United States Patent

Michalon

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[54] **APPARATUS FOR BREAKING-UP SOLID, POROUS AND ESPECIALLY VEGETABLE BODIES**

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[52] **U.S. Cl.** **146/255,** 146/223, 241/1, 241/39

[51] **Int. Cl.** **B02b 3/12**

[58] **Field of Search**.....146/227, 223, 255, 8, 8 N; 241/1, 39

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[57] **ABSTRACT**

Apparatus for breaking-up solid, porous and especially vegetable bodies, in particular for the purposes of decortication, shredding or splitting, in which a chamber filled with a liquid and/or gaseous fluid is adapted to receive said bodies, together with means for applying a variation of fluid pressure inside said chamber, and in which said variation of pressure is cyclic so as to apply a vibratory action which progressively fatigues said bodies. The cyclic pressure variation comprises at least three cycles, while the differential amplitude, namely the difference between the minimum and maximum pressures of the cycles, exceeds three bars, the number of cycles and the differential pressure amplitude being chosen in the inverse ratio with each other for the same result.

2 Claims, 9 Drawing Figures

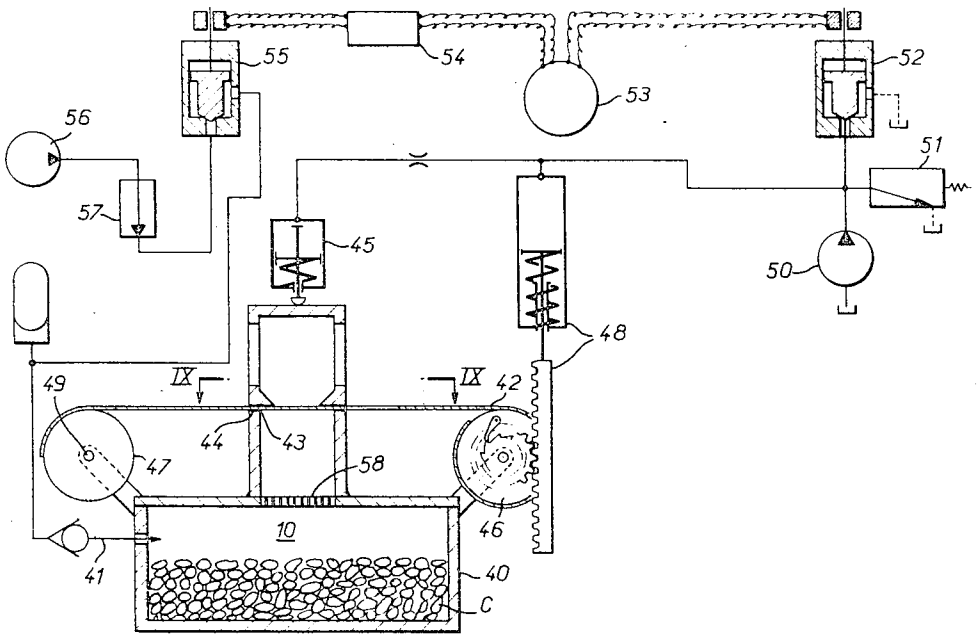

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FIG.1

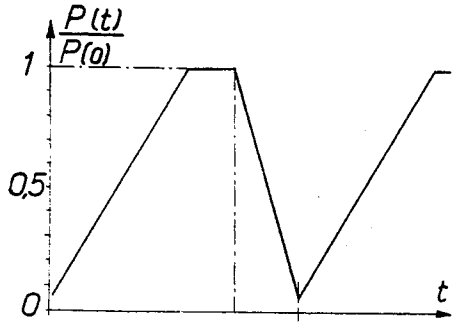

FIG.2

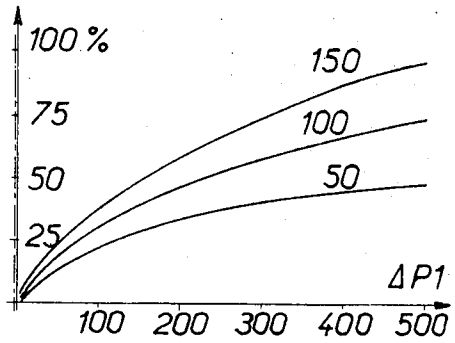

FIG.3

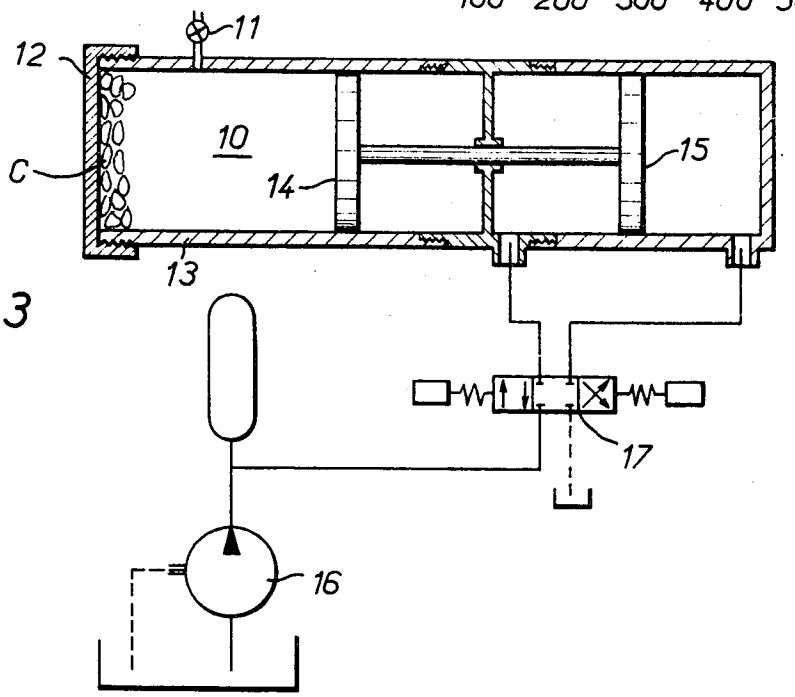

FIG.4

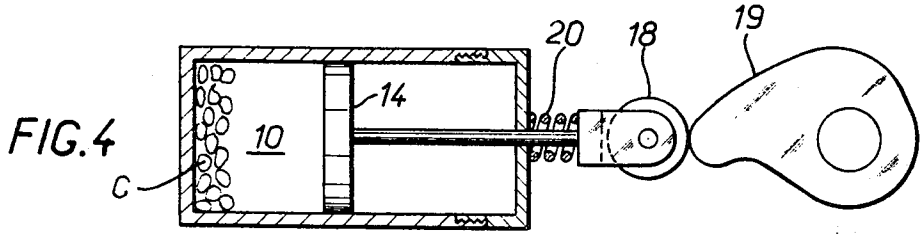

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FIG.5

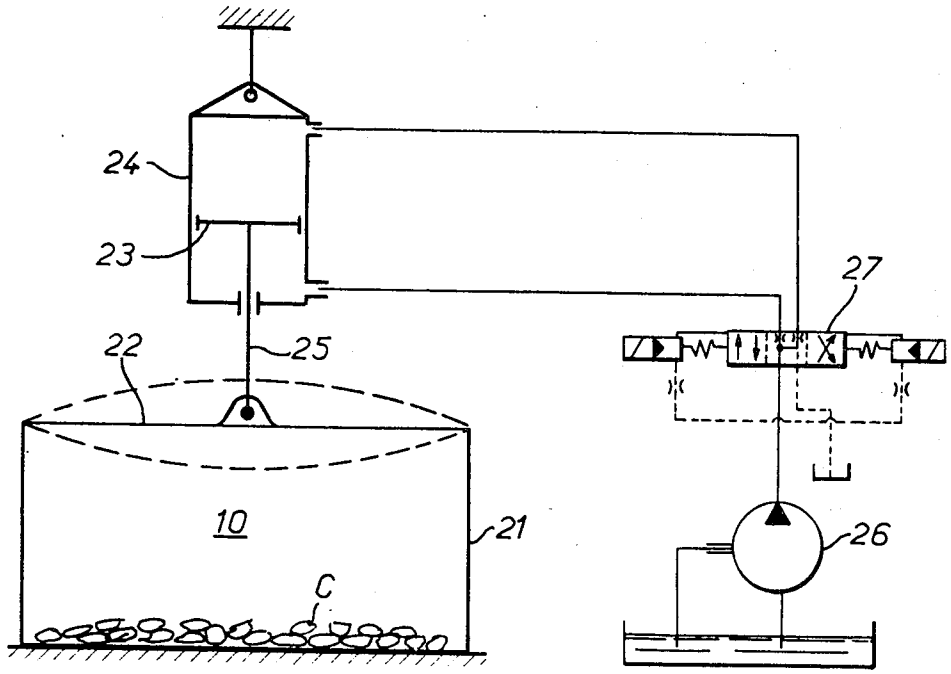
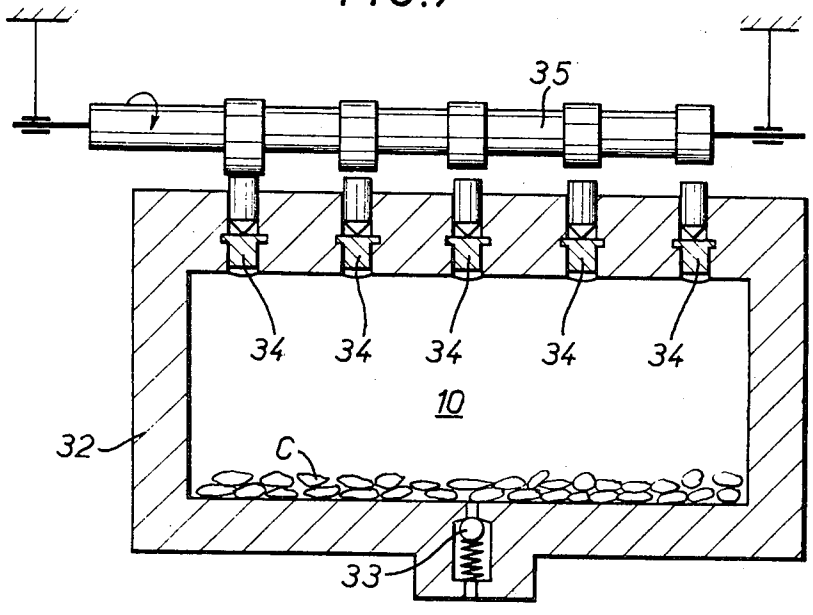


