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Blaser

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[54] **VIBRATORY GRANULATE COMPACTING APPARATUS FOR BLOCK MANUFACTURE**

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[52] **U.S. Cl.** **425/432,** 425/167, 425/352
[51] **Int. Cl.** **B28b 3/08**
[58] **Field of Search** 425/352, 355, 167, 425/432

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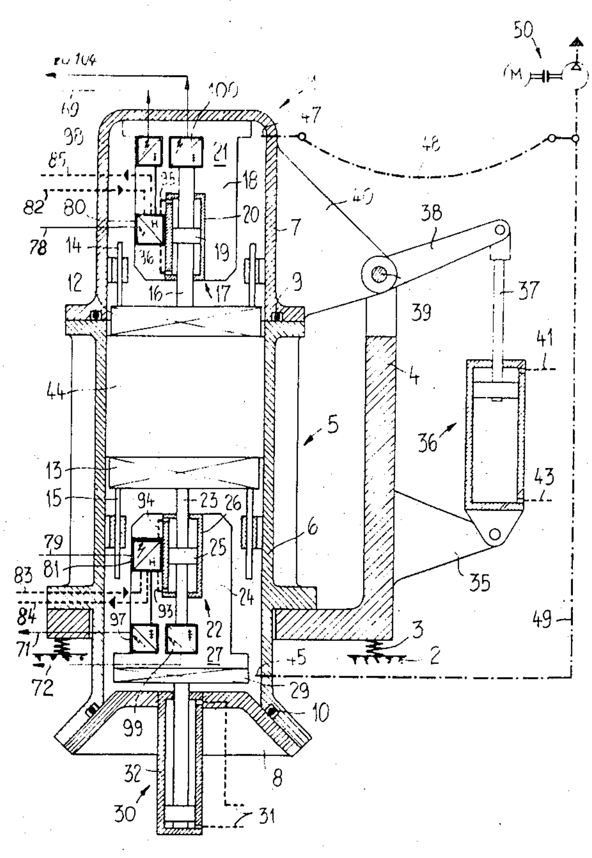
[57] **ABSTRACT**

An essentially tubular shell has movable tops and bottoms, which are subjected to vibratory impacts in noncyclically recurring pulses; top or bottom may be subjected to a constant pressure, or both may be subjected to impacts which are synchronized and opposite each other. The impact pulses are controllable both as to frequency (which may be zero), amplitude and wave shape, the impulses being preferably controlled from an electrical programming source which controls application of pressure fluid to the top and bottom.

