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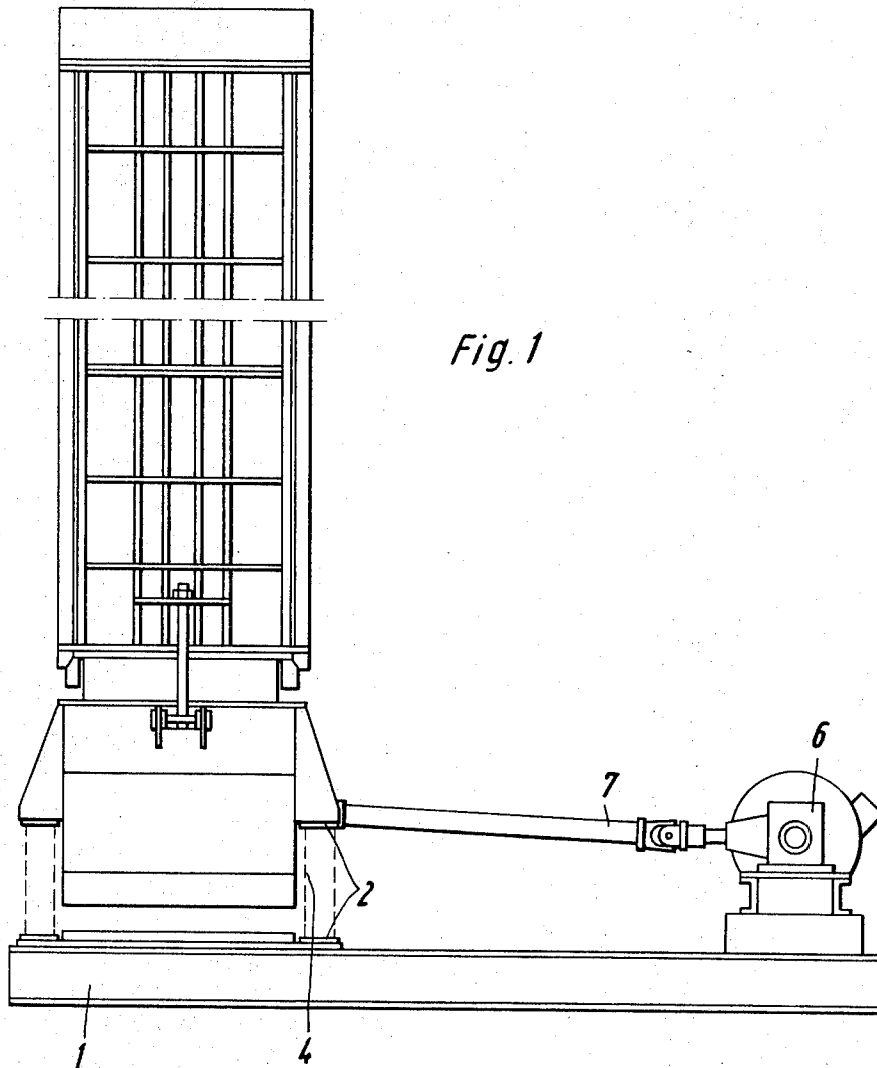
G. WEINHOLD

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APPARATUS FOR SHAPING OF GRANULAR SUBSTANCES

Original Filed Oct. 13, 1967

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Inventor:
Gottfried Weinhold
by
Michael S. Striker
18 11 71

