April 29, 1969 H. T. HALL 3,440,687

MULTIANVIL PRESS

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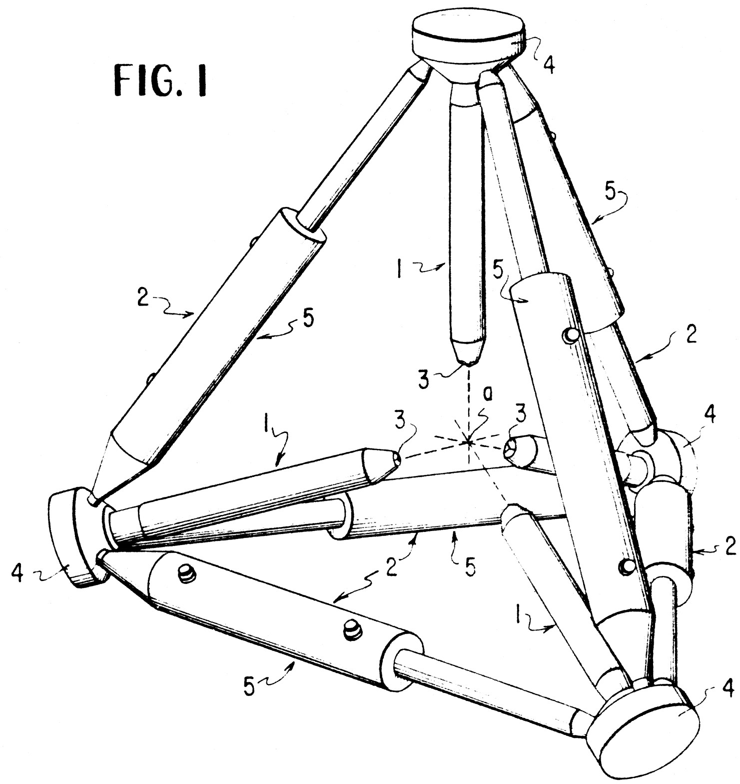
FIG. 1