FIG.7



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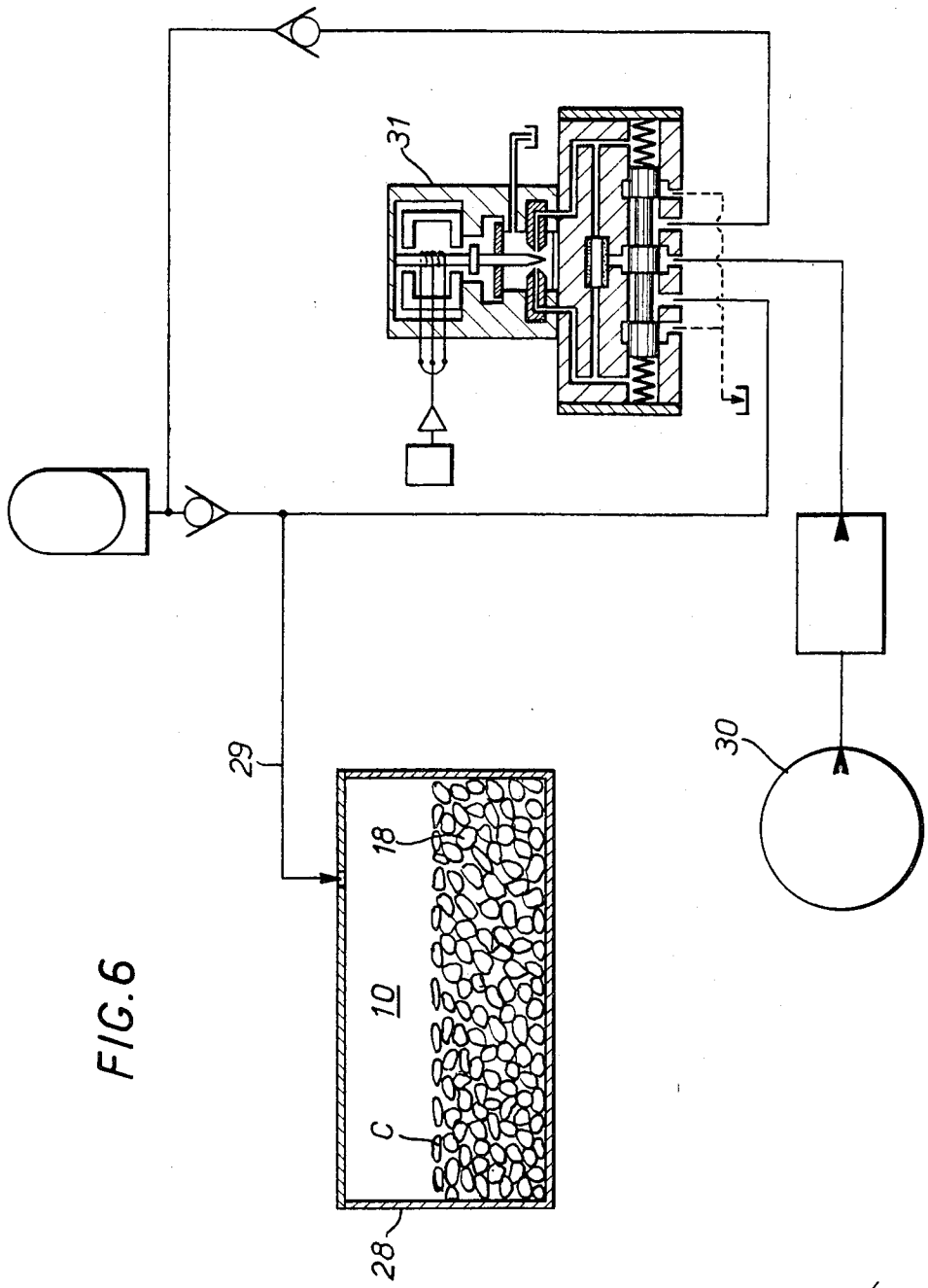

