Feb. 21, 1961 J. L. McRAE ET AL 2,972,249

KNEADER COMPACTOR

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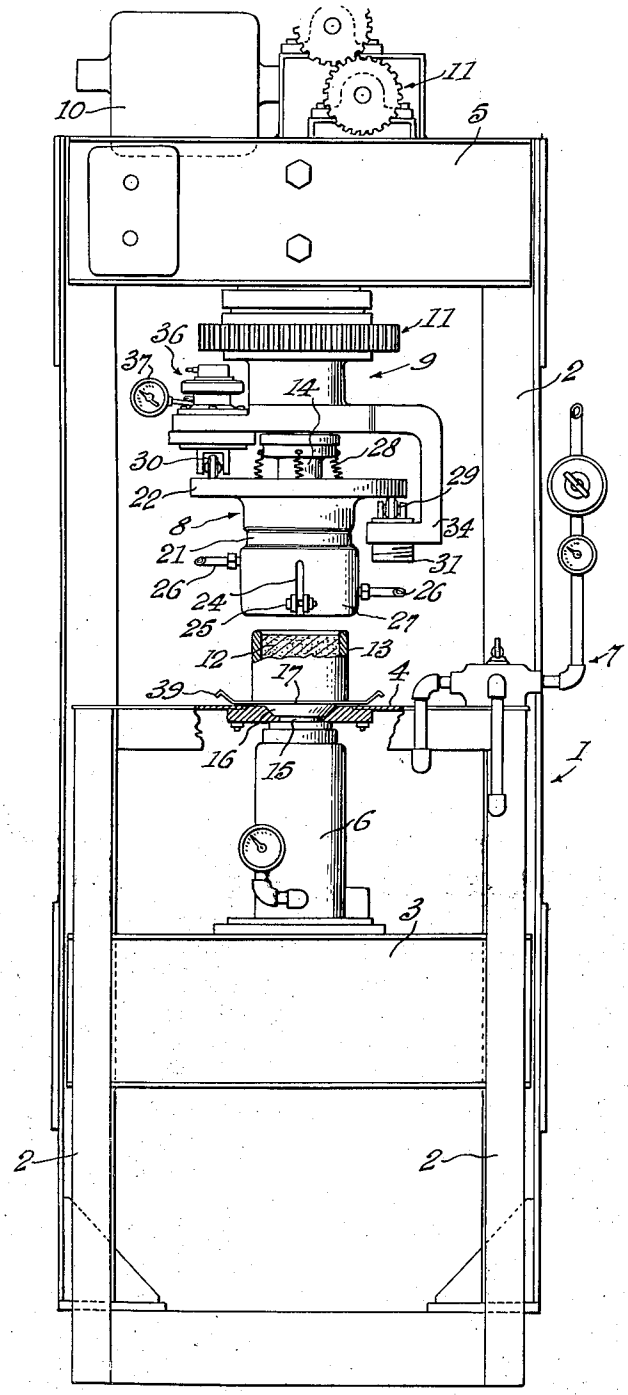


Fig. 1.

