United States Patent

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[15] **3,650,482**

[45] **Mar. 21, 1972**

[54] MATERIAL-TREATMENT MACHINES

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[22] Filed: **Jan. 26, 1970**

[21] Appl. No.: **5,871**

[30] **Foreign Application Priority Data**

Jan. 30, 1969 Great Britain.....5,533/69
Mar. 29, 1969 Great Britain.....16,576/69

[52] **U.S. Cl.**.....**241/153,** 241/175, 241/199, 259/59

[51] **Int. Cl.**.....**B02c 17/06,** B02c 17/14

[58] **Field of Search**.....241/137, 153, 175, 199, 284; 259/54, 56, 59, DIG. 42; 74/38, 40; 51/163

[56] **References Cited**

UNITED STATES PATENTS

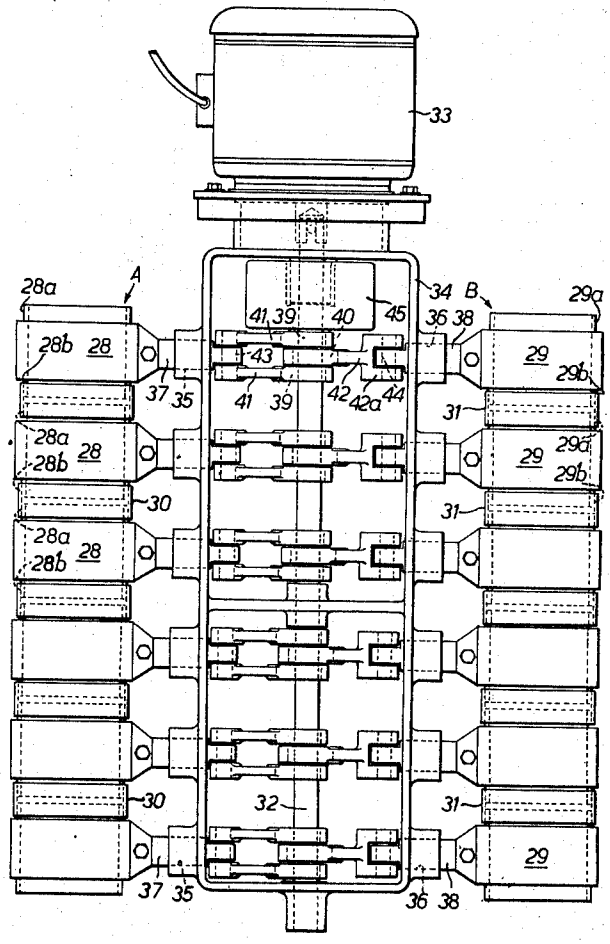
3,433,421 3/1969 Moore.....241/175
3,212,722 10/1965 Maeder et al.....241/153

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[57] **ABSTRACT**

A machine for the treatment of material, for example for the size reduction of solid materials, comprises carrier means for supporting the material and means for suspending and positively driving the carrier means so as to vibrate the latter at a fixed amplitude and frequency. A plurality of the carrier means is provided, suspended and positively driven in such manner that the two or more carrier means and driving means are inherently balanced.