FIG. 6

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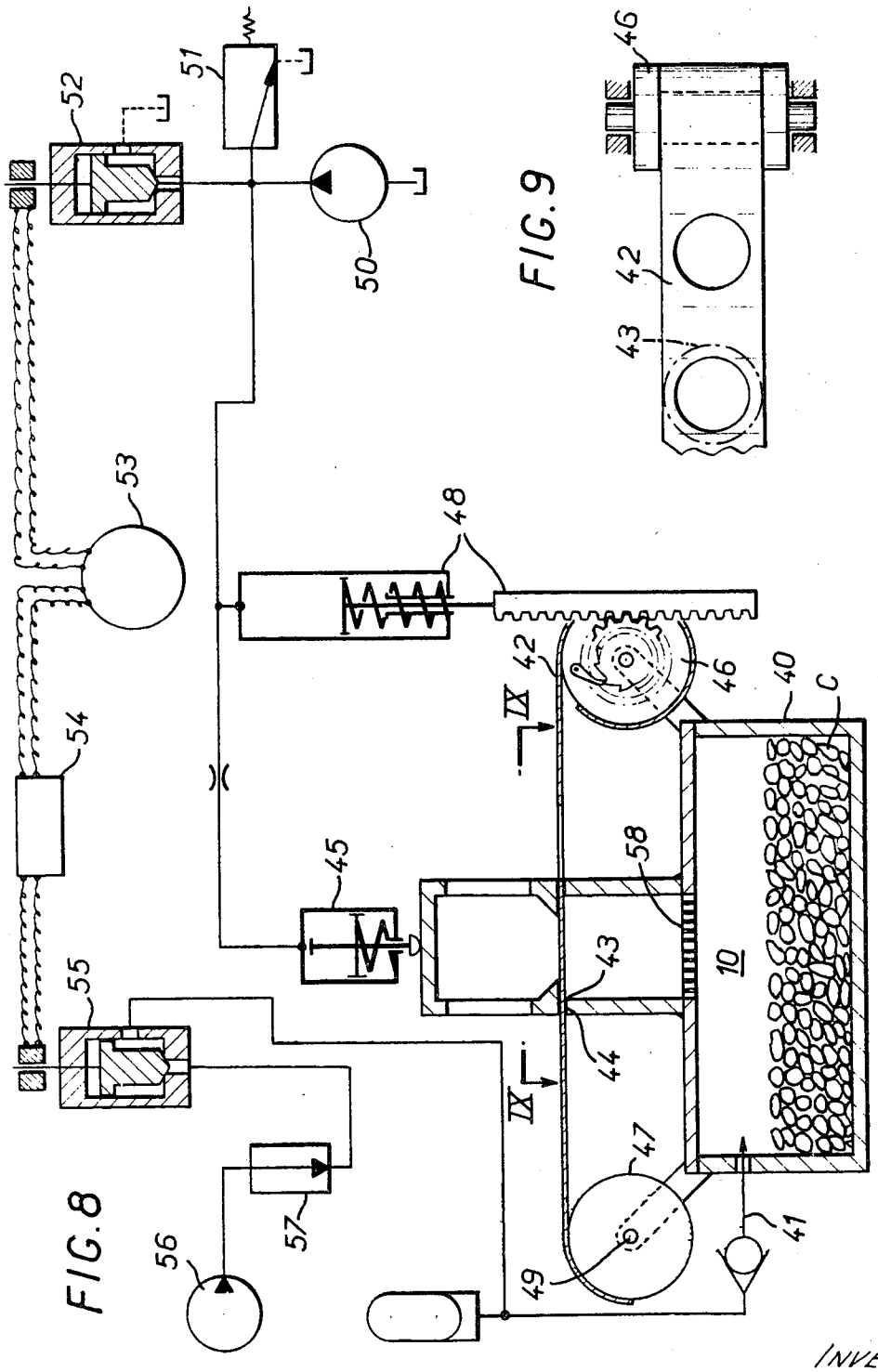

