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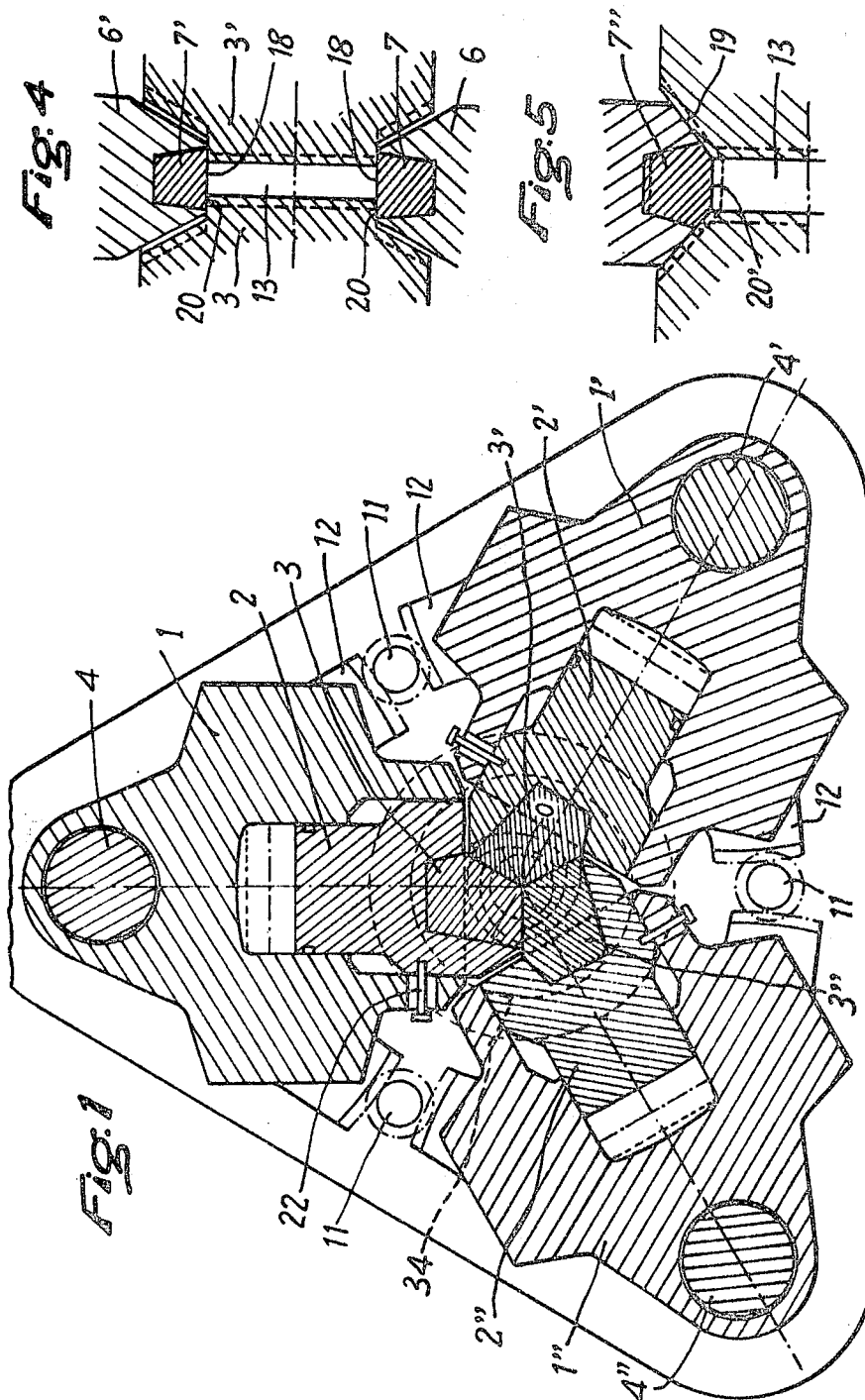
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APPARATUS FOR PRODUCING VERY HIGH PRESSURES

