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HIGH-PRESSURE ROLLER MILL HAVING VIBRATING LATERAL WALLS

The invention relates to a high-pressure roller press for comminuting brittle material for grinding, comprising at least two grinding rollers next to each other, rotating in opposite directions, which form a roller gap between them, wherein a first grinding roller is a fixed roller and a second grinding roller is a floating roller, and a respective lateral wall at the two ends of the roller gap.

For comminution or compression of brittle, granular grinding material such as ores and rocks, it is common to use high-pressure roller presses, which comprise of two rotatable roller presses arranged next to each other, rotating in opposite directions and generally of the same size, revolving at the same circumferential speed and forming a narrow roller gap between them. The material for grinding, which is to be comminuted or compacted, is drawn through this roller gap, wherein the material for grinding is comminuted or compacted under the high-pressure in the roller gap. The result of this treatment, namely, comminution or compression, is largely dependent on the material properties of the material for grinding to be comminuted. The comminution in the roller gap described here, without shearing and also without impact, was first described by Schönert et al. in the German patent application DE 27 08 053 A1 as high-pressure comminution and it is since considered as a class of comminution type apart from grinding by shearing and breaking. High-pressure roller presses for comminution of granular material according to Schönert fundamentally differ from the other presses, which are used for comminution of other materials. In particular, high-pressure roller presses, which are intended for comminution of rocks, are not comparable to roller presses, for instance, to comminute grains. Grains are pulverized in grain rollers. They have weights in the range of a maximum of 100 kg. The overall instrumental setup of a grain roller greatly differs from high-pressure roller presses. Additionally, grain rollers work with a shearing action. In contrast, high-pressure roller presses work without shearing. This means that the two grinding rollers have exactly the same surface speed in the roller gap and do not slip against each other when running. High-pressure roller presses also differ considerably from strip rollers for rolling of steel. Steel strip rollers are distinguished by their use-related smooth running. The steel between the strip rollers is either very ductile because the steel to be rolled is hot-formed, or the steel can be cold-formed. Consequently, the steel roller has quite a smooth running due to the nature of the rolling method. It is thus possible to operate two rollers arranged horizontally, one on top of the other, wherein the roller gap pressure can be generated by the inherent weight of the rollers as well as the hydraulic tools. The steel to be rolled passes from the roller gap of a strip roller in the horizontal direction, i.e. perpendicular to the gravity pressing down the upper grinding roller on the strip steel. Depending on the steel to be rolled, strip rollers reach a roller gap speed of up to 200 km/h. Steel strip rolling is absolutely comparable to a dough roller, which rolls over raw pizza dough spreading out the pizza dough, although the forces acting in the steel strip roller are many orders of magnitude greater. In contrast, high-pressure roller presses for comminution or ores and rocks generally have rollers arranged horizontally next to each other with a passage of the material for grinding in the vertical direction. In the process, the roller gap speeds in high-pressure roller presses for comminution of ores and rocks reach speeds in the lower two-digits km/h range at the most.

Strip rollers for steel thus work in a different operating extreme than the high-pressure roller presses. Strip rollers run fast and uniformly and deform the ductile steel, which deforms under the rollers. High-pressure roller presses run slowly, and in the roller gap the material for grinding spontaneously and suddenly escapes the pressure in the roller gap due to its brittleness. The rollers are horizontal to each other in the high-pressure roller presses and form a roller gap, where the material for grinding runs through vertically. High-pressure roller presses have a roller gap pressure of 50 MPa and more. Due to the horizontal arrangement next to each other and the operation with brittle material, the entire mechanical behavior of the high-pressure roller press is not comparable to the mechanical behavior of the strip rollers lying vertically on top of each other, which also exhibit damped and uniform running due to the ductility of the steel to be rolled.