19 Claims, 3 Drawing Figures



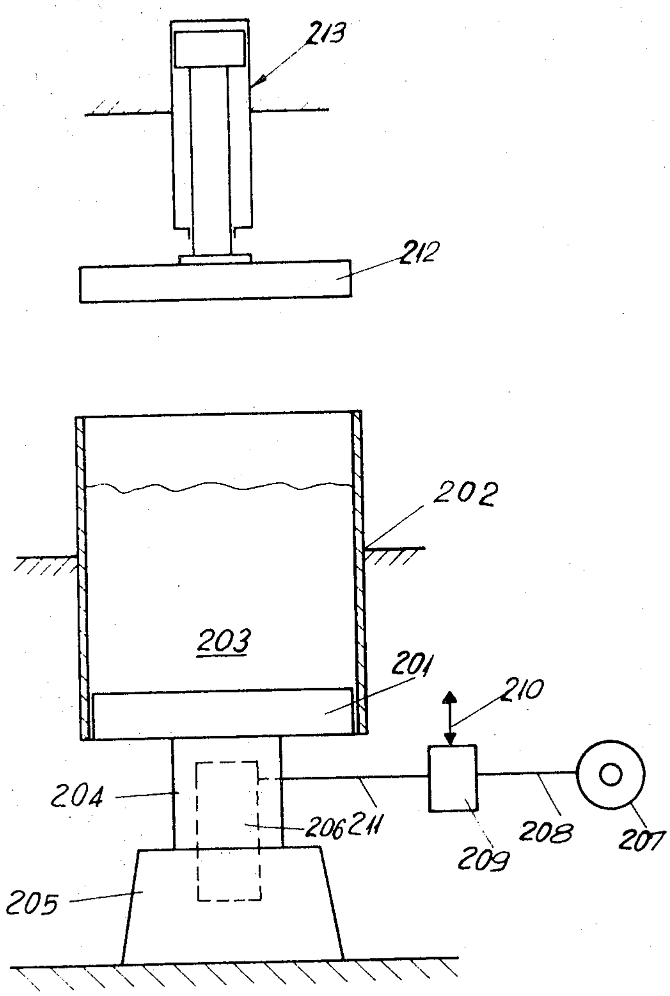


FIG. 1

Fig. 2a

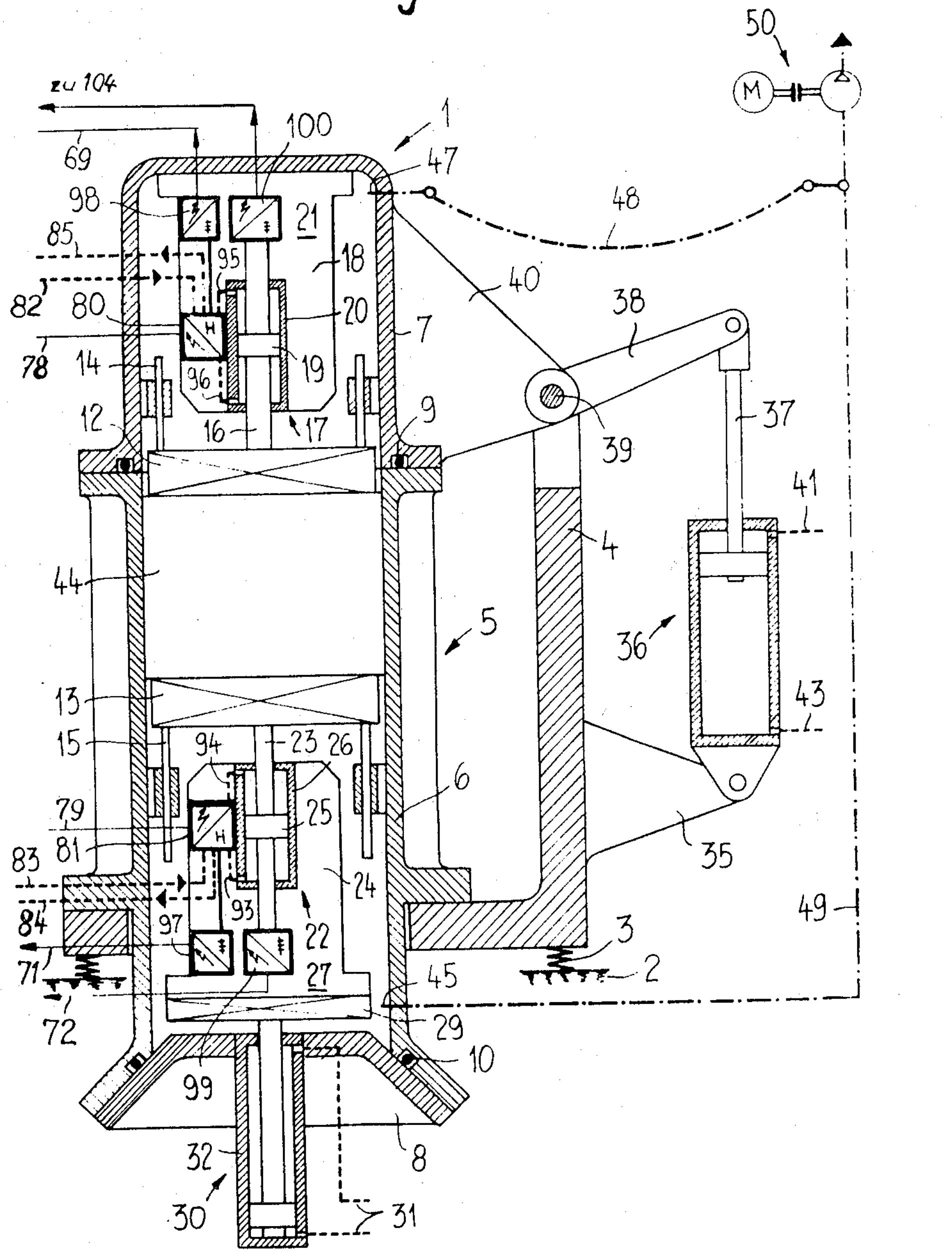

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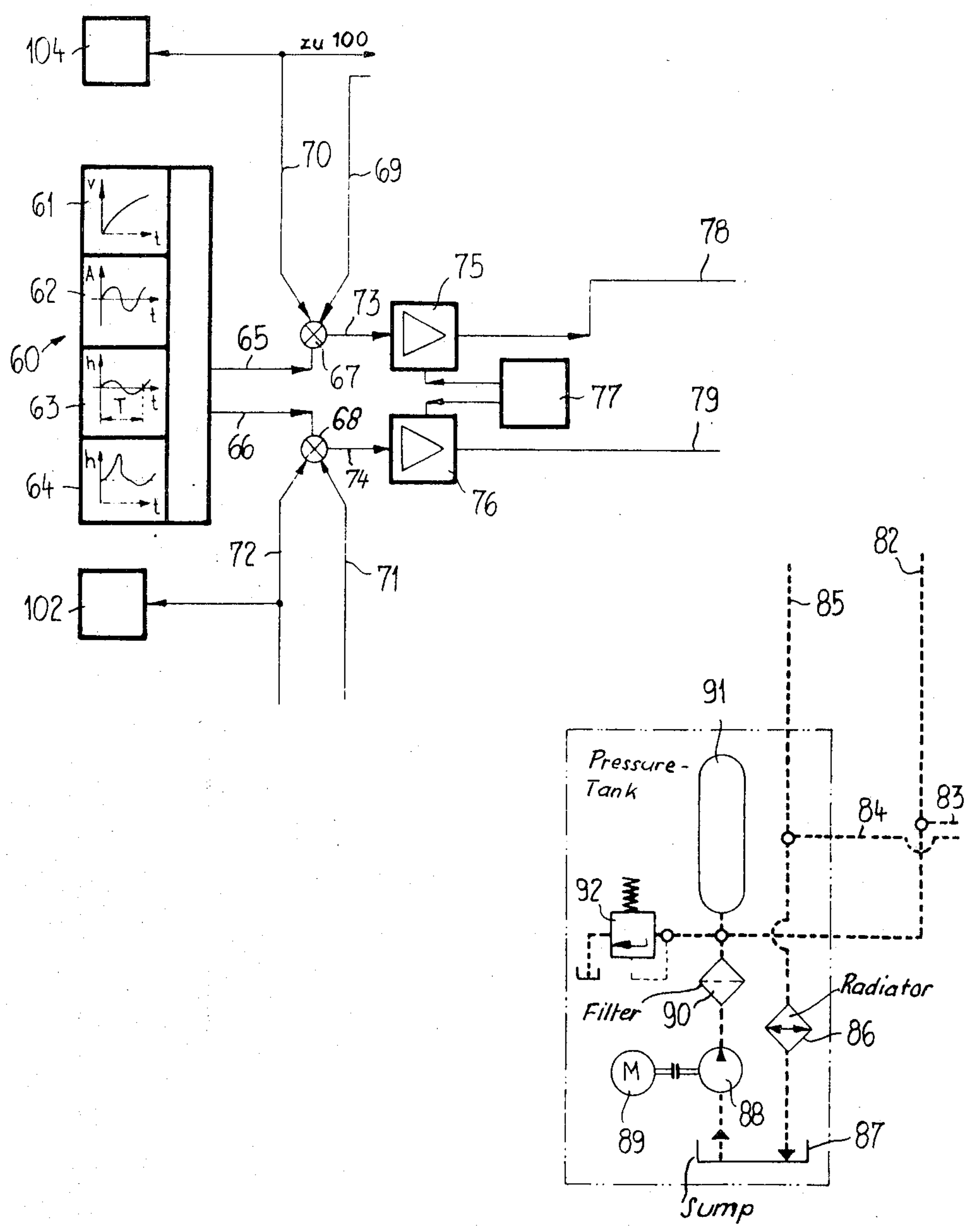
Fig. 2b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71
102
82
85
91
Pressure-Tank
84
83
92
Filter
90
Radiator
86
M
89
88
87
Sump

VIBRATORY GRANULATE COMPACTING APPARATUS FOR BLOCK MANUFACTURE

The present invention relates to a vibratory compacting apparatus particularly to manufacture blocks from granulates, such as block anodes, in which granulates are placed into a shell and subjected to vibration treatment, in which the granulates are compacted.