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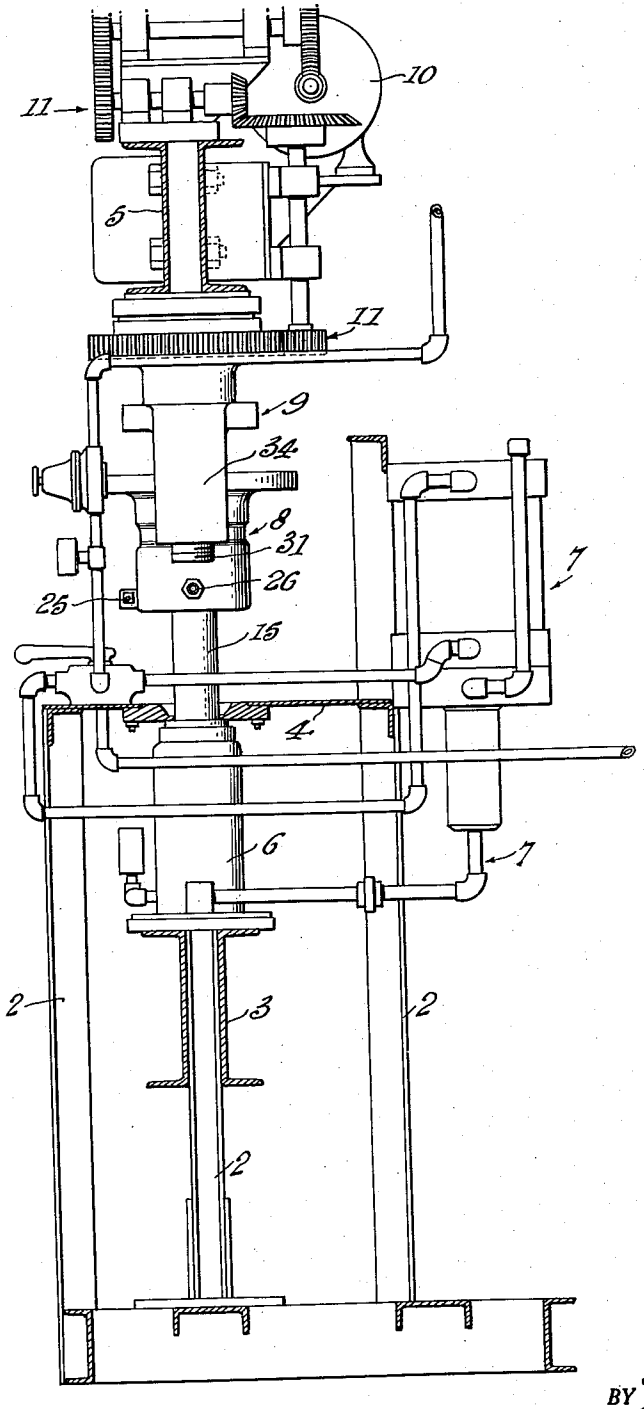


Fig.2.

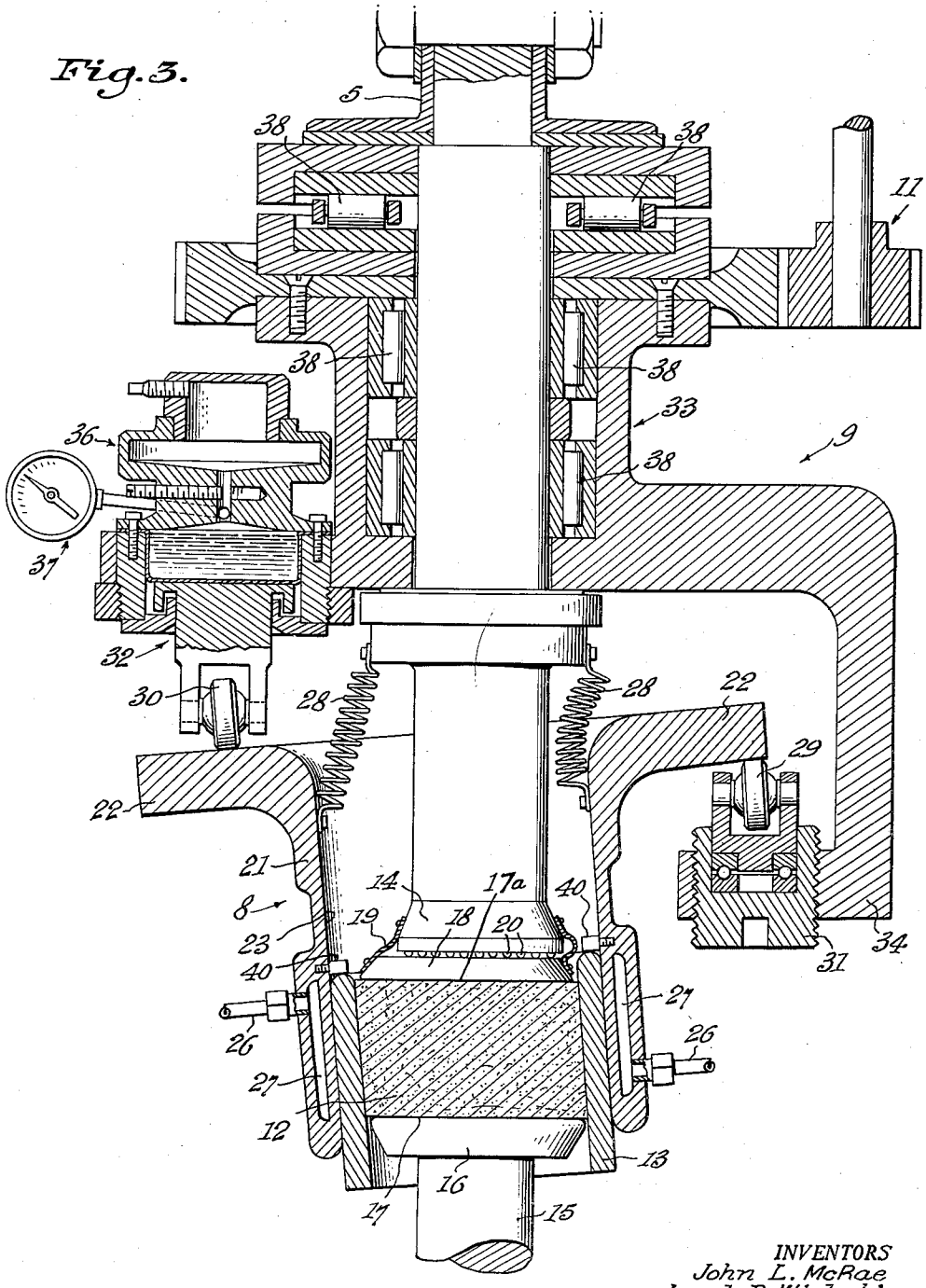
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Fig. 3.