FIG. 8

FIG. 9

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APPARATUS FOR BREAKING-UP SOLID, POROUS AND ESPECIALLY VEGETABLE BODIES

The present invention relates to a device for breaking-up or comminuting porous solid substances, especially vegetable, in particular for the decortication of oleaginous pips and seeds and of leguminous plants, the fruit of which is a shell, and for the shredding or splitting of substances, especially vegetable, in which a chamber filled with a liquid and/or gaseous fluid is adapted to receive the substances, while means are provided for applying a variation of the fluid pressure inside the said chamber.

Numerous vegetable oils are extracted from seeds or pips, such as sunflowers, grapes, walnuts, peanuts, etc.

Now, the problem of decortication, that is to say the separation of the shell and of the kernel, has not been resolved in a satisfactory manner; in fact, the losses during this operation, which is generally carried out mechanically at the present time, are very large, and may even reach half of the crop.

It is also known that partial decortication, and in particular on kernels with hard shells, such as walnuts and pistachio nuts, can be obtained by subjecting these latter to an external pressure. In all cases, this operation is effected once only, and generally by utilizing steam pressure which essentially has the effect of making the shell fragile. Satisfactory decortication, that is to say when complete separation is obtained between the kernel and its shell without damage to the kernel, cannot be obtained by these means.

A seed or a pip is formed of the following three main parts:

On the periphery, a cellulose skin which is relatively hard and does not adhere to the kernel;

In the interior, the kernel, generally fairly soft and containing fatty substances;

Between the two, a thin membrane adhering to the kernel protects the latter from attacks by a more or less moist ambient air, these attacks being liable to form undesirable free fatty acids and various other substances.

Other known means of decortication, such as scraping the kernels between two grinding wheels or stirring in a "squirrel cage" have the following disadvantages:

Very many kernels are broken into a number of pieces and very often, by the effect of friction (skin - kernel - grinder) they are converted to fine dust. This breaking-up of the seed into a number of fragments facilitates attacks on this latter by the ambient air (oxygen, water vapor, microbes, etc.);

After decortication and during the separation of the broken kernels from the pieces of skin, for example by blowing, a large quantity of kernels reduced to dust, is evacuated at the same time as the skins.

To these various drawbacks, already serious since they may result in a loss equal to half the crop, there must be added the necessity of only shelling the kernels a few hours at most before pressing, in order to avoid attack of the product by the ambient air, this necessity making it difficult to constitute the necessary buffer-reserves in the case of continuous manufacturing lines.

The present invention has for its object apparatus for breaking-up porous solid bodies, especially vegetable, in particular for decortication, shredding or splitting, in which a variation of fluid pressure is applied and which complies better than in the past with the various requirements of practice.

The invention is especially characterized in that the variation of pressure is cyclic, in such manner as to apply a vibrator action which progressively fatigues the substances, and in that this cyclic variation comprises at least three cycles, in that the differential pressure amplitude, that is to say the difference between the minimum pressure and the maximum pressure of the cycles, is greater than three bars, and in that the number of cycles and the differential pressure amplitude are chosen in an inverse ratio one to the other, for the same result.

In this way, the grains and pips are decorticated while keeping the kernel entirely whole.

The grains enclosed in a chamber capable of withstanding pressures and depressions, are subjected to a treatment by variation of pressure on each side of the porous skin, thus giving an alternating movement to the skin until it becomes broken by fatigue.