The manufacture of blocks from granulates by means of vibratory treatment is known. It has been proposed to utilize resiliently supported tables, or the like, on which the form in which the granulates are filled, is mounted. Such a vibratory table usually has a pair of rotating, unbalanced weights applied thereto. The unbalanced weights may be so arranged that their horizontal components cancel each other. Small vibratory tables of this type can utilize an electric motor which is mounted directly on the vibratory table in order to drive the rotating unbalanced weights. Large vibratory tables, however, require remotely located electric motors. The drive to the unbalanced weights then is over shafts with universal joints therein, or otherwise flexible shafts. Rotation of the unbalanced weights results in an essentially harmonic oscillation of the vibratory table, the granulate within the form being vibrated into one compact block. The compaction of the granulate upon vibration depends on the frequency and amplitude of vibrations.

Remotely located drives, transmitting power over shafts having universal joints, or the like therein are practically always used for vibration tables of high power. Such an arrangement requires a substantial amount of space, since the shafts and the universal joints require a considerable length in order to compensate for the motion of the vibration table. The frequency can be changed by changing the speed of rotation, and amplitude of vibration can be changed within small limits; the type of vibration is, however, always cyclically recurring, due to the drive from a constant speed, or essentially constant speed motor.

It has been found that vibration of granulates to provide compaction is not as effective as non-harmonic, that is non-cyclically recurring vibrations, such as pulses, impacts and abrupt blows, presenting a well-defined maximum of energy for a short period of time, that is, when looked at in an oscillograph representation, presenting sharply defined peaked pulses.

It is an object of the present invention to provide a compacting apparatus to compact granulates into blocks, which is compact, utilizes but small space for the energy source,and which is capable of providing energy for compaction which is non-cyclically recurring. By non-cyclical recurrance rate, as referred to in the present specification, a motion is meant which is non-harmonic in the sense of showing cyclically recurring oscillations.

Subject Matter of the Present Invention

Briefly, a shell is provided having movable top and bottom parts, which are connected to a power transfer device such as a pressure fluid operated piston-cylinder arrangement. The granulate to be compacted is placed within the shell, and energy pulses are applied to at least one of the top, or bottom parts in non-cylically recurring pulses. One of the parts may be subjected to a constant compaction pressure, while the other is subjected to impacts, so that blows will be transmitted to

the granulate to be compacted; or, both the top and bottom cover parts may be operated in synchronism, and in counter-acting directions so that compacting blows are delivered against the granulate within the shell, from both the top and the bottom.

In accordance with a feature of the invention, the blows are controlled from a programming source, which may be electrical, which provides a control for a transducer applying pressure fluid to the cylinder-piston arrangement. In addition to the cylinder-piston arrangements transmitting the blows, a steady compacting pressure may be exerted, for example by mounting one of the cylinder-piston arrangements transmitting the blow on a housing portion which is subjected to pressure, for example hydraulic pressure.

In accordance with a feature of the invention, both the amplitude, wave form and frequency of the compacting impulses is changeable; the frequency of compacting pressure applied to one of the cylinder-piston arrangements may be zero, that is, provide a constant essentially unvarying compacting pressure.

By providing pressure fluid operated cylinder-pistons, directly acting over movable parts of the container within which the granulate is placed, space for the apparatus is reduced and the source of energy may be located anywhere, connected to the apparatus itself merely by a fluid pressure line, such as a hydraulic pressure fluid line. Control of admission of the hydraulic pressure fluid is simple and can be carried out by means of electromagnetically operated valves, in accordance with an established program.

The invention will be described by way of example with reference to the accompanying drawings, wherein:

FIG. 1 is a highly schematic illustration of the apparatus to make blocks, and generally illustrating the application of the invention;

FIG. 2*a* is a schematic longitudinal sectional view through an apparatus to compact granulates; and

FIG. 2*b* is a schematic diagram illustrating control connections, and programming control for the apparatus of FIG. 2*a*.

Referring to FIG. 1: A press, or similar suitable arrangement has a movable bottom **201**, slidable within a shell **202**. Granulate, generally indicated at **203** is placed into the shell. The bottom **201** is connected to a stand **204** which bears against a base **205** in any suitable manner, and not illustrated in FIG. **1**. The bearing connection between base **205** and bottom **204** can be fixed, or can be resilient, that is, can be over interposed springs (not shown). An impacting apparatus **206**, providing upward motion to the bottom **201** is located within base **204**. Since the impacts can be recurring, the apparatus will be referred to as a "vibrator" although it is to be understood that the recurrence rate of vibrations applied to the bottom **201** on which the granulate **203** is located is non-cyclical. The vibrator, or impacting device **206** has an impacting transducer operable in only a single direction, namely axially with respect to the shell **202**, and transmitting blows or impacts against the granulate. In FIG. **1**, the direction of impacts is vertical. This permits utilization of a single vibrator, which has advantages based on economics and space availability. The vibrator apparatus **206** provides blows and impacts which are non-harmonic, that is, non-cyclically recurring.