Jan. 19, 1971

G. WEINHOLD

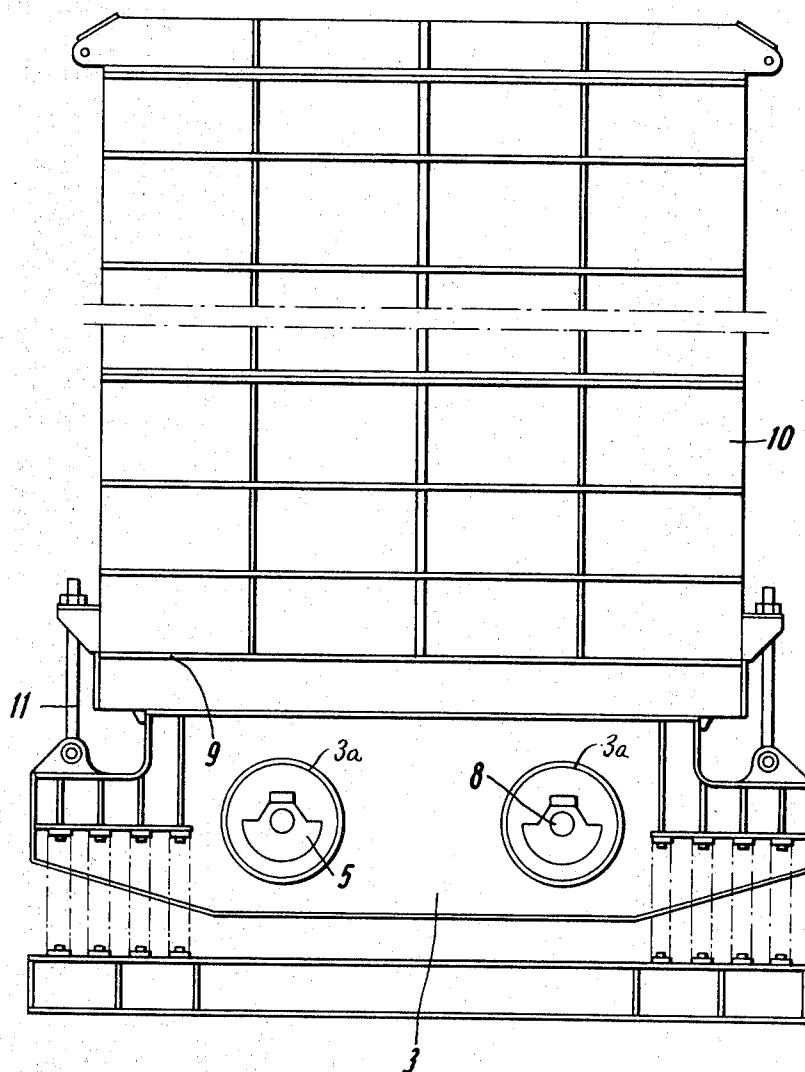
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APPARATUS FOR SHAPING OF GRANULAR SUBSTANCES

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Fig. 2



Inventor:

Gottfried Weinhold

by Michael J. Striker
Attorney

Jan. 19, 1971

G. WEINHOLD

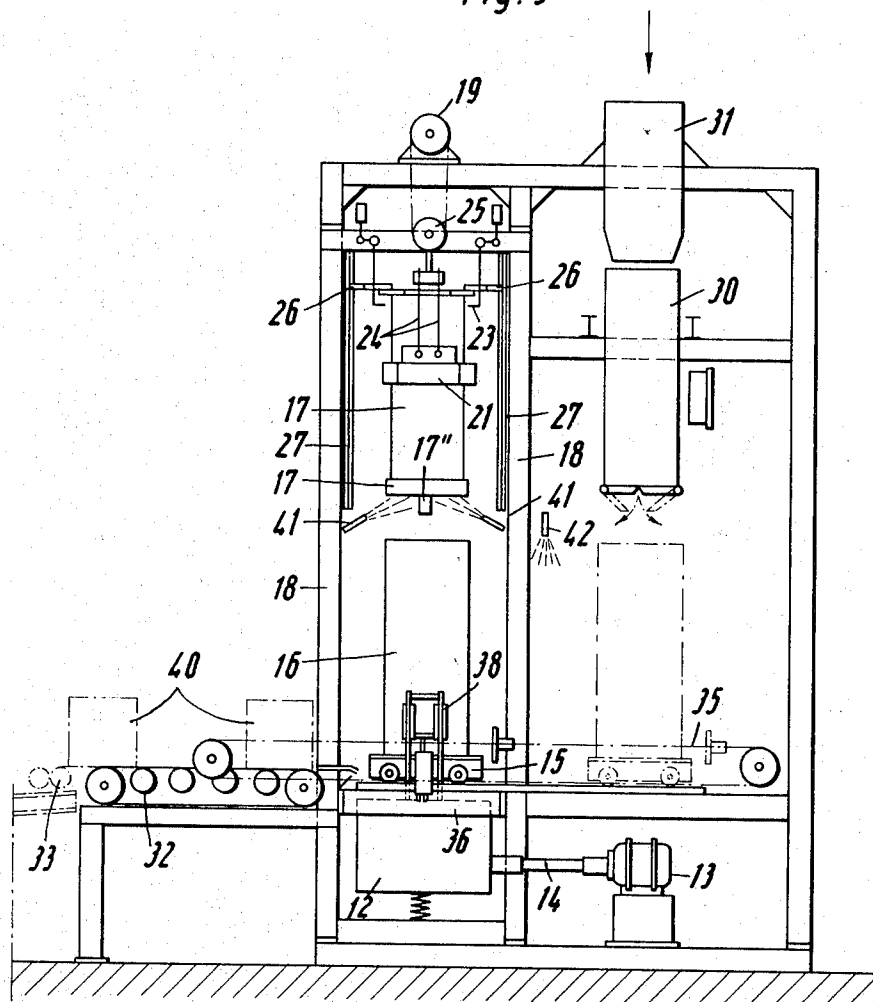
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Fig. 3



Inventor:

G. WEINHOLD

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Michael J. Stricker
att.

Jan. 19, 1971

G. WEINHOLD

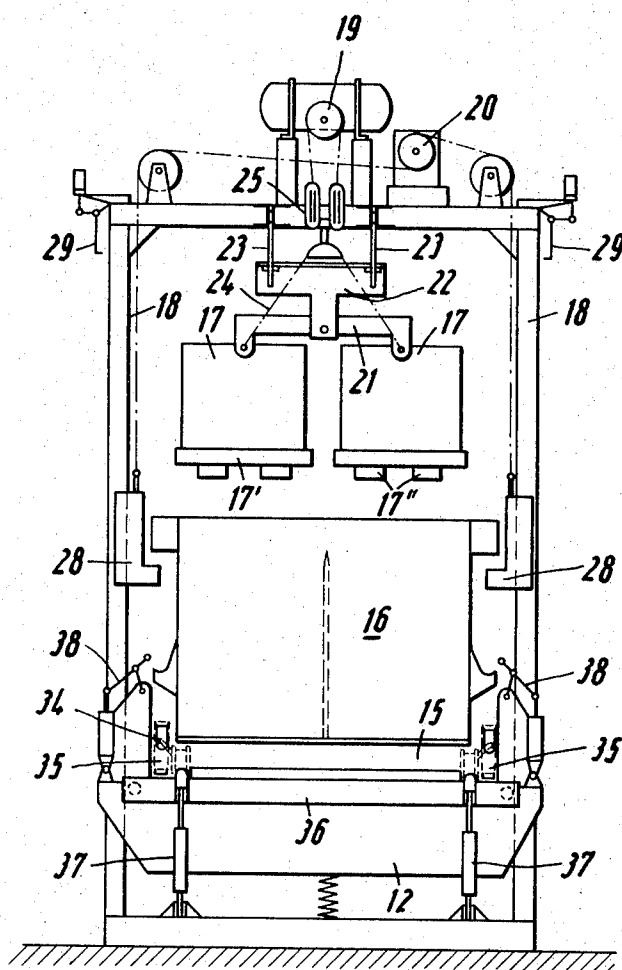
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APPARATUS FOR SHAPING OF GRANULAR SUBSTANCES