10 Claims, 4 Drawing Figures



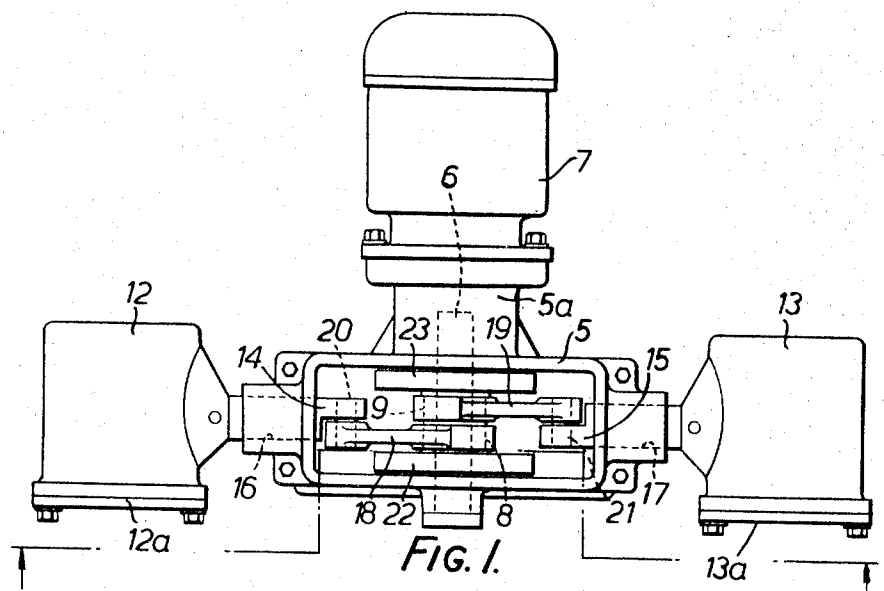


FIG. 1.

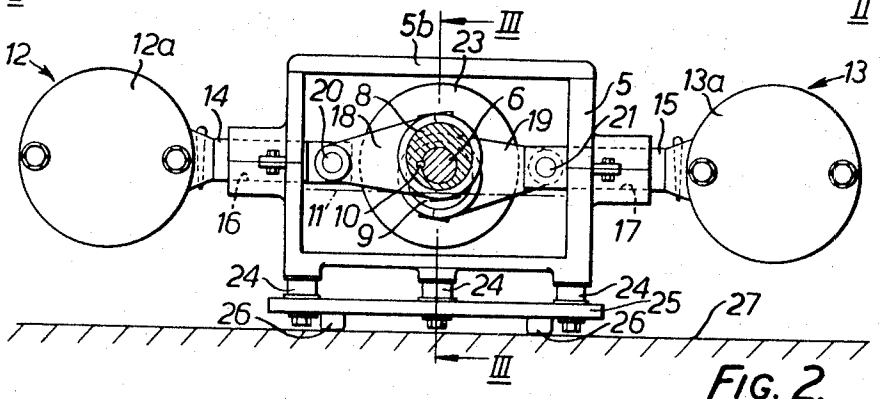


FIG. 2.

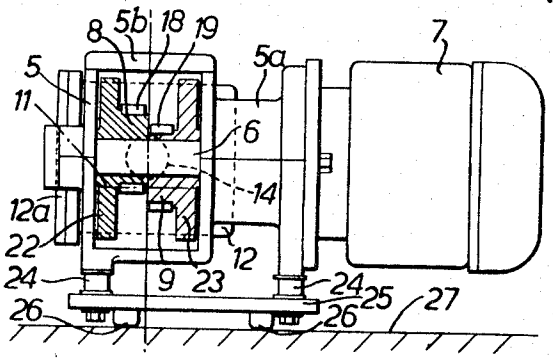


FIG. 3.

