural or other rupture of the bag.

Even in large hydro-pressures in which the working chamber is of considerable volume, resulting in severe initial elongations in the bag-walls in filling the chamber and in abutting the bag completely against the chamber walls, fluid cells of this class fail to show any evidence of rupture after many thousands of operating cycles, and regardless of the upper limit of the hydraulic pressure, which often exceeds 5000 pounds per square inch for this species.

In FIGURES 4 and 5 there is shown a species of cell in which, by taking advantage of a novel arrangement of the long-chain, side-linked elastomer molecules with respect to each other and to the transverse dimension of the core and reinforcing plate, neither the bulbous edges 17 and 18 of FIGURE 2 nor the extremely thick masses 30A and 30B of elastomer embodied between the edges of the plate and the adjacent exterior faces of the elastomer are mandatory in order to prevent tearing of the envelope. Instead, in a manner hereinafter described, the elastomer for the envelope 33 is so calendered into sheet form as to dispose the long-chain, side-linked connected molecules in such manner as to extend out the sheet that either when the sheet is stretched around the reinforcing plate to form the envelope or when the fluid-tight envelope is distended by the pressure-fluid, the molecules of the elastomer are oriented into parallel lines consisting of the "long-chains" of the molecules connected by the side-link atoms with the parallel lines spaced apart transversely of the sheet. Running transversely of the plate.

The direction in which these long-chain molecules run is indicated in FIGURE 4 by arrows 34 extending transversely of a plate 35 substantially the same in configuration and location in the elastomer as described in connection with FIGURE 3 and having the same type of upwardly reflected edges 36. By virtue of this arrangement of the molecules, the amount of elastomer disposed between the edges of the plate and the exterior surface of the envelope at the side and end walls thereof may, if desired, be appreciably reduced. Or, if the amount of rubber is maintained as in the species of FIGURE 3 and the principle of molecular orientation also is employed, these features will enable the envelope to withstand an indefinitely large amount of cycling, regardless of the local initial elongations in the lower stratum, provided the bag sufficiently to fill out the working chamber and to form smoothly actuate the diaphragm of even the largest presses. In the event these two features are combined, the thickness of the lower stratum 32 adjacent the upper portion 20 and the recurved portion 20A is maintained as described with reference to these portions in FIGURE 3.

Thus, the power package is adapted to actuate forming diaphragms for successfully forming sheet metals of abnormally thick gage. As shown in FIGURE 6, the reinforcing plate may be constructed with either bulbous edges or filled tubes 37, which differ from the enlarged edges 17 of FIGURES 1 and 2 chiefly in that they lie entirely on the upper side of the reinforcing plate and extend inwardly from the edges thereof only a short distance. This plate may be employed in the manners explained in connection with either FIGURE 3 or FIGURES 4 and 5.

In FIGURE 7 there is shown a species of elastomeric fluid cell which is conceived along substantially the same principles as those aforesaid for efficiently and powerfully applying hydraulic force to a confronting diaphragm without liability to failure in the crucial flexure-regions, and, in addition to the above merits, incorporates the further advantage of being rather more easy and inexpensive to fabricate, and to enable
replacement of the elastomeric part of the cell with ease and rapidity when requisite. As shown, this cell comprises a rigid, substantially planar base sheet or liner 38 which has its peripheral edges either thickened or angled upwardly—preferably rectangularly—as shown at 39, the plate 38 having, as those before, a central fluid-aperture, not shown, surrounded by means, not shown, for suspensively attaching thereto and conductive means being substantially the same as those shown in FIGURE 5.

An elastomeric stratum 41 is configured for slipping over and around the peripheral edges of the liner 38 to serve as the distendible, or working, wall of the cell, somewhat in the manner of an "overshoe." To this end, member 41, at its periphery is provided with an inwardly curved marginal portion 42 adapted to conform tightly to both the inner and the outer faces of the lip 39 of the base plate, and to the upper surface of the base plate. The outer portion 43 of this recurred portion partakes of the nature of this portion in the aforedescribed cells and for the same purposes. The inner portion 44 is an anchoring portion and to this end is provided with corrugations 45 for engaging complementary corrugations 46 on the lip 39.

Further to secure the stratum 41 to the base plate, an annular member of resilient elastomer 67 is disposed on the upper face of the base plate with its outer periphery abutting the inner periphery of the elastomeric stratum 44. A lip 48 is provided on the lower face of the outer portion of the clamp and a complementary groove 49 is provided in the portion 44. Radially inwardly of the cell's periphery the clamp is provided with fastening bolts 51 which reach into the base plate.