If the material for grinding in a high-pressure roller press has unevenly permeated air in it, while passing through the roller gap, the material for grinding can escape into the air gap and thus avoid the high pressure in the roller gap, wherein the comminution efficiency of the high-pressure roller press is considerably reduced. Furthermore, this can cause the high-pressure roller press to run unevenly, where the rollers perform rotary oscillation because the drive of the high-pressure roller presses repeatedly brakes and runs freely. This abrupt load change continues in the entire high-pressure roller press and can be seen as vibration of the entire high-pressure roller press. In unfavorable conditions, the vibration can continue into the foundation and in the worst case, even damage the foundation.

In order to load the roller gap uniformly with the material for grinding for a uniform and smooth run of the high-pressure roller press, there are feeders for grinding material in such a high-pressure roller press, which vary the inflow of the material for grinding in a regulated manner so that a constant material cone is formed in the space between the two rollers rolling in the opposite directions. However, depending on the nature and consistency of the material for grinding, this type of loading the roller gap is not enough to ensure vibration-free running of the high-pressure roller press rollers and achieve a continuous working of the entire comminution machine as high-pressure roller press. Uneven grain distribution in the material for grinding and air pockets in the fill cannot always be sufficiently homogenized by only regulating the material cone in the space between the rollers running in opposite directions.

The German utility model DE 20 2009 014 079 U1 proposes placing vibration rods, for example, as known from the concrete vibrators from concrete casting technology, in the feeders, which reach up to the compaction zone of the material for grinding to be comminuted. The vibration rods ventilate the material for grinding by their fluidization and ensure a more uniform running. It has been found in actual operation that the vibration rods are not enough for the harsh conditions in the high-pressure roller press. The vibration rods get worn or even bent very quickly by the material for grinding. The service life of the concrete vibrators or metal rods vibrated using the concrete vibrators is not enough to ensure a sufficiently long operation of the high-pressure roller press without stopping.

In order to be able to operate the surface of the rollers of the high-pressure roller presses up to the maximum load and thus maximize the grinding efficiency, it is extremely important to be able to absolutely rule out overloading of the surface of the grinding rollers in the form of an extremely high roller gap pressure. Otherwise, specifically when operating in the overload range, the surface of the grinding roller can break away, causing the surface finish to be lost at the place of break. Due to the surface of a grinding roller breaking away, it is no longer possible to uniformly operate the high-pressure roller press. As a result of the surface breaking away, the grinding roller is forced to switch over to an impacting operation because the roller gap pressure suddenly drops when the surface that has broken away passes through the gap and suddenly rises again when the point where the surface has broken away again leaves the roller gap.

It is important for the optimum operation of a high-pressure roller press that the pressure in the roller gap remains as stable as possible over time. To this end, the German patent application DE 10 2011 018 705 A1 teaches regulating the hydraulics that maintain the pressure in the roller gap according to vibration of the high-pressure roller press. This regulation results in a smooth and even running of the high-pressure roller press. The document DE202012012460U1 discloses a high-pressure roller press having a control device for regulating the roller gap pressure.

The present invention relates to pressure distribution along the roller gap from the center of the roller gap up to both the ends of the roller gap. Since the roller gap is open on both sides, there is a flowing movement of the material for grinding along the compaction zone, which begins just above the roller gap and extends into the roller gap. The flowing movement results in a material flow from the center of the roller gap up to both the ends of the roller gap. Since the material for grinding can flow out of the roller gap at the roller gap ends, the material for grinding follows the pressure gradient in the gap and thus escapes the compression.

The unwanted pressure drop described earlier from the center of the roller gap to the two ends also cannot be completely eliminated by a uniform feeding of the roller gap through a feeder from above. As a result of this pressure drop, the pressure in the center of the roller gap is greater. The floating roller in the high-pressure roller press therefore tends to perform an oscillating movement around a vertical axis around the pressure point in the middle of the roller gap, whereby the oscillation frequency is 0.1 Hz or even lower. As a result, the roller gap is not always the same width, but is shaped like a wedge, with the greatest roller gap pressure in the center of the grinding roller. The grinding roller thus suffers from wear during prolonged operation, which transforms the cylindrical grinding roller into a waisted shape. A grinding roller deformed in this way is not usable for further use.

The task of the invention is therefore to equalize the pressure distribution along the roller gap.