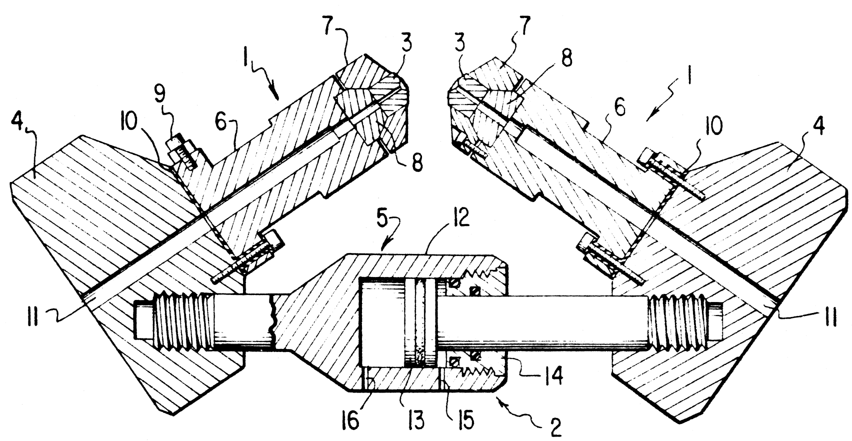


FIG. 2

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FIG. 3

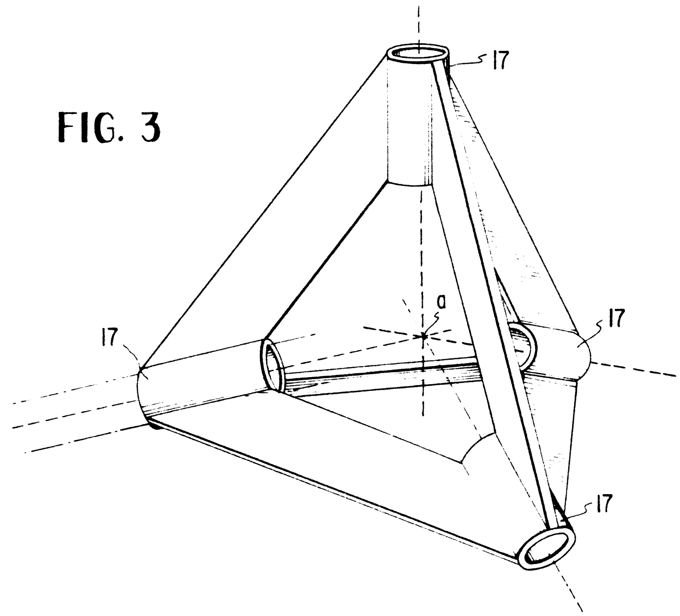
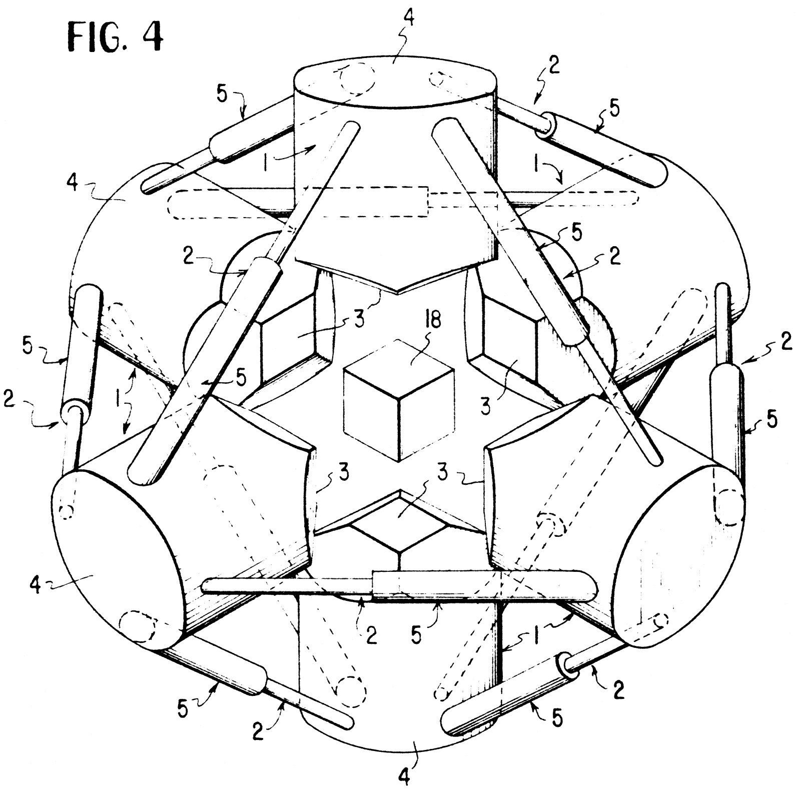


FIG. 4



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MULTIANVIL PRESS

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U.S. Cl. 18-16 5 Claims

ABSTRACT OF THE DISCLOSURE

A multiaxial press has a plurality of press members each having at one end an anvil face corresponding to a face of a polyhedron and arrayed with their anvil faces inwardly directed toward a common point and retractible guide means connecting the outer ends of adjacent press members to maintain the array and to urge the press members along rectilinear paths toward the common point upon retraction of the guide means. The retractible guide means may incorporate pull-type hydraulic rams or other power devices.

The invention relates to multiaxial presses and particularly to such presses wherein a plurality of press members are guided and urged into pressing relation along a plurality of rectilinear axes by means of retractible guide means interconnecting the outer ends of the press members.

The prototype multianvil high pressure apparatus, a tetrahedral press, was described in U.S. Patent 2,918,699. In multianvil presses the moving pressure inducing element usually consists of a relatively incompressible body that has a generally prismatic-shaped working end called an anvil. Anvils are commonly constructed of cemented tungsten carbide, the most resistant material to breakage by compression currently available. Simple tetrahedral anvils are shown in this patent. The anvils depicted, which have triangular faces and sloping shoulders on the working end, will fit together when moved inwardly along the tetrahedral axes. When so fitted, they completely enclose a regular tetrahedral void. The anvils of a multianvil press are thrust together by mechanical, hydraulic, or other means.