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Fig. 4



Inventor:
Gottfried Weinhold
by
Theodore J. Fritter
Attorney

Jan. 19, 1971

G. WEINHOLD

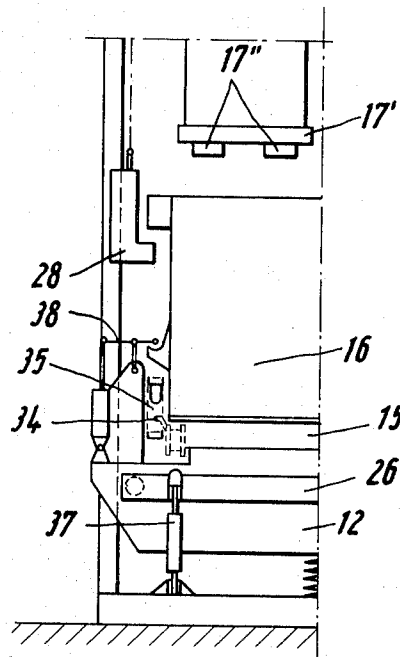
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APPARATUS FOR SHAPING OF GRANULAR SUBSTANCES

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Fig. 5



Inventor:

Gottfried Weinhold

Attorney

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APPARATUS FOR SHAPING OF GRANULAR SUBSTANCES

Gottfried Weinhold, Norf-Derikum, Germany, assignor to
Vereinigte Aluminium-Werke Aktiengesellschaft, Bonn,
Germany

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Divided and this application June 18, 1969, Ser.
No. 834,364

Claims priority, application Germany, Oct. 14, 1966,
V 32,125; July 1, 1967, K 62,705

Int. Cl. B29c 3/00

U.S. Cl. 18—5

10 Claims

ABSTRACT OF THE DISCLOSURE

A form is adapted to accommodate a quantity of granular material and is suspended on a plurality of springs for movement in a plurality of directions, including a pair of mutually opposite directions. At least two imbalanced masses are mounted on the form for rotation in mutually opposite directions. Drive means rotates the imbalanced masses in said directions so that the vibratory stresses transmitted by the rotating masses to the form, and tending to cause movement of the same in the plurality of directions, are balanced whereby the form performs movements only in the mutually opposite directions.

CROSS-REFERENCE TO RELATED APPLICATIONS

The present application is a division of my application Ser. No. 675,209, filed Oct. 13, 1967.

BACKGROUND OF THE INVENTION

The present invention relates to the shaping of granular masses in general, and more particularly to an apparatus for carrying out the shaping.

In a variety of applications it is necessary to compact granular materials into a predetermined shape so that they will form homogeneous bodies of uniform density. The materials used for this purpose are of sand-like consistency and of viscous character without, however, having a plastic character. In the aluminum-making industry with which the present invention is particularly concerned without, however, being limited thereto, such bodies are required as electrodes for electrical furnaces and consist of pole granules.

It is well known that in the aluminum industry the trend to ever larger furnaces requires the provision of ever larger anodes. Such anodes may reach weights of 4 tons and, once they have been formed from coal granules, are baked before they are ready for use. Until comparatively recently shaped bodies of this type were manufactured by compacting the granular masses in effect manually, namely by hand-held compacting tools or rammers which are operated by compressed air. However, this is a time-consuming and expensive process and is economically feasible only for certain special applications. An alternate solution was found in manufacturing the electrodes in presses, specifically in extrusion presses. However, these are suitable only for the production of comparatively simple and small-dimensioned articles because they limit the cross-sectional area of the article which can be manufactured and in practice permit only the production of one standard-sized article per extrusion press.

To manufacture larger dimensioned articles it has lately become known to use a stamping process where rammers are driven by eccentric shafts and stamp the granular mass for the purpose of compacting it into the desired shape. Machines of this type are relatively inexpensive as compared to extrusion presses capable of producing

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similarly dimensioned shaped articles. However, the stamping produces very significant vibrations and it is therefore necessary to construct special foundations for the machines to prevent the transmission of these vibrations to the buildings in which they are housed. This is expensive and, furthermore, even with these machines the size of articles which can be produced is relatively limited. An additional drawback of this type of machine lies in the fact that if the shaped articles are to be flawless and homogeneous throughout, the granular mass must be stamped in several layers which requires that the manufacturing process be subdivided into several stages. These problems exist particularly if the shaped articles, which hereafter will be referred to as electrodes because of the particular utility of the present invention for the manufacture of such electrodes, but which are not limited in this sense, exceed weights of approximately 3000 kg.