The task according to the invention is solved by the fact that each lateral wall has a vibration device which causes the lateral wall to vibrate mechanically. Further advantageous embodiments are given in the sub-claims to claim 1.

According to the idea of the invention, it is provided that the lateral walls of the high-pressure roller press, which close the roller gap, are caused to vibrate mechanically by a vibration device. The mechanical vibrations fluidize the material for grinding and thus facilitate the roller gap passage, so that the roller gap pressure in the area of the roller gap ends is constantly increased. As the roller gap pressure is a quotient of the pressure area, namely the height of the compaction zone above the roller gap, and the product of the height of the actual compaction zone times the length of the roller gap, the roller gap pressure decreases in the middle of the roller gap and increases at the ends of the roller gap. As a result, the roller gap pressure is equalized over the length of the roller gap. This pressure equalization means that the floating roller does not wobble, i.e. it does not rotate by fractions of an angle around a vertical axis. Without this wobble movement, the high-pressure roller press works with constant efficiency over a longer period of time. The wear pattern of the grinding rollers is also evened out, so that the grinding rollers do not become so heavily waisted due to wear.

In an advantageous manner, the energy input of the vibration device into the material for grinding is such that the vibration device operates at a frequency of between 10 Hz and 150 Hz, preferably at a frequency of between 10 Hz and 60 Hz, and directs an energy input of between 0.1 kJ/m^3 and 10 kJ/m^3, preferably between 0.1 kJ/m^3 and 1.0 kJ/m^3 into the material for grinding. The design required for this can be determined by simple experimental measurement. The energy input depends on the exact geometry of the lateral wall, which shows an individual wave pattern for the present geometry when vibrated. The wave pattern in turn is responsible for the points at which the energy input into the material for grinding occurs. The simple experiment requires the measurement of the power consumption and the mass flow, which can be determined by weighing the material for grinding.

During operation, it has been found that there exists an optimum for the energy input. In this way, it may be provided in an advantageous manner that the vibration device has or is connected to a control device which regulates the vibration intensity according to the energy absorbed for operation, whereby an increased energy absorption results in a reduction in the vibration intensity and a reduced energy absorption results in an increase in the vibration intensity. This control strategy prevents the lateral wall from interfering too much with the grinding behavior and causing damage itself.

The control strategy can also include controlling according to the energy absorption of the roller drive. It can therefore be provided that the control device controls cumulatively or alternatively according to the energy consumption of a roller drive, whereby an increased energy absorption of the roller drive results in a reduction in the vibration intensity and a reduced energy absorption results in an increase in the vibration intensity. This control strategy takes into account the fact that when a fluidization effect develops in the material for grinding, the average pressure in the roller gap increases and requires a high drive power of the grinding rollers. However, operation with high drive power is not necessarily the most energy-efficient drive.

Finally, controlling can be carried out cumulatively or alternatively. It may be provided that the vibration device is additionally controlled according to the gap width of the roller gap, whereby an increased gap width results in an increase in the vibration intensity and a reduced gap width results in a reduction in the vibration intensity. This control strategy takes into account the noticeable effect that the roller gap widens when the roller gap is

overfilled. Fluidization of the material for grinding helps to eliminate the short-term overfilling effect.
Still another cumulative or alternative control strategy may include additionally controlling the vibration device according to the inclination of the floating roller to rotate about a vertical axis, increasing the vibration intensity as the frequency of rotation of the floating roller increases and vice versa. This control strategy involves avoiding a wobble movement of the floating roller by fractions of an angular degree, with the wobbling occurring at a frequency of less than 0.1 Hz. This control strategy involves rather slow changes of parameters with a longer actuating time than is the case with the previous control strategies. In order to measure the wobble movement, position sensors can be used on the bearings, which measure the relative distance of the roller axes of both axes at both ends of the rollers and store it over a longer period of time in the range of 1 min to 10 min for a statistical analysis of the wobble.
The vibration device can also be used on an impulse basis. For this purpose, a manual triggering device can be provided for the vibration device. For this purpose, an operator operates the triggering device when overfilling is detected in the roller gap.
The invention will now be explained in greater detail on the basis of the following figures.
In the figures:

Fig. 1 shows a sketch of a high-pressure roller press according to the invention in a side view,

Fig. 2 shows a top view of a roller gap covered with material for grinding in a high-pressure roller press without lateral walls, here in view of the grinding rollers,

Fig. 3 shows a top view of a roller gap covered with material for grinding in a high-pressure roller press with lateral walls from the PRIOR ART,

Fig. 4 shows a top view of a roller gap covered with material for grinding in a high-pressure roller press according to the invention.