Filed Oct. 16, 1967

3 Sheets-Sheet 1



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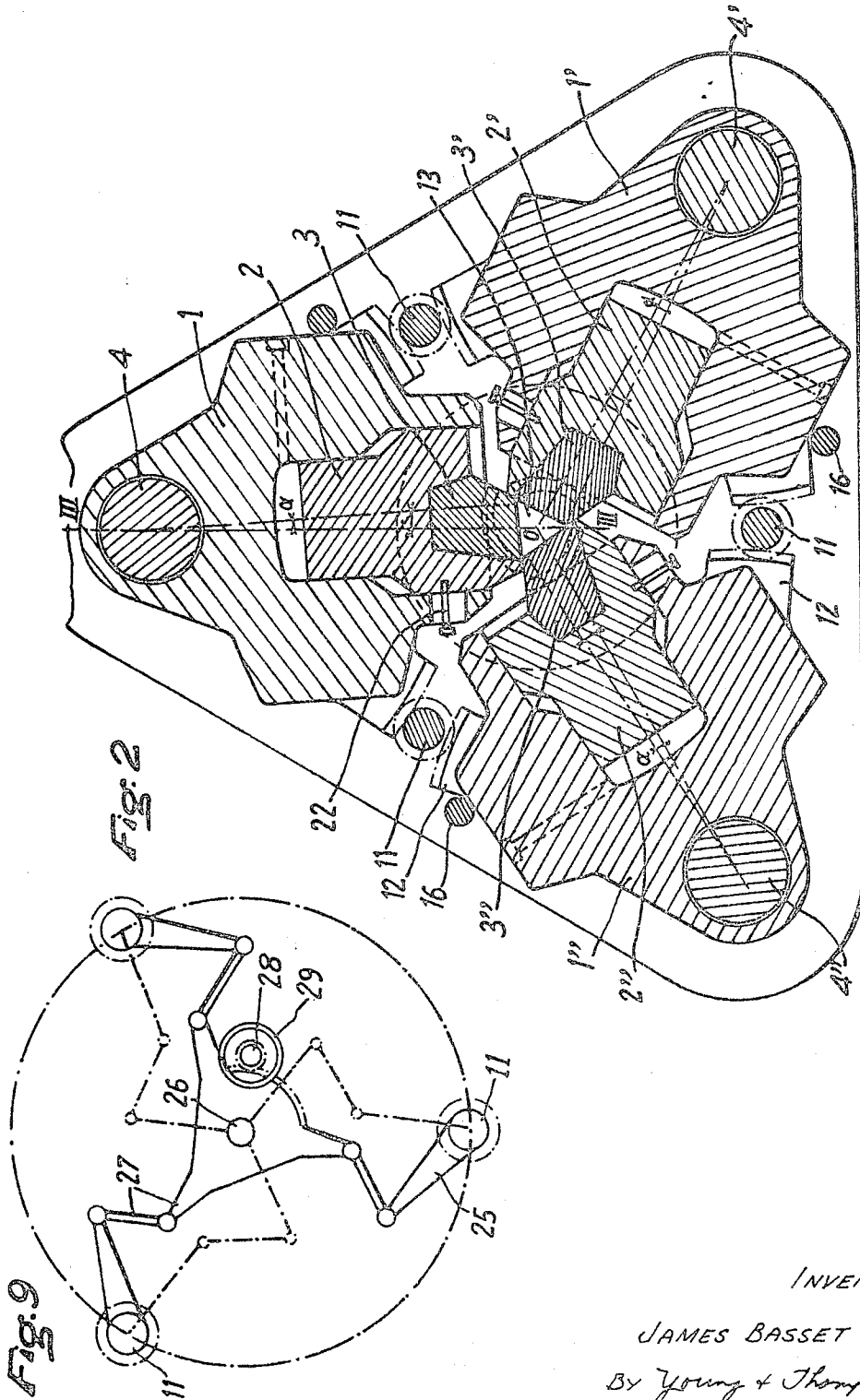
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