SUMMARY OF THE INVENTION

The present invention overcomes the disadvantages discussed above.

More particularly, the present invention provides an apparatus for manufacturing shaped articles from granular masses wherein the granular mass, whose consistency may range between a state of high viscosity—but not plasticity—and actual crumbliness, is subjected to compacting forces of between 10,000 and 30,000 kg. by having transmitted thereto a low frequency preferably in the range of 20–30 Hz. In accordance with the invention this low-frequency vibratory stress is transmitted by imbalanced masses which act upon the form in which the granular mass is accommodated and which stresses are so balanced by a spring mounting system for the form that the need for a special foundation is eliminated.

In accordance with one feature of my invention I provide an apparatus including means for suspending the form—in which the granular material to be compacted is accommodated—for movement in a plurality of directions including a pair of mutually opposite directions. I transmit to the form vibratory stresses at a plurality of points, which cause the form to attempt movements in the plurality of directions. Further in accordance with the invention I balance these stresses so that the resultant stress causes the form to perform movements only in the aforementioned pair of mutually opposite directions so that the granular material contained in the form is compacted into a solid body while the influence of the stresses is substantially limited to the form and the need for providing a special foundation is obviated.

By providing my novel apparatus I make it possible to manufacture the electrodes at a significantly lower cost than in the aforementioned prior-art process, taking into account the maximum size of electrodes which can be produced. Elimination of the special foundation constitutes a significant saving and, furthermore, means that the machine can be moved rather than having to be stationary. The entire quantity of granular material required for producing a given electrode, regardless of the size of the finished body, can be worked upon in a single operating stage and the size and configuration of the electrode can be varied in a most simple way by exchanging differently shaped and/or configured forms. This makes it possible to manufacture rather small electrodes, which are preferably constructed in a relatively large form which is subdivided into a plurality of individual compartments each of which corresponds to the size of the desired electrode so that several of the electrodes can be manufactured at the same time, as well as to manufacture large electrodes having a weight of 4 tons and even more. Furthermore, the homogeneity of the articles produced in accordance with the present inven-

tion is significantly better than what has been known heretofore.

My invention is based on the fact that two oppositely rotated masses with an exciter frequency w_{er} produce the force $m \cdot r \cdot w_{er}^2$. This causes vertical oscillations of the apparatus at a characteristic frequency w_e . In view of the fact that the masses are rotated in mutually opposite directions the main vibration stress components do not act in outward direction in the horizontal. The vertical oscillation produces in the supporting springs which are utilized in accordance with the invention, forces P_f which can be calculated for small amplitudes and for a non-damped arrangement as follows:

(r =dynamic factor)

$$P_f = \mp r \cdot m \cdot w_{er}^2$$

$$\gamma = \frac{w_e^2}{w_e^2 - w_{er}^2}$$

Thus, if w_e is smaller than w_{er} , r becomes smaller than 1, and in borderline cases r approaches 0.

This means that dynamic forces are practically eliminated in the springs and that a balance is established between exciter force and mass force so that no special foundations need to be erected for vibrating and compacting granular material into large-dimensioned bodies with an apparatus according to the present invention.