The treatment preferably complies with the following conditions:

a. The treatment should comprise a number of alternating conditions which may be either compression - decompression, or decompression-recompression (see FIG. 1, in which the time t in milliseconds is plotted in abscissae, while the ordinates represent the ratio $P(t)$ of pressure external to the grain at the time t to $P(0)$ the maximum pressure external to the grain for a given type of test);

b. During the course of these repeated cycles, the pressure in the chamber containing the grains or pips is subjected to fluctuations such that between the maximum pressure and the minimum pressure there is a difference $\Delta P1$ which is a function on the one hand of the number of cycles chosen and on the other hand of the nature of the grains or pips to be decorticated. Thus, as shown in FIG. 2, if $\Delta P1$ is chosen to be 500 bars for example, about 150 cycles will be necessary in order to obtain complete decortication. On the other hand, if $\Delta P1$ is chosen very low, of the order of a few bars, in this case it will be necessary to make several hundred cycles in order to obtain complete decortication.

The curves of FIG. 2, which correspond respectively to 50 alternations or cycles, 100 cycles and 150 cycles, show the variation of the percentage of seed decorticated for a given number of cycles, as a function of the $\Delta P1$ chosen.

c. $\Delta P1$ may have any desired value comprised between 1 bar and 500 bars.

d. The pressure P1 in the working chamber can vary from -1 to $+500$ bars.

e. $\Delta P1$ can be chosen over the whole extent of the scale of P1. For example, a $\Delta P1$ of 20 bars can be effected when P1 is equal to 19 bars and when the minimum pressure is less than atmospheric pressure, or alternatively this $\Delta P1$ of 20 bars may be effected for example between 100 and 80 bars when of course P1 is equal to 100, etc.

f. Whatever may be the number of cycles and the $\Delta P1$ chosen within the range of pressures recited above, it is finally necessary that a fraction $\Delta P2$ of the total variation of $\Delta P1$ should be effected with a decompression gradient at least equal to 105 bars per second. This decompression gradient $\Delta P2$ should be obtained during at least half of the number of cycles chosen.

g. The compression gradient must be at least three times smaller than the decompression gradient of $\Delta P1$.

The preceding values are valid for the case where the ambient atmosphere surrounding the seeds is compressible (air for example). In the case where this ambience is incompressible (fluid silicone for example) the minimum values given above can be substantially reduced.

If sunflower seeds are subjected to a decortication process according to the invention and what takes place is examined by extracting seeds at the various stages of the operation, it is found at the end of a certain number of cycles that at the pointed extremity of the seed, the skin opens, somewhat like a bud which bursts; then the various parts of the skin progressively move outwards like the sepals of a flower until they fall by simply rolling between the fingers. At the end of the operation, there is obtained a mixture of kernels, for the greater part intact, and fragments of skins entirely separated.

The invention offers the following advantages:

The decortication times are much shorter than all those obtained by known means;

The separation of the skin from the kernel is effected without breaking the kernel;

The kernel remains protected by its anti-corrosion membrane, which makes it possible for oil producers to constitute buffer-reserves of decorticated seeds without any risk of deterioration of the kernels;

The kernels remain for the greater part intact, and the losses during decortication are very considerably reduced;

The power required for carrying out a decortication process according to the method of the invention is very much less (4 to 5 times) than the power at present absorbed by the known systems such as grinders, mixers, etc.

In addition to the decortication of oleaginous seeds and amongst others, the invention can be employed for operations such as shelling leguminous plants or the shredding of vegetable fibers. It is known in fact in the paper industry that when shavings have been cooked in lyes of various kinds such as soda, bisulphite, etc., after having been subjected to a long cooking period, they are separated into fibers and homogenized. The present well-known means for carrying out this operation of shredding and refining make use of mechanical grinding or rasping systems which have the disadvantage, on the one hand of consuming enormous amounts of power and on the other hand of only giving very small production rates.

There may also be cited a further non-limitative example of application of the invention. In fact the invention can be used with success for causing certain ores and in general all bodies having porosity, to burst into small fragments.

The present invention has also for its object a device for carrying the above method into effect, this device being characterized in that it comprises: a chamber adapted to receive the bodies, means for filling the chamber with a gaseous fluid and/or liquid, means for applying a cyclic variation of the fluid pressure inside the chamber.