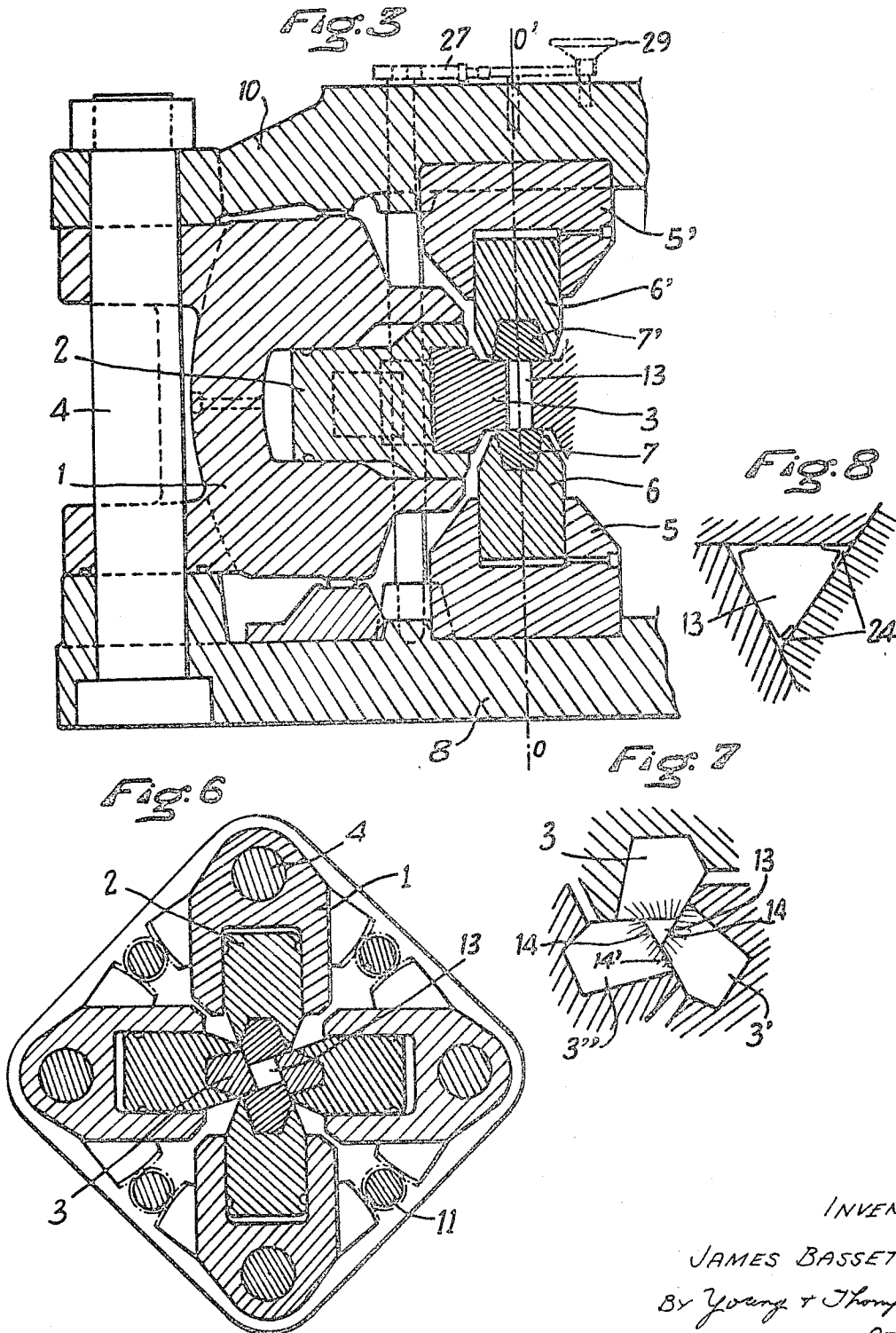
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APPARATUS FOR PRODUCING VERY HIGH PRESSURES

