# VARIOUS VIBRATION METHODS FOR THE FORMING OF CARBON PRODUCTS

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## 1. Introduction:

In many industrial fields the vibration or shaking principle is a well-known technique for compacting granular materials. The vibration methods differ widely. Vibratory compaction can be very effectively applied to shape green carbon mixtures. During the last two decades a fascinating development took place in the area of vibration forming of carbon products. For sake of its own manufacture of large anode and cathode blocks for aluminium reduction cells and also other electrodes the Vereinigte Aluminium-Werke AG has been strongly engaged in the development and application of vibrating machines.

## 2. Principle of a vibratory compacting machine:

The fundamental parts commonly used for the construction of a vibratory moulding apparatus for green carbon mixtures are illustrated diagrammatically in Fig. 1. The arrangement and connection of the moulding parts (designated as 2, 3 and 4 in Fig. 1) on the vibrating table (1) plays a significant role for the efficiency and uniformity of compaction. Viscous carbon mixes containing pitch-coated coke particles do not behave like dry granular materials. They exhibit a high damping factor. During vibration the heavy top weight acts as a counter-mass and exerts compressing impacts on the carbon mixture. One variable clearly defined in the vibrating system is the exciting force and its frequency.

It is however very difficult to describe the mechanism of the whole vibrating machine by useful mathematical equations. Furthermore there are compaction parameters of the carbon mixtures like binder viscosity, kind of filler material and plasticity.

## 3. Types of vibratory compacting machines:

On the basis of the construction elements in Fig. 1 a series of forming modifications were investigated in our laboratory ten years ago. Some models are shown as simplified drawings in Fig. 2 to 6. Generally it could be stated that excellent compaction is attained if the main parts of the moulding equipment are allowed to vibrate independently. Relative motions should occur between bottom plate, shell and top weight. It was observed that even good compactness could be reached when transferring vertical vibratory motions from the shell surface to the green carbon mixture by friction forces. The arrangement according to type V (Fig. 3) has become our standard shaping procedure in our laboratory to develop product formulations. The assembly according to type IV (Fig. 2) is applied for most of the industrial vibration units, because it has obviously less engineering problems.

Additional measures may be taken to intensify compaction by a variable speed drive to adjust the frequency to an optimum, by hydraulic or pneumatic pressures upon the top weight to induce a slight continuous flow in the viscous medium (see Fig. 4), or by application of vacuum to remove the detrimental air from the carbon mix (see Fig. 5). The pronounced advantages of vacuum vibration forming are increased apparent densities of the carbon products by 0.05 to 0.1 $g/cm^3$, an improved shape stability of large blocks and a better homogeneity and structure. An example of a vibration mould for special shapes is depicted in Fig. 6.

## 4. Plant vibratory machines:

Most modern vibratory compacting machines are characterized by maximum exciting forces of about 1000 kN at 1450 r.p.m. and combined application of variable rotation speed, vacuum and additional hydraulic pressure to the top weight. These machines are capable of moulding carbon blocks up to a weight of about 3.3 metric tons and a length of 3.7 m (12 feet).

## 5. Development of continuous vibrating methods:

A continuous compacting and shaping method might be desirable when a great number of identical pieces has to be produced. The vibrator has not to be started and stopped for each carbon body formed. The passage of critical vibration regions is avoided and time is saved for "working" of the green carbon mixture.

The vertical section of an experimental strand vibratory compactor is shown in Fig. 7. It represents a first attempt in the direction in making electrodes without interruption. The mixture is filled into a vertically vibrating tube and sinks down into a funnel-shaped compacting chamber, where it is compressed from a larger to a smaller diameter by horizontally vibrating wall-segments. The wedge-shaped space is alternately narrowed and widened. So far promising results have been obtained.

Another concept for a continuous vibratory moulding procedure is outlined in Fig. 8. The carbon mixture is moved on a conveyor belt with L-shaped mould sections between a vibrating table and a top weight carrying a sloping bottom plate. The side walls (not shown in Fig. 8) are fixed to the vibrating table and form a lane through which the L-shaped sections travel.

The above-mentioned methods exemplify the great versatility of the vibration principle for forming carbon bodies.