The novel features which are considered as characteristic for the invention are set forth in particular in the appended claims. The invention itself, however, both as to its construction and its method of operation, together with additional objects and advantages thereof, will be best understood from the following description of specific embodiments when read in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a somewhat schematic side view of an apparatus according to the present invention;

FIG. 2 is a front view of the apparatus illustrated in FIG. 1;

FIG. 3 is a diagrammatic side view of an apparatus according to my invention;

FIG. 4 is a view, with parts omitted for clarity, toward the right-hand side of FIG. 3; and

FIG. 5 is a detail view of FIG. 4.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Discussing now the drawing in detail, and firstly FIGS. 1 and 2 thereof, it will be seen that the machine according to the present invention comprises a base or frame 1 on which there are mounted the coil springs 4 which support the form, including the vibratory support 3 thereof. FIGS. 1 and 2 clearly show that the vibratory support 3 is mounted in "floating" condition—that is for free movement in all directions—on the springs 4 which are retained in suitable holders 2. Built into the support 3 are the imbalanced bodies 5 which are rotatable in recesses 3a in support 3 on the shafts 8 by having rotary movement transmitted thereto through the articulated shafts 7 from the drives 6. A suitable scale may be provided on the bodies 5 and permit adjustment of the vibratory force between zero and the maximum permissible range.

A forming plate 9 is supported on the support 3 and a form 10 is carried on the forming plate 9 and is rigidly but releasably connected with the vibratory support 3 and thus with the forming plate 9 by the hold-down arrangements 11. A suitable metering arrangement fills the interior of the hollow form 10 with the requisite quantity of granular material and, when a cover plate has been placed onto the granular material in the form 10 in a manner which will be subsequently discussed in more detail, vibratory movement is initiated. By guiding the

cover plate within the form 10 I assure that the body which is being produced receives a smooth, straight upper surface.

While FIGS. 1 and 2 show the bodies 5 connected to the support 3, it is to be understood that the vibratory force could also be transmitted through the aforementioned cover plate, in which case the bodies 5 would have to be mounted for rotation on or in the cover plate in a manner which will be readily understood by those skilled in the art.

Coming now to FIGS. 3-5, which illustrate an embodiment of the invention in more detail, it will be seen that the vibration apparatus comprises a vibratory support 12 which may be vibrated for instance by two oppositely rotating imbalanced masses or bodies in the manner illustrated in FIGS. 1 and 2. These bodies are rotated by respective electromotors 13 via two shafts 14 and suitable couplings or gears, which are not illustrated because they are conventional. A forming plate 15 is provided with fields and a form 16 is supported on the forming plate 15. A cover plate or weight 17 is provided and, to permit removal of the cover plate 17 and of the form 16 individually upon completion of the compacting process, a frame 18 is provided on which electrically operated lifts 19 and 20 in form of pulleys or the like are arranged. The cover plate 17 is supported on a traverse 21 whose upper portion 22 is held by grippers 23 in the rest position, and these grippers may be hydraulically operated. It will be understood that, if a plurality of relatively small finished bodies are to be produced rather than a single large body, the form 16 may be subdivided internally into a plurality of compartments. In that case the cover plate 17, which rests on the granular material within the form 16 to weight this material, may be similarly subdivided in that it comprises a plurality of portions each of which extends into one of the compartments and rests on the granular material therein. This assures that the weight is equally distributed to the material in all of the compartments.

The traverse 21 is connected to the lift 19 by means of cables 24 and pulley wheels 25. FIG. 3 shows that glides 26 are provided on the traverse which engage guide rails 27 on opposite sides. Inasmuch as the guide rails are connected to the frame 18 the cover plate 17 is thus reliably guided for straight movement. It is advantageous that the guide rails 27 be so configured that their profile tapers in downward direction in such a manner that during the actual vibration the glides 26 will have no contact with the guide rails.

In view of the fact that the cover plate 17 is intended to be usable both under circumstances where a single large body is to be produced and under circumstances where a plurality of relatively small bodies are to be produced in the form 16, it is advantageous that a plurality of projecting rams 17' be provided which are mounted on a replaceable bottom plate 17' so that a simple exchange suffices to convert the plate 17 to the desired mode of operation.