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KNEADER COMPACTOR

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5 Claims. (Cl. 73—88)

(Granted under Title 35, U.S. Code (1952), sec. 266)

The invention described herein may be manufactured and used by or for the Government for governmental purposes without the payment of any royalty thereon.

The present invention relates generally to materials testing apparatus and specifically to apparatus for the compaction of samples of soils or paving materials to use as laboratory specimens in the testing of those materials to obtain data from which construction specifications may be derived.

In the design of specifications for subsoil, base course and surfacing or paving mixes as, for example, earth or bituminous or asphaltic concrete mixes for road or airfield construction, it is necessary to prepare compacted test specimens of the materials approximating the densities developed in finished products, either through preparation or actual use.

Previous laboratory compaction machines have been of several types. In one type, the soil or bituminous paving material to be compacted is placed in a metal cylinder or mold and compressed or compacted by a hydraulic or other press acting on a metal plunger of slightly less diameter than the cylinder. In this type of apparatus, the compaction is dependent entirely on the static compression of the plunger and there is very little movement or adjustment of particles such as occurs in soils or paving materials during the actual construction of roads or airfields as a result of the combinations of static pressure and the kneading action of rollers or other dynamic compaction. Static compression compaction does not produce test samples having density and internal structure (arrangement of aggregate particles) equivalent to the actual road or airfield as does the kneading-type compactor disclosed herein which induces a gyratory motion of the test mold in conjunction with an applied compression load causing a kneading action as the material is compressed and compacted.

In another type laboratory compactor the soil or paving material, as a bituminous mixture, is placed in a metal cylinder or mold and compacted by striking it a prescribed number of times with a metal tamper having a contact area considerably smaller than the cross-section area of the mold in which the material is compacted. Generally, the tamper is specified as a free-falling metal rod, the weight of the tamper and the height of fall being prescribed. This type machine also does not produce test samples having density and internal structure equivalent to the prototype as does the instant kneading-type compactor.

In still another type laboratory compactor, the soil or bituminous mixture is placed in a mold and compacted by repeated application of a metal plunger of considerably smaller contact area than the cross-section area of the mold. In this apparatus, the metal plunger operates at a prescribed contact pressure and the load is generally maintained for a prescribed period of time. This type of compactor does produce a certain amount of relative-movement among particles and specimens prepared in this fashion approach actual product conditions; however, specimens thus prepared are not uniform in density from top to bottom, often being much more dense in the top than in the bottom, and therefore even this type of compactor does not produce test specimens having density and internal structure as nearly equivalent to an actual road or airfield as does the kneading-type compactor disclosed herein.