An energy source **207** which may, for example, be a source of compressed air, hydraulic fluid, or electrical energy, provides energy over line **208** to a control device **209**. The controlled energy is then transmitted over line **211** to the vibrator. The interconnection of lines **208, 211,** and the placement of the control apparatus **209** is variable in accordance with available space, and operating requirements.

Control apparatus **209,** providing controlled application of energy over line **211** to the impacting apparatus **206** is itself controllable by means of a controller **210** which may be manually operated, or electrically, for example by means of a programming source.

The vibrator itself is a cylinder-piston arrangement having masses movable relative with respect to each other, as controlled by the energy over lines **208, 211.** One of these masses can be fixed with the bottom **201,** or can be elastically secured thereto.

The granulate can be vibrated entirely from the bottom. It is, however, preferred and increases the compacting effect when the top of the granulate is likewise loaded. A top cover **212,** within a cylinder-piston device **213** is provided, which can be lowered against the top of the granulate. The cylinder-piston arrangement **213** provides a steady constant pressure against the granulate or, as will appear hereafter, can likewise be controlled to provide impacts or blows against the granulate, preferably in synchronism, and in opposite direction with the blows provided by device **206** and connected to the bottom. The top compacting arrangement is not strictly necessary, however, since the non-cyclically recurring, that is the non-harmonic vibrations transmitted from the device **206** already provide for substantial compaction.

A specific example of the apparatus is shown in FIG. 2a, wherein the device **1** is shown as a whole. A base **2** has a machine frame **4** supported thereon by means of springs **3.** A housing **5** is located within frame **4,** the housing including a shell **6,** a top cover **7** and a bottom cover **8,** the parts **6, 7** and **8** being sealed with respect to each other by seals **9, 10.**

The interior of shell **5** has a top part **12** and a bottom part **13,** parts **12, 13** being longitudinally guided by rods **14, 15,** in the direction of the longitudinal axis of the housing **5.**

Top part **12,** which forms a pressure piston, has a piston rod **16** secured thereto; slidable within a piston-cylinder arrangement **17.** The cylinder-piston arrangement **17** includes a cylinder portion **18** within which a cylinder **20** and a cylinder housing **21** are located. The cylinder housing **21** also carries control equipment to be described below. Cylinder housing **21** is secured to the inner wall of the upper cover **7.**

A cylinder-piston arrangement which may be identical, or similar to the one just described, is located at the bottom of the shell, beneath a bottom part **13** forming a counteracting piston. Bottom part **13** has a piston rod **23** connected to the bottom part **13.** It includes a cylinder portion **24** and a piston **25.** Cylinder portion **24** has a cylinder **26** and a cylinder housing **27,** the cylinder housing **27** carrying control equipment to control the piston drive **22,** and which will be described below. Cylinder housing **27** is not connected to the bottom shell, as the top cylinder housing, but rather is connected to a table **29** of an additional cylinder-piston drive **30.** The cylinder **32** of the additional cylinder-piston drive is secured to the lower portion **8,** closing off the shell. Pressure lines **31** lead to the additional cylinder **32.**

A bracket **35** extends from frame **4,** and supports a further cylinder piston arrangement **36.** The piston rod **37** is pivotally connected to a link **38** which is secured to a shaft **39,** journalled on machine frame **4.** An arm **40** is secured to the top cover **7** for the shell and is likewise connected to shaft **39.** Upon application of differential pressure to lines **41, 43,** into cylinder-piston drive **36,** the piston rod **37** is lowered, thus swinging shaft **39** and permitting removal of the top cover **7** and all mechanism enclosed therein from the shell **6,** so that granulate **44** can be introduced within the shell **6,** for compaction therein.

Line connections **45, 47** are introduced above the top piston **12,** and below the bottom piston **13,** and in the top and bottom regions of the apparatus. Connections **45, 47** are connectable with lines **48, 49** which can be connected to a suction apparatus **50** of any suitable form.