Forms of embodiment of the invention will now be described below by way of example, reference being made to the accompanying drawings, in which:

FIGS. 1 and 2 are diagrams;

FIGS.3 to 8 relate respectively to six different forms of embodiment of the invention, illustrated diagrammatically;

FIG. 9 is a partial view taken along the line of the arrows IX—IX of FIG. 8.

Reference will first be made to FIG. 1, As ordinates there are plotted the ratios $P(t)/P(o)$ between the pressure in the working chamber at a variable time (t) and the maximum pressure in the working chamber for a given type of test. This ratio varies from 0 to 1. As abscissae there are plotted the times in milliseconds corresponding to the application of pressure to the chamber and to the decompression of the said chamber. It will be observed from this figure that the pressure curves corresponding to a given cycle are asymmetric, due to the fact that the gradient of the pressure application and the gradient of expansion are definitely different.

In the diagram of FIG. 2 there are plotted as ordinates the percentages of completely decorticated seeds, while the abscissae represent the values of $\Delta P1$ corresponding to the variation of pressure when the working chamber is expanded.

On the three types of curves drawn, corresponding to tests carried out on one of the devices which will be described later, it will mainly be observed that for a $\Delta P1$ of 100 bars for example, it is possible to obtain:

15 percent of decorticated seeds, after having carried out 50 cycles;

28 percent of decorticated seeds after having effected 100 cycles;

40 percent of decorticated seeds after having carried out 150 cycles.

When the value of $\Delta P1$ FIG. 7, for a given number of cycles, the percentage of decorticated seeds also increases.

Reference will now be made to FIG. 3.

A device for breaking-up solid, porous, and especially vegetable bodies C, in particular for decortication, shredding or splitting, comprises a chamber **10** adapted to be filled with a liquid and/or gaseous fluid by means of a cock **11**. The chamber **10** is arranged to receive the bodies C by means of a removable end **12**, while means **15**, **16**, **17** are provided so as to apply a variation of the fluid pressure in the said chamber **10**.

The variation of pressure is cyclic in order to apply a vibratory action which progressively fatigues the bodies C. This cyclic variation comprises a minimum of 3 cycles. The differential pressure amplitude $\Delta P1$, that is to say the difference between the minimum pressure and the maximum pressure of the cycles is greater than three bars. The number of cycles and the differential pressure amplitude are chosen in inverse ratio to each other. For example, for the same result it is possible to choose between a small $\Delta P1$ with a large number of cycles, or a large $\Delta P1$ with a small number of cycles, In addition, these cycles can be carried out either in very short times or alternatively in very long times and therefore at low frequencies.

For the purpose of accelerating the rate of decortication, it is preferably desirable to utilize frequencies higher than several cycles per second.

The minimum pressure of the cycles is advantageously less than atmospheric pressure and the maximum pressure of the cycles is higher than several multiples of 10 bars.

The chamber 10 comprises a cylinder 13 which receives a piston 14. The means for applying a cyclic variation of pressure comprise an actuating device 15 which causes a reciprocating movement of the said piston 14. This actuating device 15 is operated by fluid at 16, 17.

More particularly, the cyclic variation of pressure in the decortication chamber 10 is obtained by the movement of the piston 14 effected through the intermediary of the actuation device 15, constituted by a second piston mounted coaxially in the cylinder 13 and controlled either pneumatically or hydraulically.

The alternating lateral movement of the piston 15 is effected by utilizing, for example, a pressure generator 16 and a four-way electro-valve 17. These members 16 and 17 are of a usual type and are not therefore described here in detail.

In FIG. 4, the control of the piston 14 is mechanical. More particularly, the piston 14 which defines the chamber 10 is actuated in one direction by means of a roller 18 and a cam 19, while the return movement is effected by a spring 20.

This device makes it possible to work at relatively-high frequencies and relatively-low pressures. Furthermore, the cam does not impart a constant speed to the piston, its profile being such that the compression of the working chamber 10 is effected slowly according to a given pressure gradient, and the decompression takes place abruptly following a second given gradient.

Reference will now be made to FIG. 5, in which the chamber 10 comprises a chamber 21 having a diaphragm 22. The means for applying a cyclic variation of pressure comprise an actuating device 23 which is adapted to displace the said diaphragm 22 with a reciprocating motion.

More particularly, in FIG. 5, the variation of the volume of the working chamber 10, which has the purpose of creating alternately a compression and an expansion, is obtained by elastic deformation of the said diaphragm 22.