Figure 1 shows a sketch of a high-pressure roller press 100 according to the invention in a side view. The high-pressure roller press 100 according to the invention for comminution of brittle material for grinding M has at least two grinding rollers 110, 120 arranged next to one another and rotating in opposite directions. The two grinding rollers 110, 120 form a roller gap W between them, through which the material for grinding M is drawn without or with only very slight relative slippage of the grinding rollers 110, 120. A first grinding roller (110) is a fixed roller and a second grinding roller 120 is a floating roller. The floating roller 120 has two degrees of freedom of movement. It can move away from the fixed roller 110 while widening the roller gap W and can also rotate about the vertical axis A by fractions of an angle. In order to prevent the material for grinding M from flowing to the opening of the roller gap W lying in the image plane and falling out there, a lateral wall 150, 150' is provided for both openings of the roller gap W. According to the idea of the invention, each lateral wall has a vibration device which causes the respective lateral wall 150, 150' to vibrate mechanically. This mechanical vibration is transmitted to the material for grinding M, which is located in the proximity of the respective end of the roller gap W and flows on or in the compaction zone. This vibration fluidizes the material for grinding M and thereby helps it to pass through the roller gap W, in which a pressure of 50 MPa or higher prevails.

Figure 2 shows a top view of a roller gap W of a high-pressure roller press 100 without lateral walls 150, 150' covered with material for grinding M, here as seen from the grinding rollers 110, 120. The material for grinding M is placed on the roller gap W as a bulk material and covers the roller gap W. Arrows are drawn on the material for grinding M, which show the approximate flow movement of the material for grinding M on the roller gap W up to the area of the compaction zone. The actual movement of a ground particle is not necessarily the length of the arrows but can also move only a fraction of the length along the paths of the arrows. To the right of the sketch in Figure 2 is a diagram showing the position x along the roller gap W as the pressure p in the roller gap W, if any. In this open high-pressure roller press, the pressure drop in the roller gap W towards the ends is very large, so that the pressure in the roller gap W drops sharply from over 50 MPa in the area of the roller ends. As a result, efficient comminution by compaction no longer takes place in the area of the roller gap ends.

Figure 3 shows a top view of a roller gap W of a high-pressure roller press 100 with static lateral walls 150, 150' covered with material for grinding M, here viewed from the grinding rollers 110, 120. The pressure drop in the roller gap W towards the roller shoulder, i.e. in the area of one end of the roller gap, is significantly reduced compared to the assembly in Figure 1, but is still present. This effect is called the “edge zone effect”. This effect is partly caused by the friction on the lateral wall. The lateral wall forms a flow barrier and the resulting friction increases with increasing pressing pressure as the back pressure on the lateral wall surface increases. The more the material is pressed out of the gap against the lateral wall, the greater the coefficient of friction and therefore less material flows into the edge zone of the gap. As a result, the good bed compression and thus the resulting pressure of the edge zone is reduced accordingly. This tends to lead to an approximately bell-shaped pressure distribution along the roller gap.

Figure 4 shows a top view of a roller gap W covered with material for grinding M of a high-pressure roller press 100 according to the invention with vibrating lateral walls 150, 150', here viewed from the grinding rollers 110, 120. The vibration is generated by a vibration device 160, the intensity of which is controlled by a control device 170 if necessary. The vibrating lateral wall (150, 150') maintains the pressure at the ends of the roller gap W as the material for grinding M can flow into the roller gap W unhindered. The vibration helps the material for grinding M to pass through the roller gap. The unimpeded material flow along the entire width of the roller ensures a uniform pressure profile and uniform wear and tear of the grinding rollers 110 and 120, so that no pronounced waist formation occurs.