An important object of this invention is to provide a laboratory compaction machine for soils, paving mixtures, or other comminuted solids that duplicates the density and internal structure of these materials in actual use.

Another object is to provide a compaction machine that compacts with a kneading action.

Another object is to provide a compaction machine that produces a uniform, continuous gyratory oscillation of the compaction test mold while the material is being compacted.

Another object of the invention is to provide a compaction machine in which the compression pressure on the sample is automatically maintained constant at a selected value during compaction.

Another object is to provide means for measuring the pressure required to produce the kneading action in the test sample that is being compacted.

Another object is to provide means for controlling the pressure that produces the kneading action in the test sample that is being compacted.

Other objects and advantages of the invention will be apparent as the description proceeds and the features of novelty will be pointed out in detail in the appended claims.

Briefly, in accordance with the invention, there is provided a compression compaction machine including opposed plungers fabricated to compress materials within a removable cylindrical mold modified by the inclusion of an oscillant mold chuck about the mold. The mold chuck is mounted for gyratory oscillation or wobble about a point on the axis of the plungers at the base of the material in the mold and oscillated in a conical fashion about the axis of the plungers to produce kneading stresses in the material within the mold. Oscillation of the mold is caused by the camming action of a pair of transverse opposed power driven roller bearings on a radial flange on the mold chuck; the two roller bearings, spaced at 180°, bear on opposite faces of the flange and are driven around the flange course by a powered bearing carriage.

In the accompanying drawings forming a part of this specification and illustrating a preferred embodiment of the improvements comprising the invention—

Fig. 1 is a front elevation, partly in section, of a laboratory compaction machine incorporating the novel oscillatory kneading device of this invention;

Fig. 2 is a side elevation, partly in section and with upper frame members removed, of the compaction machine of Fig. 1; and

Fig. 3 is an enlarged vertical section of that portion of the compaction machine of Figs. 1 and 2 incorporating the novel structure of the instant invention.

Referring more specifically to Figs. 1 and 2 of the drawings illustrating a complete compacting machine including the novel kneading improvement, the machine is generally comprised of a frame 1 including, in addition to vertical members 2, jack support beam 3, table 4, and overhead beam 5. The frame supports hydraulic jack 6, fluid pressure system 7, mold chuck 8, mold chuck oscillator 9, motor 10, and gear train 11. The sample 12 of the soil, mix, or other material to be compacted is confined in open ended cylindrical mold 13 and

receives static compression directly from the heads of axially aligned vertical plungers 14 and 15. Plunger 14 is stationary and depends rigidly from overhead beam 5 while lower plunger 15 is the moving shaft of hydraulic jack 6. Static pressure for compression is imparted to the sample 12 by jack 6 as actuated by the fluid pressure system 7. The foregoing structure forms but one arrangement for imparting static pressures to materials confined within an open ended cylindrical mold.

The present invention contemplates a kneading of the material 12 through a gyratory oscillation of the mold 13 while the material is under compression as described above. The illustrated embodiment of the invention as detailed in Fig. 3 is accomplished by providing the compressing plunger 15 with a beveled head 16 loosely fitted within mold 13 and then oscillating the mold 13 with a conical gyration about the bearing surface 17 of head 16, or more specifically, symmetrically about the point defined by intersection of the axis of plungers 14 and 15 with surface 17. The loose fit of head 16 in the mold, which head terminates in bearing surface 17 fitting closely or more exactly in mold 13 permits angular motion of mold 13 with respect to the common axis of the plungers 14 and 15 while the close fit of the bearing surface also serves to prevent escape of a test material from between the head and the mold wall. To obtain freedom of movement as described for the mold, stationary plunger 14 is provided with floating head 18, having bearing surface 17*a*, secured in any reasonable manner, as for example, by flexible skirt 19 illustrated and bearing against the end surface of plunger 14 through freely moving ball bearings 20. Floating head 18 is also tapered inwardly from bearing surface 17*a* in the same manner and for the same purpose as head 16. As the mold is oscillated in this gyratory fashion without rotation, a constant pressure is maintained on lower plunger 15 by means of the fluid pressure system 7 subjecting the sample 12 to the dual stresses of compression and distortion which together constitute kneading. This kneading, or distortion while under compression, ensures a frictional movement and realignment among the particles of sample 12 accomplishing the ultimate in compaction.