The compactor **1** is operated by hydraulic pressure. The hydraulic pressure, that is, the pressure pulses, are controlled from a programming source **60** (FIG. 2b), which is programmed to provide output signals which can vary as schematically indicated by boxes **61, 62, 63, 64.** The programmer thus provides an output signal in which the feed of projection of any one of the pistons **12, 13** can be controlled (see box of diagram **61**). Likewise, amplitude A (diagram **62**); frequency, or duration of impact (diagram **63**) and wave shape (diagram **64**) are controllable. The signal provided from programmer **60** represents a command signal. It is applied over two parallel channels **65, 66** to comparator **67, 68,** where the command signal is compared with actual position signals applied over lines **69, 70** and **71, 72,** respectively. The error signal is applied over line **73, 74** to amplifier **75, 76,** supplied from a power source **77,** the amplified signal being conducted over lines **78, 79** to transducers and amplifiers **80, 81** (FIG. 2*a*). The transducer-amplifiers **80, 81** may be electro-hydraulic servo valves which apply pressure fluid, such as hydraulic pressure fluid to the piston-cylinder arrangement **17, 22,** respectively.

The valve may also control compressed air, or other pressure fluids; rather than utilizing valves, the control signals can be applied to magnetically operated impacting devices, over mechanical or solid state relays.

The transducers **80, 81** as shown in FIG. 2a are supplied over lines **82, 83** with hydraulic fluid under high pressure; the fluid at low pressure is taken over lines **84, 85** back to a reservoir or sump **87** (FIG. 2*b*), preferably over a radiator **86** to cool the fluid, to be then picked up by a pump **88,** driven by a motor **89,** and supplied over a filter **90** to a pressure reservoir **91.** The pressure at pressure reservoir **91** is controlled by means of a pressure regulating valve **92.**

Transducer-amplifiers **80, 81** are connected over lines **93, 94, 95, 96** with the two piston-cylinder arrangements **17, 22** respectively. Position transducers **97, 98** for the transducer amplifiers **80, 81,** and position transducers **99, 100** for piston rods **16, 23** provide feedback signals which are conducted over lines **69, 70, 71, 72** to the comparators **67, 68** (FIG. 2*b*), to be there compared with the command signal from the programmer **60.**

A completely closed control loop is provided. The arrangement need not, however, have the closed control loop, in which measured position signals are compared with command signals, and the motion is controlled by an error signal. Other arrangements are possible. In the particular example shown, the two piston-cylinder drives **17, 22** provide the same impacts to the granulate **44** within shell **5,** that is, both piston-cylinder drives are controlled by a single programming source **60,** acting in opposition from each other, so that pistons **12, 13** will have the same motion, directed towards each other, in synchronism. Different programming arrangements can be used, that is, each one of the pistons **12, 13** may be controlled by its own programmer, or a single programmer can be used in a time-sharing arrangement. The feeback circuit described in detail is not necessary, but it provides for greater accuracy; direct connection of control signals from a programmer **60** to the respective pistons **12, 13** can likewise be used.

The pressure medium applied to the cylinder-piston combinations **17, 22** is either hydraulic, or pneumatic. Indicators **102, 104** (FIG. 2*b*) can be included in the feedback circuit **70, 72** which indicates the actual position of the pistons **12, 13** confining the granulate within the shell. Other indicators, or controllers and recorders can be connected as is well known in the art.

In the described example, the position of the pistons **12, 13** is used as a feedback signal. It is also possible to measure pressure being exerted by the pistons and compare the exerted pressure with a programming source providing pressure impacting signals.

The apparatus of the present invention can be used in accordance with various combinations of feed, steady pressure, impacts, and impacts superimposed on steady pressure or slowly varying pressure. At pressure variation with zero frequency, that is, at even or only very slowly changing pressure feed, the granulate is compacted by the pressure of the two piston-cylinder arrangements **17, 22** compressing the granulate. Superimposed non-cyclically recurring impacts provide additional energy for effective compaction of the granulate.

Various changes and modifications may be made within the inventive concept.

I claim:

1. Vibratory granulate compacting apparatus for the manufacture of blocks comprising

a housing;

a multi-part container having a bottom part, a top part and a shell part located between the bottom and top part and having a central axis, the granular material being placed within the container for compaction;

a piston means connected to at least one of the parts to move the connected part in axial direction for compaction of material located within the container by steady-state pressure and, selectively, vibratory motion;

fluid energy means connected to said piston means and moving said piston means to provide compacting pressure and vibratory impacts in axial direction, the energy having parameters including amplitude, frequency, wave shape;

a fluid energy source;

electrical signal controlled fluid control means controlling application of fluid energy from said source to said energy means; and

programmed electrical control means generating signals representative of at least one of said parameters, connected to and controlling said signal-controlled fluid control means to apply said fluid energy controlled by one of said parameters.