LIST OF REFERENCE SYMBOLS

100	High-pressure roller press	A	Axis
110	Grinding roller	M	Material for grinding
120	Grinding roller	W	Roller gap
150	Lateral wall		
150'	Lateral wall		
160	Vibration device		
160'	Vibration device		
170	Control device		

HØJTRYKSRULLEPRESSE MED VIBRERENDE SIDEVÆGGE

PATENTKRAV

1. Højtryksrullepresse (100) til makulering af sprødt pressemateriale (M), omfattende
   - mindst to sliberuller (110, 120) som er anbragt ved siden af hinanden og roterer i modsatte retninger og danner en rullespalte (W) mellem sig, idet en første sliberulle (110) er en fast rulle og en anden sliberulle (120) er en løs rulle, og
   - en sidevæg (150, 150') i hver af de to ender af rullespalten (W),

   karakteriseret ved, at

   hver sidevæg (150, 150') omfatter en vibrationsanordning (160), som får hver sidevæg (150, 150') til at vibrere mekanisk.

2. Højtryksrullepresse ifølge krav 1,

   karakteriseret ved, at

   vibrationsanordningen (160) fungerer med en frekvens på mellem 10 Hz og 150 Hz, fungerer fortrinsvis med en frekvens på mellem 10 Hz og 60 Hz og leder en energitilførsel på mellem 0,1 kJ/m^3 og 10 kJ/m^3, fortrinsvis mellem 0,1 kJ/m^3 og 1,0 kJ/m^3, ind i pressematerialet (M).

3. Højtryksrullepresse ifølge et hvilket som helst af kravene 1 eller 2,

   karakteriseret ved, at

   vibrationsanordningen (160) omfatter en reguleringsanordning (170),
   som regulerer vibrationsintensiteten i henhold til dens absorberede energi til drift, et øget energiforbrug, hvilket resulterer i en reduktion i vibrationsintensiteten og et reduceret energiforbrug i en stigning i vibrationsintensiteten.

4. Højtryksrullepresse ifølge krav 3,

   karakteriseret ved, at

   reguleringsanordningen (170) også regulerer energiforbruget af et rulledrev, hvor et øget energiforbrug af rulledrevet resulterer i en reduktion i vibrationsintensiteten og et reduceret energiforbrug i en stigning i vibrationsintensiteten.

5. Højtryksrullepresse ifølge et hvilket som helst af kravene 3 eller 4,

karakteriseret ved, at

vibrationsanordningen (160) også reguleres i henhold til spaltebredden af rullespalten (W), med en øget spaltebredde, hvilket resulterer i en stigning i vibrationsintensiteten, og en reduceret spaltebredde, hvilket resulterer i en reduktion af vibrationsintensiteten.

6. Højtryksrullepresse ifølge et hvilket som helst af kravene 3 til 5,

karakteriseret ved, at

vibrationsanordningen (160) også reguleres i overensstemmelse med hældningen af den løse rulle (120) for at rotere om en lodret akse (A), idet vibrationsintensiteten øges, når rotationsfrekvensen for den løse rulle (120) øges og omvendt.

7. Højtryksrullepresse ifølge et hvilket som helst af kravene 1 til 6,

karakteriseret ved,

at der er tilvejebragt en manuel frigørelsesanordning til vibrationsanordningen (160).