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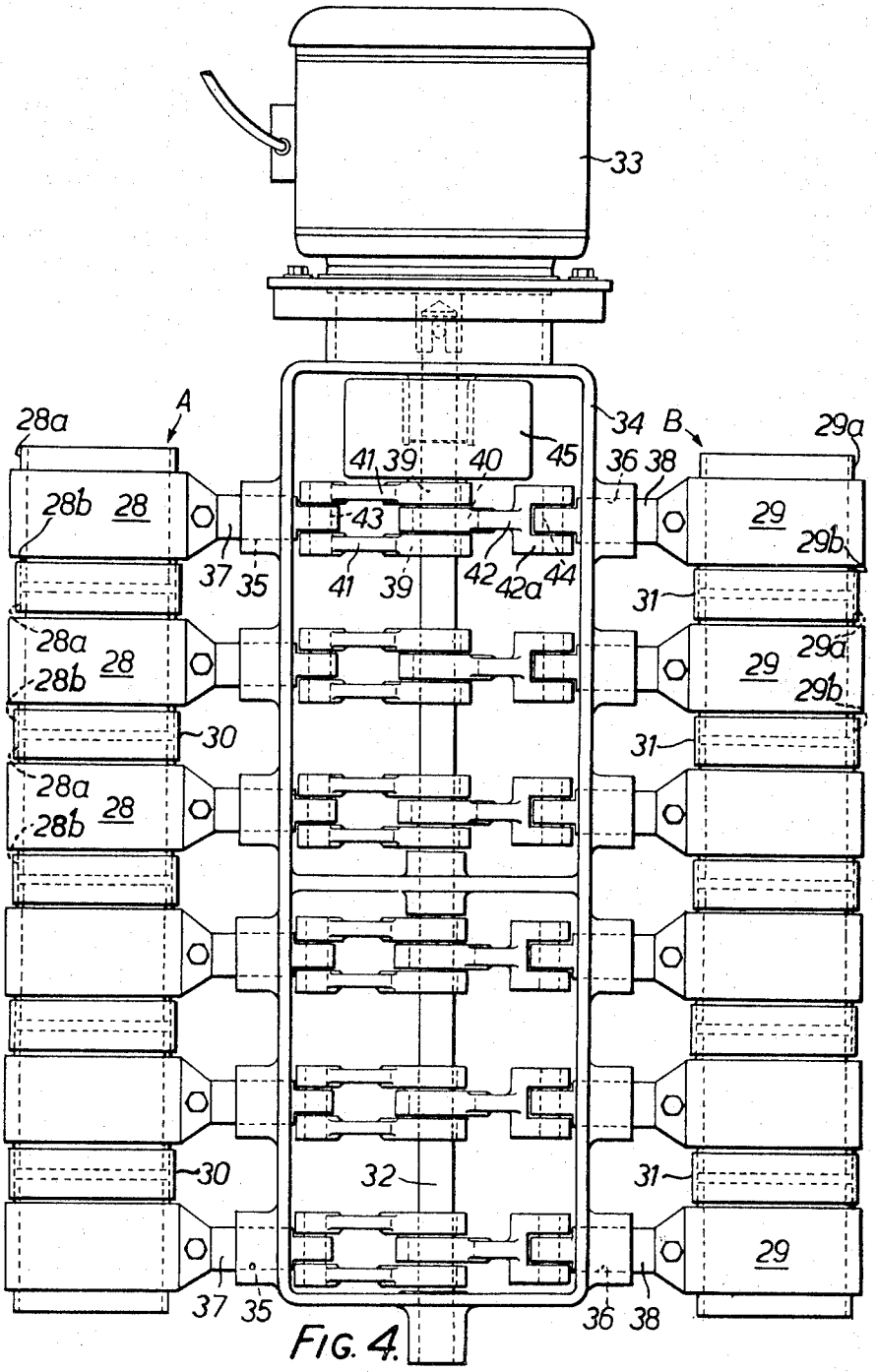


FIG. 4.

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MATERIAL-TREATMENT MACHINES

This invention relates to machines for the treatment of material supported by carrier means subjected to motion during operation of the machine. Examples of such material-treatment machines are machines for the comminution of matter into smaller particles, such as milling machines for the size reduction by grinding or ores, chemicals, foodstuffs or the like.

Milling machines for large throughputs are generally of the rotating ball mill or tube mill type which rotate slowly and depend for their grinding action upon a tumbling process. Vibration milling, on the other hand, is a much higher specific energy process, allowing considerable energy to be put into relatively small volumes of material to be treated. Vibration mills, or vibratory grinding machines as they are sometimes termed, have the material to be treated supported by carrier means comprising a chamber or chambers containing the material to be comminuted, sometimes with other grinding media such as metallic or ceramic balls or rollers, and which are vibrated. The operation is sometimes carried out in the dry form, but very often liquid is added and the resulting comminuted material is taken out in the form of a paste or clay.