2. Apparatus according to claim **1,** wherein the energy means comprises a cylinder for the piston to form a piston-cylinder combination, the fluid energy being hydraulic pressure fluid.

3. Apparatus according to claim **1,** comprising a pair of energy means, one each connected to the bottom and top part of the multi-part container, respectively;

and the piston means comprises a top and a bottom piston, respectively connected to the top and bottom part.

4. Apparatus according to claim **3,** wherein one of the energy means is controllable to provide steady compacting pressure, whereby the frequency of compaction is zero;

and the other energy means is controllable to provide impacts at non-cyclically recurring intervals to prevent harmonic oscillations from being established.

5. Apparatus according to claim **3,** wherein the energy means connected to both the top and bottom parts are controllable to provide, each, counter-acting synchronized impacts directed towards each other.

6. Apparatus according to claim **3,** wherein the energy means comprises a cylinder for the piston to form a piston-cylinder combination;

one of the cylinder parts of one piston-cylinder combination is fixedly connected to the housing; the pistons of both said piston-cylinder combinations being connected to the bottom and top parts respectively; and the other cylinder part is slidably secured in the housing.

7. Apparatus according to claim **6,** including an additional cylinder-piston combination supporting the other cylinder part.

8. Apparatus according to claim **7,** wherein the housing closes the top and bottom parts and has a separable, removable top and bottom cover;

one of the cylinders being secured to the removable top cover, and the additional cylinder-piston combination being secured to the bottom cover.

9. Apparatus according to claim **8,** wherein at least one of the top and bottom covers is removable from the housing as an entirety including the respectively connected piston-cylinder combination.

10. Apparatus according to claim **1,** wherein the means applying energy to the parts, and the means controlling the frequency and amplitude parameter of application of energy comprises

a source of control signals;

transducer and amplifier means controlled by the control signal;

and means interconnecting the transducer means and the amplifier means with the energy means.

11. Apparatus according to claim **10,** wherein the control signals derived from the source provide signals of opposite polarity;

and a pair of energy means are provided acting in opposite axial directions, one energy means each being controllable by one of the signals.

12. Apparatus according to claim **1,** including resilient means supporting the housing.

13. Apparatus according to claim **1,** wherein the housing is sealed;

and suction outlet means are provided both at the upper and lower portions of the housing.

14. Compaction apparatus comprising a generally tubular shell (**6**);

top piston and bottom pistons (**12, 13**) slidable in said shell, the material to be compacted being placed in the shell between the pistons;

top and bottom housing covers (**7, 8**) secured to the shell (**6**) and enclosing said top and bottom pistons, respectively;

hydraulic power means (**17, 22**) controlling movement of the pistons into the shell to compact granulate therein;

an electro-hydraulic control loop (**60,65–85, 93-100**);

and program means (**60**) connected to said control loop and controlling the power means (**17, 22**) applying hydraulic pressure by each said pistons (**12, 13**) with respect to at least one of: amplitude; frequency; and wave shape of applied power to provide for compacting and retracting movement of the pistons and vibratory impacts thereof to be transmitted from the pistons to the material within the shell, as controlled by said program means (**60**).

15. Apparatus according to claim **14,** wherein the program means controlling the power means comprises a random signal generator providing non-cyclically recurring power control signals.

16. Apparatus according to claim **14,** wherein the program means controlling the power means comprises

a signal generator;

and the electro- hydraulic control loop comprises transducer means connected to the power means to transduce the signals from the signal generator to compression strokes by said top, and bottom piston, respectively.

17. Apparatus according to claim **16,** wherein the signal controlling application of power to one of the pistons is a slowly, or unvarying compression signal and the signal controlling the other piston is a pulse-type signal providing impact, or blow-type excursions of the other piston at non-cyclically recurring rates.

18. Apparatus according to claim **15,** wherein the signal from the signal generator controlling application of power controls both said pistons to move synchronously in opposition towards each other to provide counter-acting compression impacts against the material in the shell.

19. Apparatus according to claim **2,** comprising hydraulic connection means connecting the fluid energy source and the cylinder-piston combination, the electrical signal controlled fluid control means being interposed in the connection means and being located on the cylinder of the piston-cylinder combination.

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