The lift 20 is provided for lifting the form 16 and to this purpose counterweights 28 (compare FIG. 4) are connected to the cables of the lift 20 at opposite sides of the frame 18. Once the form 16 has been lifted off the forming plate 15 it is secured by hydraulically operated grippers 29.

A weighing arrangement 30 is provided adjacent to the frame 18 and includes a plurality of containers whose number may correspond to the number of compartments in the form 16. Advantageously the containers, which at their undersides are provided with discharge openings, are so constructed that the closure for these discharge openings will expose the entire cross section of the opening when discharge is being effected so that the granular mass, which has a tendency to clump together, will be discharged into the form 16 without danger of residual quantities remaining in the containers. Adjustable chutes

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(not illustrated because known in the art) feed a distributor device 31 which distributes the granular mass to the containers.

Located at the other side of the vibrating apparatus is a transporting arrangement for the finished compacted bodies. In the illustrated embodiment, which is only exemplary and by no means to be considered exhaustive, this arrangement consists of a driven belt which is supported by the supporting rollers 32 and which leads to an inclined roller conveyor 33 of known construction. Of course, grippers can be used to replace the driven belt and they can be so connected with the vibrating apparatus itself that they will automatically remove the finished electrodes from the apparatus and convey them to a given location.

In operation of the apparatus illustrated in FIGS. 3-5 the engagement portions 34 provided on the member 15 engage into chains 35 located at opposite sides of the member 15 so that, when the form 16 has been filled with material as illustrated in broken lines at the right-hand side of FIG. 3, the form is conveyed into its operative position over the vibratory support 12. It is advantageous if the vibratory support is surrounded by a frame which is vertically movable and which is provided with rails for the rollers of the forming plate 15. The frame is identified in FIG. 3 with reference numeral 36 and can be raised and lowered together with the form 16 by means of four hydraulic cylinders 37 which are connected at the four corners of the frame 36. By means of the frame 36 the forming plate 15 can be so lowered that it will rest with its underside on the vibratory support 12 so that the rollers of the forming plate need not carry any load. In accordance with the illustrated embodiment the projections 34 will disengage from the chains when the lowering occurs. It is advantageous that the piston rods of the hydraulic cylinders be so connected with one another that they will be maintained at identical elevation and can thus be controlled with a single regulating valve. This assures that no tilting of the frame 36 occurs. In accordance with the invention it is further advantageous that, as the frame 36 is lowered, the plate 17' of the cover plate 17 is sprayed with a suitable emulsion, for instance an oil emulsion, from several nozzles 41 which are actuated by such lowering via a suitable control device many of which are known in the art and which does not constitute a part of the invention. The oil emulsion is provided for the purpose of facilitating separation of the plate 17 from the compacted body and excess emulsion is allowed to drip into the form 16.

It will be understood that the form 16 and the vibratory support 12 must be rigidly connected with one another for operation of the device. It is therefore advantageous to effect such connection by means of hydraulic cylinders which act upon a force-magnifying lever arrangement being such that the use of the lever arrangement permits advantageous dimensioning of the hydraulic cylinders as far as size and force are concerned.

In operation of the device it is advantageous that the plate 17 is lowered into the upper open end of the form 16 while the latter is being releasably coupled to the vibratory support 12. Of course, it will be understood that the plate 17 must rest loosely on the mass in the form 16 so that, as the volume of the mass decreases during compaction, the plate 17 will continue to rest on the upper surface of the mass and will exert pressure at all times. The actual vibration procedure in the apparatus according to the present invention will last approximately 4 minutes and, when it is completed, the form 16 is first lifted slightly which will ease separation of the electrode from the form, and thereupon the plate 17 and the form 16 are lifted completely and withdrawn so that the shaped body, namely the completed electrode, now rests exposed on the plate 15. The electrode is now conveyed to the transport arrangement 32, advantageously by means of the chain 35 and by being conveyed over the lowered