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12 Claims

ABSTRACT OF THE DISCLOSURE

An apparatus for producing very high pressures for search or industrial purposes wherein the compression chamber, preferably in the shape of a prism with a regular polygonal outline, has its sides defined by anvils controlled by pivotally mounted jacks which are advantageously arranged radially of the cross-section of the chamber. The terminal operative surface of each anvil is slidingly engaged by a lateral surface of the next anvil forming an angle with the terminal surface of the latter, whereby the free area of the first-mentioned terminal surface forming one side of the chamber varies upon operation of the jacks which is of necessity associated with a slightly pivotal movement of the latter. This ensures a homothetical contraction of the chamber enclosed between the terminal surfaces of the anvils, substantially down to zero if required.

My invention has for its object an apparatus of a simple structure which allows enclosing between surfaces sliding with reference to each other an inner chamber of a volume adapted to gradually decrease down to substantially zero value, in which chamber it is thus possible to compress a mass of material under a very high pressure without any possible extrusion thereof.

Such a result cannot be obtained through the arrangements known hitherto, such as tetrahedric presses or apparatus provided with frusto-conical pistons since, in such prior arrangements it is necessary to leave, between adjacent surfaces of the thrust-exerting anvils entering the inner chamber, gaps which are all the larger when the material to be compressed is more readily compressible, so that said material is liable to extruded along said gaps, whereby the area subjected to compression is increased and the whole arrangement is speedily locked. In fact, the desired pressure should be obtained at the actual moment at which it is no longer possible to reduce the compressed volume any more. Such prior arrangements require furthermore an accurate and difficult machining.

Various embodiments of arrangements providing an inner chamber, the volume of which can be reduced by means of anvils sliding with reference to each other, have already been proposed, but said embodiments are subjects to the difficulty of producing a simultaneous lateral shifting of the jacks which is required for ensuring a permanent contact between the anvils and the parallel sliding of their surfaces as said anvils progress inwardly. All the arrangements proposed hitherto for removing said difficulty require very intricate mechanism, which makes it a difficult matter to reach the inner chamber.

My invention removes these drawbacks very simply by resorting to jacks pivotally secured round stationary axes constituted by uprights absorbing the thrusts exerted by the jacks; said fitting of the jacks allows an angular shifting of the jacks round their axes and consequently a permanent parallelism between the contacting sliding

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surfaces of the cooperating anvils controlled by said jacks and defining the volume of the inner compression chamber.

The execution of the parts of my improved apparatus and their assembly is a very simple matter and requires only an ordinary accuracy of manufacture, the jacks being allowed to rotate freely round their axes, whereby it is easy to reach the anvils and the inner chamber for replacing or upkeep purposes.

The pistons of the jacks carry anvils provided with plane surfaces defining the regular polygonal outline of the central prismatic chamber forming the compression chamber, each plane surface forming with the following adjacent surface of the same anvil an angle of a predetermined value which is the same for all the anvils.

In a preferred embodiment, wherein the axes of the jacks are coplanar and uniformly distributed round the central chamber in a horizontal radial plane, said angle is equal to 360° divided by the number of jacks considered, that is 120° in the case of three horizontal jacks.

In the preferred embodiment wherein three identical horizontal jacks, preferably double-acting jacks, are used, said axes all pass from the theoretical position of the jacks corresponding to an inner chamber reduced to zero, through the geometrical vertical axis of said chamber towards which they converge.

The jacks are advantageously held between two general crossbeams by vertical uprights absorbing the thrusts and ensuring together with said absorption of the thrust the securing and free rotation of the jacks round the axes of said uprights.

The thrusts exerted by the jacks cause the adjacent anvils to slide over each other along their interengaging surfaces as allowed by the simultaneous angular shifting of the axes of the jacks, which leads to a homothetical reduction of the cross-section of the central inner chamber.

The longitudinal restraint of the central chamber is ensured by axial jacks extending perpendicularly to the plane of the radial jacks, the terminal surfaces of the anvils controlled by said axial jacks closing the upper and lower terminal surfaces of the prismatic chamber defined laterally by the anvils of the radial jacks. Said terminal surfaces may either be flat surfaces, slidably engaging cooperating transverse surfaces of the radial anvils which have been machined correspondingly or else the surfaces of a frustrum of a pyramid engaging plane surfaces formed with corresponding slopes on the different radial anvils.

There are illustrated by way of example in the accompanying drawings two embodiments of the invention. In said drawings:

FIG. 1 is a horizontal cross-section of an apparatus including three horizontal jacks controlling the three anvils defining a compression chamber in the shape of a vertical triangular prism, the apparatus being illustrated at the end of its compressional operation, that is with the volume of the chamber reduced practically to zero.

FIG. 2 is a cross-section similar to FIG. 1 showing the same apparatus at the beginning of an operation, that is with a maximum chamber volume corresponding to an angular shifting of the three jacks round their vertical axes with reference to their concurrent position illustrated in FIG. 1.