The feeding of the base material into the machines, especially the larger ones, is often performed continuously and the extraction of the comminuted material is likewise carried out on a continuous basis. There are, however, many machines, especially those of smaller capacities, that comminute material within closed chambers in a single batch, the machine being stopped for extraction and replenishment of the comminuted and base material respectively.

It has been established that the efficiency and speed of comminution, especially to small particle size, demands a high energy input to the volume of the material to break down the molecular bonds. This can be performed by vibrating grinding chambers in a particular mode frequency and amplitude depending upon the specific materials and requirements. Hitherto this form of vibration grinding has utilized chambers mounted resonantly with springs or the like and excited by various means including the rotation of out-of-balance masses to give the oscillations.

However, spring or other resonant mountings are prone to fatigue failure and to variations in amplitude of vibration, and the present invention has for its main object to avoid these drawbacks.

According to the invention a machine for the treatment of material comprises carrier means for supporting the material and means for suspending and positively driving said carrier means so as to vibrate the latter at a fixed amplitude and frequency. Preferably a plurality of carrier means is provided, suspended and positively driven in such manner that the two or more carrier means and driving means are inherently balanced. Thereby leakage of troublesome and damaging vibrations into surrounding buildings or other structures—a problem which becomes more acute as the energy and size of the machinery increases—is prevented.

The aforesaid driving means preferably comprise an input shaft or the like, rotary motion of which is converted by a mechanical linkage into rectilinear vibratory motion of the carrier means. Said mechanical linkage may comprise a slider-crank mechanism. The conversion of rotary into rectilinear vibratory motion is performed in such manner that the vectorial sum of the inertia forces over the whole system is or near to zero at all times. In this manner the higher inertial acceleration forces which are generated by the violent reciprocating motion of the carrier means and driving mechanism are balanced inherently so that little or no vibration is transmitted by the machine.

In accordance with a further feature of the invention a series of the vibratory carrier means is provided and arranged with an outlet of one carrier means in close proximity to and connected with an inlet of another carrier means of the series, the arrangement being such that the material to be treated passes from one to another carrier means of the series to

receive progressive or staged treatment. When the machine is a comminution machine the carrier means may comprise a grinding chamber for containing the material to be comminuted, with or without other grinding media. The carrier means may comprise grinding chambers each having an inlet and an outlet disposed transversely of the direction of vibration, the grinding chambers being connected by tubular couplings such that they form therewith a tube or conduit along which the material to be comminuted passes.

One construction of material-treatment machine in accordance with the invention has two series of the vibratory carrier means with the driving means vibrating the carrier means of each series substantially in phase with one another and substantially in antiphase with those of the other series.

The invention will now be described as applied to vibration mills for the size reduction of solid material in the dry state. Two specific embodiments are illustrated, by way of example, in the accompanying drawings, in which:

FIG. 1 is a plan view, with the cover of the main case of the machine removed, of one construction of vibration mill in accordance with the invention and having two grinding chambers,

FIG. 2 is a front elevation of the machine, partly in section on the line II—II of FIG. 1, to show the arrangement of crank pins or eccentrics of the slider-crank mechanism of the machine resulting in an inherently balanced construction,

FIG. 3 is a side elevation of the machine, partly in section on the line III—III of FIG. 2, and

FIG. 4 is a plan view, similar to FIG. 1, but showing a multiple-chamber mill having two series of grinding chambers.

Referring to FIGS. 1 to 3, the main case 5 provides bearings for an input shaft 6 driven by an electric motor 7 bolted to an extension 5*a* of the main case. The shaft 6 has two diametrically opposed crank pins formed by loose eccentrics 8 and 9 keyed to the shaft as shown at 10 (FIG. 2). As illustrated, the shaft is supported in plain bearings which are splash lubricated, the oil level in the main case 5 being indicated at 11 in FIGS. 2 and 3. The two grinding chambers are shown at 12 and 13, each provided with a removable closure plate shown at 12*a* and 13*a* respectively.