The gyratory oscillations imparted to mold 13 are created in mold chuck 8 which includes cylindrical shank portion 21 and peripheral terminal flange 22. Bore 23 of the shank 21 is scaled to an exterior friction fit over mold 13, the shank 21 being provided with expansion slot 24 and compression bolt 25 to permit insertion of mold 13 in the bore of the shank and frictional retention therein as a result of tightening bolt 25. Chuck 8 is also provided with a fluid cooling system including ducts 26 and jacket 27 and is flexibly suspended from upper stationary plunger 14 by orienting springs 28 which permit a relatively large field of movement while under tension toward a position of alignment with the plungers 14 and 15. The actual gyrations are caused by cooperation of the flange 22 with roller bearings 29 and 30 which are supported in bearing mounts 31 and 32 respectively, carried by revolving bearing carriage 33. Bearing 29 is adjustably supported on arm 34 so as to bear against the under rim of flange 22 while bearing 30 is positioned to be thrust against the upper rim of flange 22 by pressure exerted on bearing mount 32 by fluid pressure in cylinder 36. Cylinder 36, attached to carriage 33 at 180° from arm 34, is provided with gauge 37 necessary to control of the pressure exerted through bearing 30, which pressure controls and is a means of measurement of the distortional influence on the sample 12. In the unbiased state, chuck 8 hangs in alignment with plunger 14 with the lower rim of flange 22 just free of pressure from either roller bearing 29 or 30, cylinder 36 being relieved of pressure so as to permit retraction of mount 32 to the extent that bearing 30 retains contact with but does not exert pressure on flange 22 of the chuck. Manual adjustment of bearing mount 31 controls the maximum amount of distortion obtainable in any specific application while the pressure exerted on mount 32 determines the degree of distortion and therefore the amount of kneading at any particular time. Rotation of carriage 33, which is journaled on the shaft of plunger 14 for rotation on bearings 38, by activation of motor 10 and gear train 11, causes each point on flange 22 of chuck 8 to be alternately forced up and down by passage of bearings 29 and 30 in rapid succession.

Loading of the compaction machine is accomplished by placing a mold 13 on a tray 39, filling the mold with the material to be tested, placing tray 39 and the mold on platform 4 as illustrated in Fig. 1, running the mold into the chuck as far as stops 40 by activation of the jack, securing the mold in the chuck and removing the tray by sliding it from between plunger head 16 and the mold. Operation may then be continued by again activating the jack to provide compressing pressure, activating the pressure cylinder 36 and adjusting bearing mount 31, if necessary to cause distortion, and starting motor 10 to cause the kneading. Removal of mold 13 and its included sample is simplified by the fact that the compacted test sample will not crumble or run out of the mold obviating use of tray 39.

It is to be understood that the embodiment of the invention illustrated and described is a preferred example and that various changes, as for example substitution of springs for fluid pressure systems, may be resorted to without departing from the spirit of the invention or the scope of the appended claims.

We claim:

1. A compaction machine comprising open-ended material-confining means having a central axis, compression means for subjecting material within the material-confining means to static compressive stress along said central axis, said compression means terminating in material-contacting means for retaining material within the open-ended material-confining means while permitting universal movement of said material-confining means with respect to said compression means and said material-contacting means, and tiltable casing means including drive means therefor, said drive means including rotating camming means bearing on and rotating about said casing means imparting a gyratory motion to said casing means relaive to said central axis, said tiltable casing means surrounding and contacting said material-confining means for imparting the gyratory motion about said central axis of material in said material-confining means caused by the rotational camming of said casing means so as to apply distortional stresses to the material in addition to said static axial compressive stress.