FIG. 3 is a partial vertical cross-section through line III—III of FIG. 2 illustrating one of the horizontal radial jacks and two restraining jacks acting on the transverse upper and lower ends of the chamber.

FIGS. 4 and 5 illustrate with greater detail two different arrangements of the anvils controlled by the restraining jacks.

FIG. 6 is a horizontal cross-section of an embodiment of the invention including a compression chamber in the shape of a square vertical prism defined by four anvils controlled by four horizontal jacks extending substantially at right angles with reference to each other.

FIG. 7 is a diagram illustrating the distribution of the stresses within the mass of the anvils and allowing their speedy absorption.

FIG. 8 illustrates diagrammatically the possible incorporation of extrusion-arresting troughs along the inner corners of the compression chamber.

FIG. 9 illustrates diagrammatically an arrangement which allows if required angularly shifting the radial anvil-controlling jacks out of their operative positions back into inoperative positions.

In the example illustrated more particularly in FIGS. 1 to 9, the central compression chamber 13 in the shape of a triangular prism is bounded laterally by three movable walls formed by the anvils 3, 3', 3'' made of a very hard material. Said anvils are fitted in the pistons 2, 2', 2'' of the horizontally extending jacks 1, 1', 1'' adapted to urge the pistons forwardly with their anvils so as to reduce the cross-sectional area of the chamber 13. The body of each jack can pivot round the stationary uprights 4, 4', 4'' held between the lower general cross-beam 8 and the general upper cross-beam 10. Said uprights 4 are all located at the same distance from the vertical axis 0-0' of the chamber 13 and the radii connecting said axis 0-0' with the axes of the different uprights are distributed uniformly in a horizontal plane, i.e. in the case illustrated at 120° from each other.

The whole arrangement is symmetrical with reference to the axis 0-0' and its assembly is easily executed. The jacks illustrated diagrammatically as single acting jacks are preferably double acting, so as to further the return movement of their pistons.

The axes of the uprights 4, 4', 4'' are spaced with reference to the axis 0-0' of the compression chamber by a distance such that it is an easy matter to reach the anvils for upkeep or replacement when required and to introduce the material to be compressed inside the compression chamber.

As apparent from FIG. 2 and more clearly from FIG. 7, the terminal surface 14 of each of the anvils defining the polygonal outline of the central chamber 13 is followed by an adjacent surface 14' in contacting engagement with the plane of the terminal surface 14 of the next anvil, said adjacent surfaces 14-14' forming with each other in the case illustrated of three concurrent jacks an angle of 120°. Thus, the thrust exerted by each jack and leading to an angular shifting of said jack with its piston and anvil constrains the adjacent surfaces 14' to slide along the surfaces 14 of the adjacent anvils, while the axes of the jacks move angularly by an amount such that the interengaging sliding anvil surfaces remain parallel in perfect contacting relationship, whereby the polygonal outline of the central chamber shrinks and closes homothetically down to the desired minimum which may approximate zero (FIG. 1) without any risk of extrusion between the contacting surfaces 14 and 14' of the adjacent anvils leading to each corner of the chamber.

The terminal surfaces of the anvils may be perpendicular to the line of thrust of the corresponding jacks or else form a slight angle with said line of thrust so as to produce a reaction in a lateral direction furthering the contact between the interengaging anvil surfaces to be considered. In all cases, the surfaces 14 and 14' of an anvil always form together an angle equal to that formed by the axes of the successive corresponding jacks, in the present case equal to 120°.

Starting from the position illustrated in FIG. 2 where it is assumed that the central chamber is filled with the material to be treated, it is apparent that the axes of the jacks are shifted during operation by a same angle α with reference to the radii connecting the axis 0-0' of the

chamber with the pivotal axes of the jacks round the uprights 4. Since the thrusts are in principle exerted equally and simultaneously by the jacks, the different anvils progress each by urging transversely the adjacent anvil, the terminal surface 14 of which is in contact with its lateral surface 14'. This leads to a simultaneous sliding movement of the anvils along each other, which reduces gradually the cross-sectional area of the chamber, theoretically down to zero, as illustrated in FIG. 1, without at any moment the anvils moving apart. This ensures the compression of the material contained inside the chamber 13, the axes of the jacks crossing them substantially the vertical axis 0-0' of the chamber 13.