To generate pressure the anvils impinge (in a symmetrical manner along the tetrahedral axes) upon a tetrahedral cell. The triangular faces of the tetrahedral cell are larger in area than the corresponding faces of the anvils. As the anvil faces push against the cell faces, edges of the "oversize cell" are extruded into the spaces between parallel sloping shoulders. This automatically forms a "gasket." With continued advance of the anvils, the gasket compresses, yields, flows, extrudes and dynamically achieves a balance between frictional, pressure, and other forces to seal and provide for pressure build-up within the tetrahedral cell. Nominal pressure of 100,000 atmospheres (1,500,000 p.s.i.) are readily achieved within the tetrahedral cell in actual devices.

The cell is usually constructed of a fine-grained solid substance with proper frictional, compressional, thermal, electrical and chemical characteristics. An oft-used cell material is the hydrous aluminum silicate mineral pyrophyllite, which is known in the trade as grade A lava or wonderstone. The tetrahedral cell is cut apart and/or drilled to provide cavities for the sample, electrical heaters, thermocouples, and other bodies. The dismembered cell is then cemented back together to enclose the sample and other desired elements. A resistance furnace within the cell makes it possible to readily achieve a 2000º C. temperature simultaneously with the 100,000 atmosphere pressure. In some instances it is desirable to utilize preformed gaskets along the six edges of the tetrahedral cell rather than have the gaskets automatically formed.

Although the simple tetrahedral anvils described in U.S. Patent 2,918,699 are the most commonly used, it is sometimes desirable to depart from the "perfect or exact fit geometry" of the prismatic ends. Thus edges and/or surfaces may be rounded (concavely or convexly), the angle of the sloping shoulders with respect to the face may be varied or may be sloped at one angle for a distance and then at another angle for an additional distance, or the shoulder form may be curved or contoured. The same is true for the form of the face. These modifications give anvils that fit imperfectly together with respect to the manner in which the simple anvils fit. In other words, the shoulders of the anvils do not contact each other over their entire surfaces when the anvils are brought together without a cell being present. Also, the "void" formed by the anvils in contact may only approximate the shape of a tetrahedron. In addition, the void may not be totally enclosed by the contacting anvils. Modified anvils, by achieving a more delicate balance of the forces and other factors involved in pressure generation, have made it possible to obtain pressures considerably beyond 100,000 atmospheres. Regular tetrahedral cells may be used with modified anvils, although it is often preferable to use cells conforming to the shape of the anvil ends. Molded, inorganic and filled plastic cells conforming to the exact shape of the working ends of the anvils have been extensively used in the Brigham Young University High Pressure Laboratory. Such cells have been used with and without molded, preformed gaskets.

Other cell geometrics than the tetrahedron of U.S. Patent 2,918,699 may be used such as higher order regular or irregular polyhedra, including the cube and the octahedron, as well as prismatic cells such as are described in U.S. Patent 3,159,876 and the principles of the present invention are applicable to presses with polyhedral cells of such geometrics.

A major improvement in multianvil presses came with the invention of the anvil guide described in U.S. Patent 3,182,353. This device synchronizes and coordinates the motion of the anvils so that they advance uniformly and simultaneously toward the center of the press. It also eliminates anvil alignment problems that were present in early presses. The anvil guide, however, ordinarily occupies considerable space in the vicinity of the anvils and reduces the working room there. This presents problems when certain equipment (such as an X-ray diffractometer, an external heating furnace, or a cooling system) is used in conjunction with an anvil press, because the guide mechanism is in the way. An anvil guide mechanism was not used in the hydraulically actuated X-ray diffraction press described in U.S. Patent 3,249,753. Rather each hydraulic ram was individually valved for ingress and egress of hydraulic oil and anvil position was monitored by means of dial indicator gages. Coordination of anvil motion was manually controlled by the operator as was done in the early tetrahedral presses. The improved multianvil. press of this invention provides new means for synchronizing and coordinating anvil motion and provides for open space in the vicinity of the anvils.

In the multiaxial press construction of the invention the fixed tie-bars and the ram or jack devices mounted on the bases of the anvil-face press members as described in U.S. Patents 3,159,876 and 3,182,353 are replaced by retractible members interconnecting the bases of the press members. In effect, the rigid tie bars of the earlier constructions are replaced by retractible members including pull type devices which replace the ram or jack devices in the bases of the press members of the earlier constructions.