2. A compaction machine comprising a material-confining mold having open ends and being symmetrical about a control axis, flexibly suspended support means for carrying said material-confining mold, material compressing means having two elongated aligned plungers movable relative to each other along their common axis and each having a terminal material-contacting surface normal to said common axis for subjecting material within the material-confining mold to compressive stress axially of said plungers, said common axis of the plungers and the central axis of the material-confining mold being normally coincident, said terminal material-contacting surfaces facing each other and being dimensioned to enter the open ends of said material-confining mold with a minimum of clearance, said terminal material-contacting surfaces being supported and connected to said plungers by interconnecting means of lesser dimensions than the interior of said mold so that only the material-contacting surfaces have a minimum of clearance when those surfaces enter the open ends of the material-confining mold, non-aligned bearing means rotatable about said common axis and engaging said support means for said material confining mold for canting said material-

confining mold to positions in which the central axis makes an angle with said common axis upon rotation of said bearing means to subject material within said material-confining mold to distortional stresses in addition to static compressive stress axially of said plungers.

3. A machine for compacting compactable material, comprising a frame supporting a fixed compressing member, a movable compressing member proximate to and axially aligned with the fixed compressing member, pressure means for pressing the movable compressing member axially toward the fixed compressing member, an open-ended mold coacting with the compressing members for confining material to be compacted between the compressing members, and tilting means for imparting a gyratory oscillation to the mold while said mold contains compactable material under compression between the compressing members; said compressing members terminating at their free ends in material-contacting heads shaped so as to permit a close fit within said mold to prevent loss of material being compacted but shaped so as to also permit angular movement of the mold with respect to the axial alignment of the compressing members; said tilting means including an open-ended chuck surrounding and gripping the mold, including a rotatable carriage means for canting the chuck and mold out of axial alignment with the compressing members; including motor and drive means for driving said carriage means; said chuck including a radially extending peripheral flange; said carriage means including a rotatable carriage, a first chuck-biasing means on the carriage bearing against one planar surface of the peripheral flange, a second chuck-biasing means on the carriage opposite the first biasing means with respect to the axis of the opening of the chuck and bearing against the opposite planar surface of the peripheral flange, and means for pressing the biasing members against the peripheral flange generally parallel to the axis of the compressing members; said motor and drive means including means for rotating the rotatable carriage whereby activation of the motor, drive, and pressure means will impart both static compressive stress and dynamic gyratory distortional stresses on any material within the mold.

4. A machine for the compaction of plastic material comprising an open-ended material-confining cylinder, an elongated plunger at each end of said cylinder, said plungers being axially aligned with each other and terminating in mutually facing material-contacting head surfaces fitting into said cylinder with a minimum of clearance at said surfaces, each of said head surfaces being supported by a head which except for said surface fits freely in said cylinder to permit angular movement of said cylinder with respect to said plungers about said head surfaces, said cylinder being normally axially

aligned with said axis of the plungers, said plungers being supported by support means permitting relative axial motion of said plungers to subject material within the cylinder to static compressive stress axially of said plungers, oscillatory means interconnecting said cylinder and said support means for causing said cylinder to oscillate from a normal position of axial alignment with said plungers to and among positions of non-axial alignment with said plungers to impart distortional stresses to material in the cylinder, and means for driving both the plungers and the oscillatory means.

5. A compacting machine for the compaction of plastic material comprising an open-ended material-confining cylinder, an elongated plunger at each end of said cylinder, said plungers being axially aligned with each other and terminating in mutually facing material-contacting heads fitting into said cylinder, said material-contacting heads having material-contacting head surfaces remote from said plungers which head surfaces are generally normal to the axis of the plungers and fit into said cylinder with a minimum of clearance to prevent loss of material and to subject all said material to compaction, said material-contacting heads each having a body portion tapering from said head surface toward the plunger to which it is affixed to form a reduced portion permitting free angular oscillation with respect to the axis of said plungers about said head surface, one said material-contacting head being secured to its plunger by means permitting movement of the head in a plane normal to the axis of that plunger, said cylinder being normally axially aligned with said axis of the plungers, said plungers being supported by means permitting an axial motion changing the distance between said head surfaces of said plungers to subject material within the cylinder to static compressive stress axially of said plungers, oscillatory means including a flanged cylindrical chuck surrounding said cylinder and also including rotating means cooperating with the flange of the chuck, said oscillatory means interconnecting said cylinder and said support means for causing said cylinder to oscillate from a normal position of axial alignment with said plungers to and among positions of non-axial alignment with said plungers to impart distortional stresses to material in the cylinder, and means for driving both the plungers and the oscillatory means.

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