The expansion of the chamber is performed through a sliding and receding movement in the opposite direction of the anvils and of the jacks which are interconnected in the manner disclosed hereinafter, the chamber increasing in volume homothetically up to a maximum illustrated in FIG. 2 and defined by a bearing of the jacks against the stationary lateral stops 16, the axes of the jacks forming then against an angle α with the position illustrated in FIG. 1.

In the direction of the axis 0-0' perpendicular to the plane of operation of the jacks, the chamber 13 is closed at both ends by restraining means including a lower jack 5 and an upper jack 5', the pistons 6, 6' of which, preferably double acting jacks carry anvils 7, 7' closing permanently the lower and upper ends of the chamber 13.

In the case illustrated in FIG. 4, the anvils 7, 7' terminate with flat surfaces 18 engaging permanently the comparatively broad horizontal surfaces 20 formed on the anvils 3, 3', 3'' of the radially extending jacks at the ends of the chamber 13. During the radial shifting of the anvils 3, 3', 3'' between the position illustrated in dotted lines and that illustrated in solid lines, said anvils slide through their surfaces 20 along the corresponding surfaces 18 of 7, 7' so as to close fluidtightly the ends of the compression chamber.

The modification according to FIG. 5 intended in principle for the case of very high pressures includes restraining anvils, each in the shape of a frustum of a pyramid 20', each surface of which registers with a corresponding radial anvil, provided with an oblique surface of same slope 19. During the compression, the progression of the radial anvils between the position illustrated in interrupted lines and that illustrated in solid lines urges the axial anvils 7'' slightly inwardly of their jacks, perfect fluid-tightness being ensured by the permanent contact between the surfaces of the pyramid and the corresponding surfaces of the radial anvils.

It is important that during the operation of the apparatus the axes of the jacks move simultaneously by a same angle so that the anvils may progress by equal amounts. To this end, three control pinions of which the spindles 11 are held between the two cross-beams 8 and 10, are arranged symmetrically at the same distance from the axis 0-0' and between and at equal distances from the axes of the adjacent uprights 4, 4', 4''. Said pinions mesh with similar toothed sectors 12 rigid with one of the adjacent jack bodies. Said gearing obviously constrains the radially extending jacks to pivot at any moment through equal angles and consequently the cross-sectional area of the chamber to contract and expand homothetically in spite of the mechanical imperfections or possible stresses.

Said arrangement may be replaced by any other mechanical arrangement, for instance by shackles substituted for said gearing.

FIG. 9 illustrates an advantageous embodiment of mechanical means adjusted to control simultaneously the pivotal movements of the jacks and comprising a central toothed sector 26 coaxial with the axis 0-0' of the central chamber and controlling the three pinions carried by the spindle 11 through the agency of the pivotal levers 25 and pivotal links 27. Thus, by acting on the hand-wheel 29 and consequently on the pinion 28 meshing with

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the central pinion 26, the pinions 11 are caused to rotate by equal amounts together with the jacks. The stops 16 are removable and the links 27 are disconnectable so as to allow a free pivotal movement of the jacks beyond their normal operative paths.

In FIGS. 1 and 2, the axes of the jacks cross the ridges of the terminal surfaces of the corresponding anvils but they may as well pass through any other portion of said surface in order to improve in particular the mutual contact between the cooperating anvil surfaces.

FIG. 7 shows an example of the position of the anvils at the end of the stroke under maximum pressure with a fanwise distribution of the stresses within the mass of the anvils, starting from the portion of the anvil surface subjected to pressure.

If the material to be compressed is very fluid, liquid for instance, it is possible to prevent any leak by fitting in the corners of the chamber between adjacent anvils small metal troughs 24, as illustrated in FIG. 8 or else the material to be compressed is enclosed inside a metal casing or a casing of plastic material, which ensures its restraint.

Verniers 22 (FIGS. 1 and 2) extending for instance through slots in the walls of the jacks, allow checking at any moment the position of the pistons and may serve possibly for controlling the progression of the anvils through adjustment for instance of the operative pressure or of the output of the pumps feeding the different jacks.

In order to reduce friction, the sliding surfaces of the anvils are preferably coated with a slight layer of a lubricant.