Each grinding chamber 12 or 13 is positively mounted on a crosshead slide member 14 or 15 respectively which is free to move linearly along the axis of a bearing 16 or 17 integral with the main case 5. It will be seen from FIGS. 1 and 2 that the axes of the two crosshead slide members are collinear, and along this common axis the two grinding chambers 12 and 13 are reciprocated in opposition by the diametrically opposed eccentrics 8 and 9. This balanced reciprocation of the two grinding chambers is achieved by converting the continuous rotary motion of the shaft 6 into rectilinear motion of the chambers through a mechanical linkage consisting of the eccentrics 8 and 9, connecting rods 18 and 19 and the crosshead slide members 14 and 15. As will be seen from FIG. 1, the connecting rods 18 and 19 are axially offset and are connected to the collinear crosshead slide members 14 and 15 by gudgeon pins 20 and 21. The slider-crank mechanism thus constituted provides a positive drive to the grinding chambers 12 and 13.

As with the plain bearings of the shaft 6, the crank pin and gudgeon pin bearings are splash lubricated by the oil 11 in the main case 5, as are also the crosshead bearings 16 and 17. The main case 5 is provided with a cover 5*b* which may be removed for oil replenishment as required. Alternatively, of course, any or all of the aforesaid bearings may be pressure lubricated; moreover the bearings for the shaft 6 may be of the ball or roller type.

The high inertia forces transmitted through the connecting rods 18 and 19 give rise to a large cyclically fluctuating inertia torque on the shaft 6 and accordingly a flywheel system is incorporated in the driving means to limit the variation in shaft speed to a low value and enable the electric motor 7 to operate satisfactorily. In the construction illustrated two flywheels are provided, each eccentric 8 or 9 having a flywheel 22 or 23 respectively integral therewith, as best seen

in FIG. 3, so that the inertia torque is taken directly into each flywheel from the connecting rod through the eccentric. Thereby no undue cyclic torsion is transmitted through the shaft.

As illustrated, the machine is free standing with the main case **5** mounted through the intermediary of rubber bushes **24** upon a base plate **25** which is itself provided with rubber feet **26** by means of which the machine stands upon a bench, floor or other surface **27**.

Although the machine described has two grinding chambers driven from two diametrically opposed eccentrics in order to provide a design in which all inertia forces are inherently balanced, it will be understood that the same result may be achieved with three chambers driven from three eccentrics at 120° spacing, and so on.

Referring now to FIG. 4, the machine illustrated therein again has paired grinding chambers driven from diametrically opposed eccentrics. However, in this machine there is a series of grinding chambers on each side of the input shaft, each series forming a vibrating conduit. Thus, the conduit A consists of a series of six grinding chambers **28** having transversely arranged inlets and outlets **28***a*, **28***b*, respectively, with the outlet of the first grinding chamber of the series in close proximity to the inlet of the second, and so on, and with the outlets and inlets connected by flexible tubular couplings **30**. Similarly the conduit B consists of a series of six grinding chambers **29** having transversely arranged inlets and outlets **29***a*, **29***b*, respectively, with the adjacent outlets and inlets connected by flexible tubular couplings **31**.

The material to be comminuted passes along the tubular conduits A and B from end to end, receiving vibrational energy in the grinding chambers **28** and **29** as it progresses therealong. All sections of the conduit A are vibrated substantially in phase with one another and in antiphase with the corresponding sections of the conduit B. The vibrations of the individual conduit sections **28** and **29** are generated by positive driving means similar to those already described with reference to FIGS. **1** to **3**, thus achieving overall force balance throughout the system. As illustrated, the machine has an input shaft **32** common to all the grinding chambers **28** and **29** of both series and driven by an electric motor **33** at one end. The shaft **32** is carried in bearings in an elongated main case **34** which, as before, provides bearings **35** and **36** for crosshead slide members **37** and **38** by which the grinding chambers **28** and **29**, respectively, are carried. On the shaft **32** are mounted the operating eccentrics **39** and **40** by means of which the continuous rotary motion of the shaft is converted into rectilinear motion of the crosshead slide members **37** and **38** through connecting rods **41** and **42** and gudgeon pins **43** and **44**, respectively.