The number of press members is the same as the number of faces in the polyhedron defined by the anvil faces and the number of retractible guides is the same as the number of edges in the polyhedron.

Preferably each retractible guide is positioned with its axis in the median normal plane to the edge of the polyhedron defined by the anvil faces of the adjacent press members connected by such guide and is affixed at either end thereof to the bases of such adjacent press members.

This combination of the guiding and pressure exerting functions in a single element has many advantages which will be more particularly pointed out hereinafter.

Illustrative embodiments of the multiaxial press construction of the invention will be described with reference to the accompanying drawings in which:

FIG. 1 is a diagrammatic representation of a tetrahedral press embodying the principles of the invention;

FIG. 2 is a representation in partial section of two adjacent press members and connecting retractible tie members of a tetrahedral press of the type shown in FIG. 1;

FIG. 3 is a representation of a guide frame which may be used in a press of the type shown in FIG. 1; and

FIG. 4 is a diagrammatic representation of a hexahedral (cube) press embodying the principles of the invention.

In FIG. 1, the press members generally designated 1 and the guide members generally designated 2 have been shown stretched out along their major axes for greater clarity. The press members carry at their inner ends triangular anvil faces 3 and are arrayed with their longitudinal axes directed to the common point a which is the center of the tetrahedron defined by the anvil faces. The press members are maintained in this array by the guide members 2 interconnecting adjacent press members at their bases 4 and are urged toward common point a by means of retraction devices 5, which may be pull type rams more fully described in connection with FIG. 2.

In FIG. 2. the press members 1 are shown as comprising posts 6 attached to bases 4 and carrying anvils 3 secured to the inner end of stems 6 by means of binding rings 7 and back-up blocks 8. 9 is a binding post for electric connection to the anvil and 10 represents insulating material for electrically insulating the anvil ends of the press members from the bases. The elements of the press members are provided with access holes through which X-rays, for example, may be directed at the material under pressure between the anvil faces. The retraction device 5 of the guide means 2 comprises cooperating cylinder element 12 and piston element 13 passing through a sealed aperture in cylinder lid 14. Pressure fluid may be supplied through aperture 15 for retracting and through aperture 16 for extending the guide members. The supply of pressure fluid to all of the rams 5 of the press simultaneously from a common source ensures a uniform distribution of forces in the press.

Design principles for high pressure rams of the type shown in FIG. 2 are fully discussed in The Review of Scientific Instruments 37, 568-571 (May 1966).

Additional guide means of the type shown in FIG. 3 may be provided, if desired, to improve the precision of anvil motion. While the idealized mechanical restraints imposed by the geometry of the construction shown in FIG. 1 ensures perfect alignment and motion of the anvils, practical consideration of machining tolerances, clearances of sliding fits in the rams and friction may allow too much anvil position error for very exacting experimental situations. In such cases the simple geometrically redundant guide structure of FIG. 3 is of value. The bearing ways 17 fit around the anvil posts of the press members at a distance sufficiently removed from the anvils to be out of the way. As the anvils move in and out from the common point a of the press the anvil posts slide in the bearing surfaces of way 17. These bearing surfaces may be electrically insulating. Similar structures may be used with polyhedral presses of other geometries such as cubic, octahedral and prismatic.

FIG. 4 diagrammatically illustrates the principles of the invention as applied to a hexahedral or cubic press geometry. In the figure, 18 diagrammatically represents the cubic cell while the elements of similar structure and operation to those of FIG. 1 are designated by the same reference numerals. It has six press members 1 and twelve retractible guides 2.

While hydraulic ram devices are shown in the drawings as actuating means for the retractible guides other actuating means such as mechanically or electrically powered devices may be used without departing from the principles of the invention.

The following discussion indicates some of the advantages of the presses of the invention.