A slight taper may be given to the anvils so as to compensate for allowances in manufacture and elastic deformations. One or more anvils may be separated from the pistons and jack bodies by a very thin sheet of an electric insulating material whenever it is required to introduce large heating currents into the central compression chamber. It is also possible to form small grooves in the contacting surfaces of the anvils for the passage of electric wires into the compression chamber.

What I claim is:

1. An apparatus for producing very high pressures within a compression chamber extending along a predetermined axis, said apparatus comprising at least three stationary pivots, a jack adapted to rock round each pivot and including a piston facing said predetermined axis through its outer end and adapted to move towards and away from the latter, an anvil rigid with the outer end of the piston of each jack, said anvils being each bounded outwardly by a flat terminal surface forming one of the successive sides of a polygonal outline defining the compression chamber and a flat surface following said terminal surface at an angle therewith and slidably engaging the terminal surface of the next anvil to an extent corresponding to the position assumed by the piston and anvil upon operation of the different jacks and consequent angular shifting of the latter round their pivots, said sliding engagement defining the free area of each side of the polygonal outline formed by each terminal anvil surface.

2. An apparatus as claimed in claim 1, wherein the axes of the pivots of the jacks are all parallel with the predetermined axis and are distributed uniformly round the latter at equal distances therefrom.

3. An apparatus as claimed in claim 1, wherein the axes of the pivots of the jacks are all parallel with the predetermined axis and are distributed uniformly round the latter at equal distances therefrom, said apparatus comprising furthermore two restraining jacks including pistons adapted to move along the predetermined axis towards and away from the corresponding ends of the compression chamber and anvils carried by last-men-

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tioned pistons and urged thereby into permanent closing relationship with reference to said chamber.

4. An apparatus as claimed in claim 1, wherein the axes of the pivots of the jacks are all parallel with the predetermined axis and are distributed uniformly round the latter at equal distances therefrom, said apparatus comprising furthermore a mechanism interconnecting the jacks and including stationary spindles parallel with the predetermined axis and extending each between two jacks, a pinion carried by each spindle and toothed sectors rigid with the jacks lying to either side of each pinion and meshing with the latter to synchronize the pivotal movements of said jacks.

5. An apparatus as claimed in claim 1, wherein the axes of the pivots of the jacks are all parallel with the predetermined axis and are distributed uniformly round the latter at equal distances therefrom, said apparatus comprising furthermore shackles interconnecting each two jacks to ensure synchronization of the pivotal movements of the latter.

6. An apparatus as claimed in claim 1, wherein the axes of the pivots of the jacks are all parallel with the predetermined axis and are distributed uniformly round the latter at equal distances therefrom, said apparatus comprising furthermore a disconnectable mechanism interconnecting the jacks and adapted to synchronize the pivotal movements of the latter.

7. An apparatus as claimed in claim 1, wherein the terminal surfaces of the anvils are perpendicular to the axes of the corresponding jacks.

8. An apparatus as claimed in claim 1, wherein the terminal surfaces of the anvils are oblique with reference to the axes of the corresponding jacks.

9. An apparatus as claimed in claim 1, wherein the axes of the pivots of the jacks are all parallel with the predetermined axis and are distributed uniformly round the latter at equal distances therefrom, said apparatus comprising furthermore two restraining jacks including pistons adapted to move along the predetermined axis towards and away from the corresponding ends of the compression chamber and anvils carried by last-mentioned pistons and the terminal flat surfaces of which are urged permanently into closing relationship with reference to corresponding coplanar transverse surfaces formed on the different first-mentioned anvils.

10. An apparatus as claimed in claim 1, wherein the axes of the pivots of the jacks are all parallel with the predetermined axis and are distributed uniformly round the latter at equal distances therefrom, said apparatus comprising furthermore two restraining jacks including pistons adapted to move along the predetermined axis towards and away from the corresponding ends of the compression chamber and anvils carried by including each a terminal frustum of a pyramid the sides of which are urged permanently into closing relationship with reference to corresponding sloping surfaces formed on the different first-mentioned anvils.

11. In an apparatus as claimed in claim 1, the provision of troughs fitted in the compression chamber across the joints between any two successive anvils.

12. In an apparatus as claimed in claim 1, the provision of fluidtight plastic linings for the anvils.

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WILLIAM J. STEPHENSON, Primary Examiner

U.S. Cl. X.R.