The stratum 41, or elastic overshoe, can be easily fabricated in a suitable calendaring action while the base plate can be separately fabricated, the assembly of the two requiring little time and effort. A mold which can be employed to make the fluid-cell, that is, to form the elastomeric sheet around any of the aforedescribed plates and effect attachment of the upper face of the reinforcing plate to the neoprene, or other, envelope while leaving the lower face of the plate free of the elastomer shown in FIGURES 8, 9, and 10, and will be described in connection with its use in forming the cell of FIGURES 4 and 5.

Essentially, this mold comprises a pair of planeal, rigid members or rectangular plates 56, 57, arranged in mutual parallelism and maintained spaced vertically apart by a pair of transversely spaced longitudinally extending side rails 58, one on the inner faces and which are intersected at each of the opposite ends of the mold by one of a pair of end bars or gates 59. The side rails and end gates are mortised removably into recesses as shown in the adjacent surfaces of the plates 56, 57.

The upper plate includes a plurality of counterbored bores 61 through each of which connecting means, such as a bolt 62, may be passed into the interior of the mold. At positions on the upper face of core member 35 that correspond to the bores 61 there are welded or otherwise attached socket members 63 which include the threaded bores 64 into which the bolts 62 are reached. The central core, not shown, is disengageably or permanently engaged with the core plate 35 and its upper portion passes through a suitable aperture in plate 56.

Vents 65 are provided in the upper plate 36 of the mold at various locations lying inwardly some distance from the edges thereof. "Overflow" elastomer that will normally constitute "fashing" escapes through these vents. The outer upper edge of each side rail is bevelled to define an air and molding gas outlet mouth 66 which is connected, by means of a channel 67 defined between the space upper surface of the rail and the super-adjacent surface of the mold plate, with a vent or vents 68 traversing the upper arm of the C-shaped sides rails.

The vents 65 in the top plate and the end gates exhaust air and molding gases and excess viscous rubber from the central upper region and the ends of the mold and the vents 66, 67, and 68 in the side rails induce the air, molding gases and excess or overflow or "flash" elastomer emanating from the lower portion of the mold and seeking an exit to travel around the edges of the matrix from the bottom wall of elastomer to the top wall thereof. Thus, this excess elastomer is brought around the edges of the envelope and thickens them where needed instead of remaining at the bottom of the mold, which latter occurrence would result in the edges of the bag not having the proper thickness to resist flexures when the bag is being distended. In each side rail, as shown in FIGURE 9, at suitable longitudinally spaced locations on the center plane thereof there are provided a plurality of airtraps 69 which serve to receive and trap the small amounts of air and molding gases forced out of the edges of the envelope in the initial-compression stage of the molding operation.

Other upwardly exhausting vent openings, not shown, may be provided at various suitable locations in the upper plate of the mold, if desired.

In initiating the molding procedure, the lower plate of the mold is positioned on the steam heated plates of a ram-type hydraulic press, the ram head of which is also steam-heated and the side and end bars are assembled to the lower plate. The lower face of the liner or reinforcing and core plate is of such a smooth, planeal nature that it is incapable of frictionally adhering to the elastomer but the upper face of this plate is rendered frictionally adherent as by sand or vapor blasting. If desired, the engagement between this surface and the elastomer may be aided by an interposed layer of cemenitious material.

The lower stratum of the bag is thereafter calendared onto this lower plate with the molecules so arranged that upon stretching they will assume the oriented relationships ascribed, whereby the core plate 35 is positioned on top of this stratum and, after the upper elastomer stratum has been similarly calendared in place, is attached to the upper plate of the mold.

Battens are then laid across the upper plate of the mold and the heated ram-head of the press is pressurally engaged with these battens. Such engagement is maintained until the neoprene is integrated as an envelope around the core plate or liner and is united to the upper surface of the liner.

During these steps, the excess neoprene is flowed from the lower portion of the mold around the side edges and end edges of the unit and out the bleed holes except as above, thereby to assure the presence of a sufficient amount of elastomer at these crucial regions lying between the outer faces of the upturned edges of the core plate and the outer surface of the envelope at the end walls thereof.

It will be perceived that between the upper surface of the side rails and the super adjacent surface of the top plate of the mold a gap 67 is provided while the inner face of the top plate closely contacts the upper surface of the envelope. This arrangement enables the new viscous neoprene envelope to be compressed and molded to the matrix surfaces the desired amount.