This deformation which takes place on each side of the initial position of the wall, is obtained by means of the actuating device 23, constituted by a double-acting jack, the piston of which is shown at 23 and the cylinder at 24. The piston 23 is coupled to the diaphragm 22 by a rod 25. The supply to the jack 24 is effected by a pressure generator 26 and an electro-valve 27 with four ways and two positions, of a usual type not described in detail here.

Reference will now be made to FIG. 6, in which the chamber 10 comprises a casing 28, while the means for applying a cyclic variation of pressure comprise a fluid conduit 29 coupled to the said casing 28 and associated with a source of fluid pressure 30 and a servo-valve 31.

More particularly, in FIG. 6 the servo-valve 17 is provided in such manner as to be able to pass a pressure from a maximum pre-regulated value to a minimum value close to zero at a frequency 50 times per second. The seeds C placed in the chamber 28 are subjected to a compression-decompression cycle at this same frequency, according to the method of the invention, which results in a rapid fatigue of the skin. The source of fluid pressure 30 and the servo-valve 31 are of the usual type and will not be described in further detail.

Reference will now be made to FIG. 7 in which the chamber 10 comprises a chamber 32 provided with a safety-valve 33. The means for applying a cyclic variation of pressure comprise explosion means 34 intended to be made operative successively, for example by means of a cam-shaft 35.

More particularly, the cyclic variation of pressure in the working chamber 10 is obtained by the consecutive explosion of cartridges 34. The discharge valve 33 limits the pressure in the working chamber 10 to the desired value.

The device shown in FIG. 7 has the additional advantage, as compared with the other solutions previously described, that it consumes very little power.

Reference will now be made to FIGS. 8 and 9, in which the working chamber 10 comprises a chamber 40. The means for applying a cyclic variation of pressure comprise on the one hand a pressure conduit 41 coupled to the chamber 40, and on the other hand a moving closure strip 42 which is burstable.

More particularly in FIG. 8, the device makes it possible to obtain extremely rapid expansion gradients.

The seeds C are enclosed in the fluid-tight chamber 40. A circular orifice 43 is associated with the chamber 40 and is adapted, during the compression of the chamber, to be closed by the strip 42 which is of metallic or plastic material. A seating 44 is arranged around the orifice 43 and the strip 42 is applied against the seating 44 by a single-acting jack 45. The strip 42 is arranged so as to move in front of the orifice 43 by means of two reels 46 and 47.

The reel 46 is a driving reel and is driven by a jack - toothed rack system 48, while the reel 47 is mounted freely rotatable on a shaft 49.

The reel 46 is a driving reel and is driven by

The operation of this device is as follows:

The forward movement of the strip 42 and also the closure of the escape orifice 43 are effected either pneumatically or hydraulically by a system comprising essentially a pump 50, a pressure regulator 51 and an electro-valve 52, controlled by a timing device 53.

The timing device 53 acts through the intermediary of a time-lag relay 54 to control the opening of a second electro-valve 55. This latter permits an air generator 56 to supply pressure, through the intermediary of a pressure-reducing valve 57 to the conduit 41 coupled to the working chamber 10. The pressure in this latter increases progressively up to the abrupt bursting of the strip 42 over the entire zone corresponding to the escape orifice 43.

When the explosion has taken place, the compression-decompression cycle is automatically renewed through the intermediary of the various parts mentioned above 50, 51, 52, 53, 54, 55, 56 and 57, and especially of the timing device 53. As will be well understood, these various devices are of a type known per se and it is not necessary to describe them in any further detail.

A grating 58 is provided in order to prevent the seeds C decorticated following the method of the invention, from escaping through the orifice 43.

I claim:

1. Apparatus for comminuting solids, comprising a chamber for receiving solids to be comminuted including an escape orifice, means for cyclicly varying the

pressure in the chamber through a pressure differential greater than three bars including means for intermittently sealing off the escape orifice, means for introducing fluid under pressure into said chamber subsequent to each sealing-off of said orifice, said means for intermittently sealing off the escape orifice comprising a burstable member closing said chamber, said burstable member being in the form of a strip, and means for moving said strip relative to said chamber thereby successively to present fresh portions of said strip to the fluid under pressure in said chamber, said strip being in sealing contact with said chamber when said fluid under pressure is introduced into said chamber.

2. Apparatus as claimed in claim 1, said presenting means comprising rack and pinion means for unrolling and moving said strip relative to said chamber, and means for moving said rack and pinion means in timed relation to said means for supplying a fluid under pressure to said chamber.

* * * * *