In order to achieve a collinear arrangement of the axes of each pair of crosshead slide members **37** and **38** the eccentrics **39** are duplicated and have the eccentric **40** disposed between them. Each connecting rod **41** is correspondingly of duplex construction and has the gudgeon pin **43** extending between its spaced small ends with the crosshead slide member **37** disposed therebetween. On the other hand each connecting rod **42** is of substantially Y formation with the crosshead slide member **38** disposed between the two portions **42***a* of its bifurcated small end. A flywheel **45** is arranged on the shaft **32** between the eccentrics for the first pair of grinding chambers of the two series and the electric motor **33**.

Although in the construction described a single electric motor is provided, in an alternative arrangement a pair of motors may be employed, one for starting the machine and the other for continuous operation once the machine has been started up.

It will be seen that with the material to be comminuted entering at one end of a conduit A or B it will progressively receive vibrational energy during its passage along the conduit. The two conduits may be operated in series or in parallel and may be composed of any desired number of grinding chambers depending upon the specific grinding energy necessary for the particular comminuting process and the rate of flow of the material along the conduit.

With the construction of machine described large throughputs of material can be obtained by progressive multiplication of the balanced vibration grinding chambers, and a continuous flow of comminuted material arranged.

Moreover, although in the construction described the grinding chambers of the complete series are vibrated at the same amplitude, different amplitudes may be adopted as between one pair of the series and another. For example, assuming the two conduits A and B to be operating in parallel and the material to be entering at the motor end of the machine, a diminishing amplitude of vibration of the grinding chambers may be advantageous towards the discharge end of the machine.

I claim:

1. A machine for the treatment of material, comprising a supporting structure, a plurality of carrier means for supporting the material to be treated, said carrier means being disposed outside said structure laterally thereof, and driving means comprising a crankshaft extending longitudinally within the structure, connecting rods engaging the crankshaft, and slide members mounted for linear reciprocatory motion in bearings laterally of said structure, the connecting rods being coupled to the respective ones of said carrier means through said slide members and the arrangement being such that said carrier means and driving means produce a balanced arrangement.

2. A machine according to claim **1**, wherein the carrier means are vibratory and a series of the vibratory carrier means is provided and arranged with an outlet of one carrier means in close proximity to and connected with an inlet of another carrier means of the series, the arrangement being such that the material to be treated passes from one to another carrier means of the series to receive progressive or staged treatment.

3. A machine according to claim **1** and intended for the comminution of material, wherein the carrier means comprise a grinding chamber for containing the material to be comminuted, with or without other grinding media.

4. A machine according to claim **2**, wherein there are two series of the vibratory carrier means and the driving means vibrate the carrier means of each series substantially in phase with one another and substantially in anti-phase with those of the other series.

5. A machine according to claim **1**, wherein the carrier means are supported cantilever fashion by the respective slide members.

6. A machine according to claim **1**, comprising at least one pair of carrier means disposed on opposite sides of the structure, the carrier means being vibrated in anti-phase.

7. A machine according to claim **1**, wherein the structure comprises a closed casing providing an oil reservoir with splash lubrication of the driving means housed within the casing, the casing having side walls through which the slide members project and providing said bearings therefor and end walls between which the crankshaft extends and which provide bearings for the crankshaft.

8. A machine according to claim **7**, wherein one of said end walls has an external mounting for an electric driving motor so that the motor can be coupled directly to the crankshaft to provide a self-contained balanced machine.

9. A machine according to claim **2**, wherein the carrier means comprise grinding chambers each having an inlet and an outlet disposed transversely of the direction of vibration, the grinding chambers being connected by tubular couplings such that they form therewith a tube or conduit along which the material to be treated passes.

10. A machine according to claim **9**, wherein the grinding chambers are provided with grinding media which are of different sizes as between one grinding chamber and another of the series, such that a progressive or staged size reduction of the material results as it passes along the conduit.

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