The unit is thereafter removed from the mold, the small amount of "fashing" is removed and the cell is substantially ready for use.

It will be apparent that the cell shown in FIGURE 7 is not entirely dependent upon such mold and molding procedure for its fabrication. As aforesaid, its two major components can be separately fabricated in an obvious manner and then manually assembled to form a cell.

Although the cells illustrated all have more or less rectangular planforms, it is to be understood that departures from this shape are contemplated by the invention and in no wise alter its essential nature. For example,
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for use in fluid-cell operated diaphragm presses of the so-called kettle type, fully described in my co-pending application comprising a plurality of circular, vertically stacked laminae serving as working chambers, this invention applies its concepts to provide a circular form of fluid cell to fit in and operate in the circular chambers and which is otherwise substantially the same as the rectangular form of cell.

In FIGURES 1 to 10, the cell and mold have been shown as having the fluid ingress and egress means disposed centrally of the cell and mold. However, it is to be understood that for cases where the cell is to be employed with special types of hydro-press bodies, such as the one referred to in my co-pending application as the "bench-model" type of press wherein the body lacks a central aperture in the one side thereof and in which the fluid is entrained into and out of the one end of the body, the invention contemplates that the cell and mold be so configured as to dispose the fluid inlet and outlet aperture closer to the one end thereof. Thus, suitable piping for the pressure fluid may be led from the exterior to this non-centrally located aperture.

Although several physical embodiments of the fluid-cell and a number of the methods and apparatus for fabricating these cells have been shown and described in detail, it is to be definitely understood that such details in no wise limit the scope of the inventive concepts which is to be determined only by the ambit of the subjoined claims.

I claim:

1. An actuator, comprising: an expandible expasne of material; an expasne of more rigid material, having opposed major faces, arranged with a first one of said faces lying adjacent a major face of said expandible expasne; an annular flange projecting from the peripheral edge of a second one of said major faces of said more rigid expasne; friction-augmenting formations on the inner face of said flange and on the adjacent portion of said second major face; a corresponding annular projection of the inner face of said expandible expasne adapted to fit over said said flange and having formations adapted to frictionally engage the first-said formations; an annular shoulder on the inner edge of said annular projection of said expandible expasne adapted to facewise fit the second major face of said more rigid expasne; and flow-and-return fluid conducting means debouching onto the inner face of said expandible expasne.

3. A bag as defined in claim 2, wherein said membrane forms an acute bend about said peripheral edge, and further including a guard channel mounted exteriorly of and extending over said membrane at said peripheral edge and embracing said acute bend of said membrane.

4. An actuator, comprising: an expandible expasne of material; an expasne of more rigid material, having opposed major faces, arranged with a first one of said faces lying adjacent a major face of said expandible expasne; an annular flange having an arcuate outer face projecting from the peripheral edge of a second one of said major faces of said more rigid expasne; friction-augmenting formations on said second major face on the portion thereof inwarding of the inner face of the flange; a corresponding annular projection of the inner face of said expandible expasne adapted to facewise fit the said major face of said more rigid expasne; an annular clamp engaging said annular shoulder; releasable fastening-means passing through said clamp and into anchorage with said more rigid expasne; and flow-and-return fluid conducting means debouching onto the inner face of said expandible expasne.

5. An actuator, comprising: an expandible expasne of material; an expasne of more rigid material, having opposed major faces, arranged with a first one of said faces lying adjacent a major face of said expandible expasne; a flange having an arcuate outer face projecting from the peripheral edge of a second one of said major faces of said more rigid expasne; friction-augmenting formations on the inner face of said flange and on the adjacent portion of said second major face; a corresponding projection of the inner face of said expandible expasne adapted to fit over said said flange and having formations adapted to frictionally engage the first-said formations; a shoulder on the inner edge of said annular projection of said expandible expasne adapted to facewise fit the second major face of said more rigid expasne; clamp means engaging said annular shoulder; releasable fastening-means anchoring said clamp to said more rigid expasne; and flow-and-return fluid conducting means debouching onto the inner face of said expandible expasne.

6. The inflatable bag as defined in claim 2, wherein the peripheral edge and bend have smooth rounded outer surfaces whereby to preclude sharp bends at the outer periphery of the membrane when it is distended.

7. The inflatable bag as defined in claim 2 wherein that portion of the membrane fitting into the depression is enlarged in thickness and mass whereby to increase its strength to provide a stronger anchoring port.

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