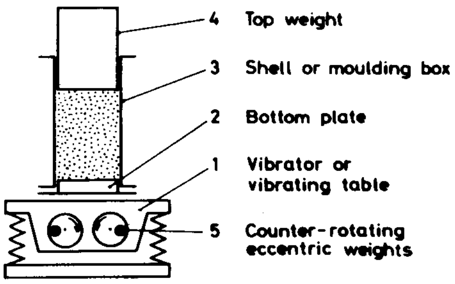



Fig. 1 Main parts of a vibratory compacting machine

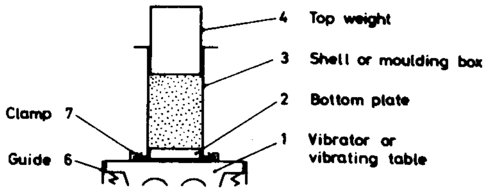



Fig.2 Vibratory compactor Type IV
Parts 1, 2 and 3 are connected

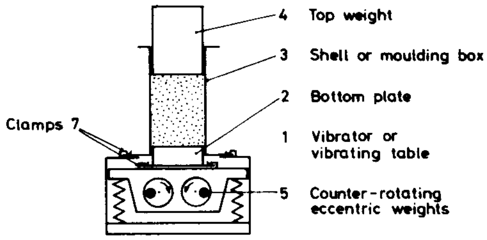



Fig.3 Vibratory compactor Type V
Parts 1 and 2 are connected, part 3 is connected to the frame

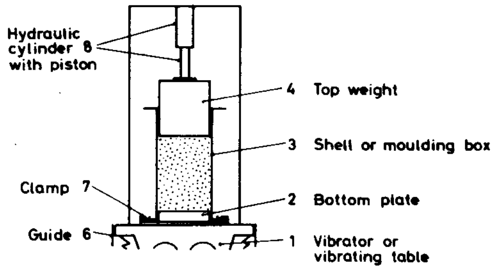



Fig.4 Vibratory compactor Type VIII
Parts are connected as in type IV.
Additional hydraulic pressure upon top weight

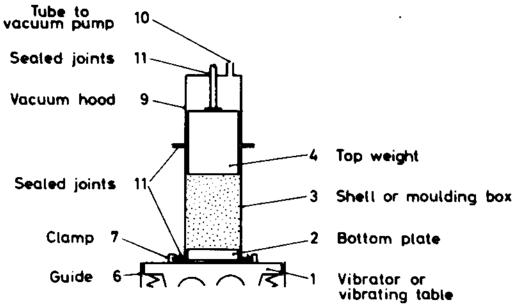



Fig.5 Vibratory compactor Type IX
Parts are connected as in type IV.
Additional application of vacuum

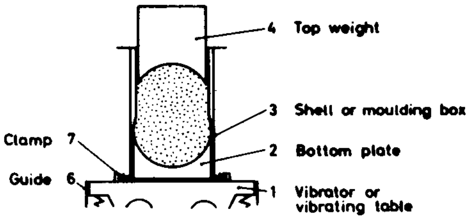



Fig.6 Vibratory compactor Type X
Horizontal forming of cylinders.
Parts are connected as in type IV

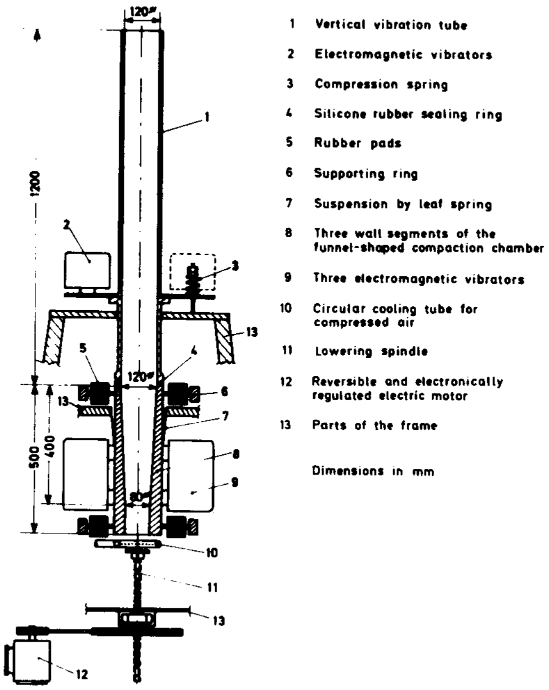
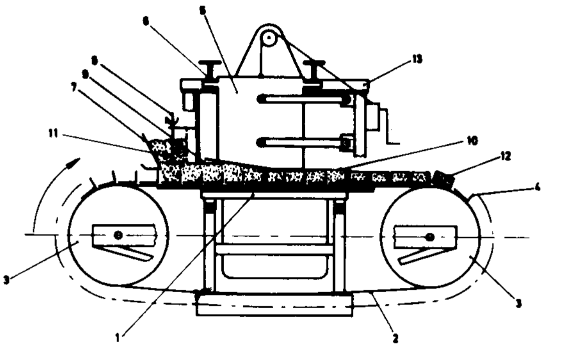



Fig.7 Diagrammatic view of our laboratory strand vibration compactor




1 Vibrating table with electromagnetic vibrator
2 Steel conveyor belt
3 Belt pulley
4 L-shaped moulding section
5 Top forming weight with slope at bottom
6 Adjusting screw
7 Charging box
8 Adjustable charging device
9/10 Sheet of spring steel
11 Green carbon mixture
12 Shaped body
13 Frame

Fig.8 Diagrammatic side view of a conveyor belt vibration compactor