In multianvil presses it is usually desirable to electrically isolate the anvils from each other in order that the anvil faces may serve as electrical connectors to resistance heating elements or other devices located within the pressure cell. This has usually been accomplished by placing insulation as shown in FIGS. 7 and 8 of U.S. Patent 2,918,699. In the present arrangement, it is desirable to place the electrical insulation at the bottom of the anvil post. This moves the insulation away from the anvil region where unit compressive stresses are high and places it in a location where the loading per unit area upon the relatively soft plastic laminates used for electrical insulation can be reduced. With this accomplished, all components in the anvil region can be constructed of metal. This makes it possible to heat the anvils (and consequently the enclosed pressure cell and its contents) by an external furnace without burning or overheating the plastic electrical insulation. It is desirable to construct the anvil post of a low thermal conductivity material, such as stainless steel, to provide a favorable situation for either heating or cooling the anvils by external means. In the latter instance, liquid nitrogen or other coolant can be circulated around the anvils to perform experiments at low temperatures. The size and mass of an anvil post is much less, of course, than that of a hydraulic ram. Consequently, the anvil region can more easily be heated or cooled without excessive transfer of heat. Also, the post can more readily be constructed of a low thermal conductivity material than can an entire ram. In addition, the anvil post can be relatively long and slender, thus providing a long heat path. A push-type ram must, of necessity, be rather bulky and constitutes a large heat sink.

Another advantage of the presses of the invention is the fact that the bases (4 of FIG. 2) can be considerably reduced in diameter and thickness over that required in a conventional press where a push-type ram is mounted on the base. The push type ram, being much larger in diameter than the post of FIG. 2, requires a correspondingly larger diameter base. This requires the tie bar ends to be fastened to the base at a greater distance from the base center line. Thus, a thicker base must be used to give the same support. The decreased size of the bases in the press of the invention allows the threaded ends of the tie bars (or the ends of other style fasteners) to be moved in closer to the center lines of the axes of the press members.

FIG. 2 shows an access hole 11 extending from the bottom of the base through the anvil post, the back-up block, and the anvil, on into the sample. Similar access holes have been described for providing means for entrance of an X-ray beam to the sample in the tetrahedral of U.S. Patent 3,249,753. However, because of the fact that a hydraulic ram was mounted on the base, the ram piston had to be hollowed and access from outside was through a section of the piston perpendicular to the ram axis followed by a section along the ram axis. In other words, the path from the outside traversed a right angle bend before reaching the sample. Additional complications arose because of the limited hollowed-out space available in the piston of the ram and also from the fact that the piston moved with respect to a stationary cylinder. In contrast to this the "line of sight" access hole in the presses of the invention is simple and uncomplicated. In the prior art press the X-ray tube had to be mounted directly inside a moving ram in a crowded, inconvenient, complicated manner. In the presses of the invention X-ray tubes or other appliances can be mounted on the bottom of a base, outside the press, where there is plenty of room for arranging the various parts.

Some comparisons between the presses of the invention and prior designs for tetrahedral and cubic presses are of interest. Consider, for example, a prior art 200 ton tetrahedral press. This is a common research size instrument in which each of the four push-type rams is of 200 ton capacity. In a tetrahedral press of the invention of the same capacity, the six pull-type rams would each be of 82 ton size. When the six rams are each exerting an 82 ton pull on the connecting bases, geometry dictates that the thrust along the anvil post axes equals 200 tons (the same as the thrust of the 200 ton push rams located on equivalent axes in a prior art design). The total ram tonnage for such a press would be 6 X 82=492 tons compared to 4 X 200=800 tons for a prior art tetrahedral press.

Now consider a 200 ton cubic press. The prior art design would use six push-type rams of 200 tons each (total tonnage is 6 X 200=1200). The press of the invention uses 12 each, 71 ton pull-type rams (total tonnage is 12 X 71=852) to accomplish the same purpose.

I claim:

1. A multiaxial press comprising a plurality of press members each having at one end an anvil face and arrayed with their anvil faces inwardly directed toward a common point, and telescopic retractible guide means interconnecting the outer ends of adjacent press members to maintain said array and to urge said press members along rectilinear paths towards said common point upon telescopic retraction of said guide means.

2. A multiaxial press as defined in claim 1 wherein each of said retractible guide means includes a pressure-fluid actuated device for effecting retraction thereof,

3. A multiaxial press as defined in claim 2 including means connecting the pressure-fluid actuated devices to a common source of pressure -fluid.

4. A multiaxial press as defined in claim 1 wherein the anvil faces of the press members define a polyhedron when urged into contact.

5. A multiaxial press as defined in claim I wherein the anvil faces of the press members define a regular polyhedron when urged into contact.

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