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forming plate 15. When this is completed the forming plate is restored to its position, the form 16 lowered onto the forming plate 15, and the form conveyed on the forming plate 15 below a spraying device 42 which is diagrammatically illustrated in FIG. 3 and which sprays an oil emulsion into the interior of the form 16. How this is accomplished, and the control of the spraying device 42 are well known in the art and need not be further described. Once the interior of the form 16 has been sprayed, the form is conveyed to the spraying arrangement 30 where it is filled with new granular mass, and it is then returned to the vibratory support. In view of the fact that all operating components of the apparatus illustrated in FIGS. 3-5 are arranged in close association with one another it is advantageous to connect the entire apparatus to a control or program device so that all steps of the operation will be automatically carried out, thus eliminating the danger of wrong operation by an operator, it being understood that if an operator were to control the manifold steps by manual actuation of switches or the like, errors could not be avoided.

It will be understood that each of the elements described above, or two or more together, may also find a useful application in other types of arrangements differing from the types described above.

While the invention has been illustrated and described as embodied in an apparatus for shaping of granular substances, it is not intended to be limited to the details shown, since various modifications and structural changes may be made without departing in any way from the spirit of the present invention.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can, by applying current knowledge, readily adapt it for various applications without omitting features that, from the standpoint of prior art, fairly constitute essential characteristics of the generic or specific aspects of this invention.

What is claimed as new and desired to be protected by Letters Patent is set forth in the appended claims:

1. Apparatus for compacting granular material, comprising in combination, a form adapted to accommodate a quantity of granular material and including a support provided with at least two recesses, a forming table carried by said support, and a hollow mold carried by said forming table and releasably connected with the same and said support; suspending means comprising a plurality of springs and suspending said form, including said support, for movement in a plurality of directions, including a pair of mutually opposite directions; and stress-producing means comprising at least two imbalanced rotating bodies each accommodated in one of said recesses for producing and transmitting to said form vibratory stresses at a plurality of points whereby said form tends to move in said plurality of directions, and for balancing said stresses so that the resultant stress causes said form to perform movements only in said mutually opposite directions.

2. Apparatus for compacting granular material, comprising in combination, a support provided with at least two recesses, a forming table on said support, and a hollow mold on said forming table and releasably connected with the same and said support; suspending means suspending said support for movement in a plurality of directions, including a pair of mutually opposite directions; and stress-producing means comprising at least two imbalanced rotating bodies each accommodated in one of said recesses for producing and transmitting to said support vibratory stresses at a plurality of points whereby said support tends to move in said plurality of directions, and for balancing said stresses so that the resultant stress causes said support to perform movements only in said mutually opposite directions.

3. Apparatus as defined in claim 2, wherein said suspending means comprises a plurality of springs mounting

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said support for said movement in a plurality of directions.

4. Apparatus as defined in claim 1, wherein said hollow mold has an upper opening; and further comprising weight means configured so as to be guidedly receivable in said upper opening and adapted to rest on the granular material accommodate in said mold.

5. Apparatus as defined in claim 2, wherein said stress-producing means further comprises drive means operatively associated with said bodies for rotating the same in mutually opposite directions.

6. Apparatus as defined in claim 4, and further comprising lifting means operatively associated with said weight means and said mold and operative for lifting the former from the latter and for lifting the latter from said forming table.

7. Apparatus as defined in claim 4, wherein said mold comprises at least two discrete compartments, said weight means comprising a mounting member and at least two weight members carried by said mounting member and each receivable in one of said compartments.

8. Apparatus as defined in claim 1, further comprising connecting means for rigidly but releasably connecting said forming table with said vibratory support.

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9. Apparatus as defined in claim 8, said connecting means comprising a plurality of fluid-actuated cylinder and piston units, and force-magnifying lever means associated with said units.

10. Apparatus as defined in claim 8; further comprising a frame surrounding said forming table peripherally thereof and supporting said forming table and said mold; and control means for lowering and raising said frame between positions in which said forming table respectively rests on and is upwardly spaced from said support.

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CHARLES W. LANHAM, Primary Examiner

M. O. SUTTON, Assistant Examiner

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