Fig. 1

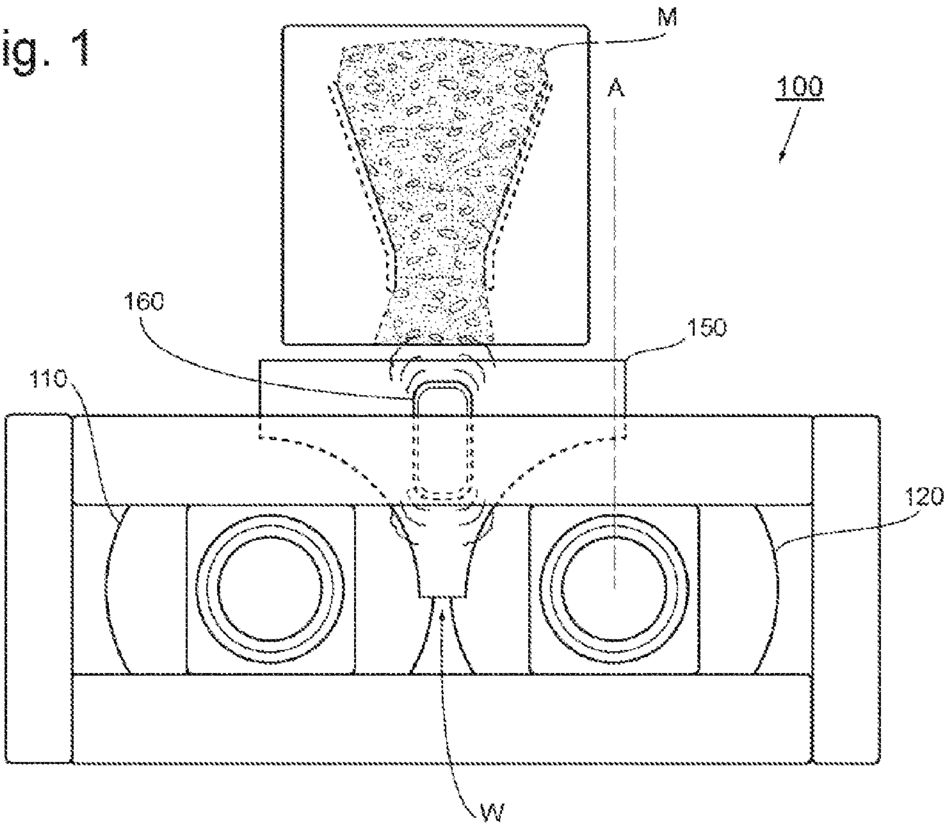


Fig. 2

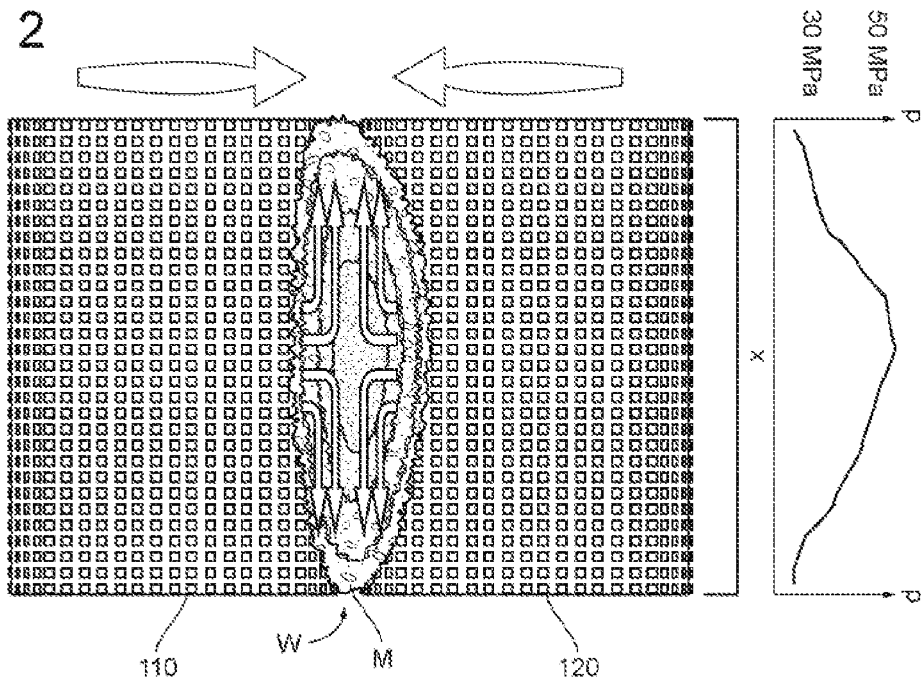
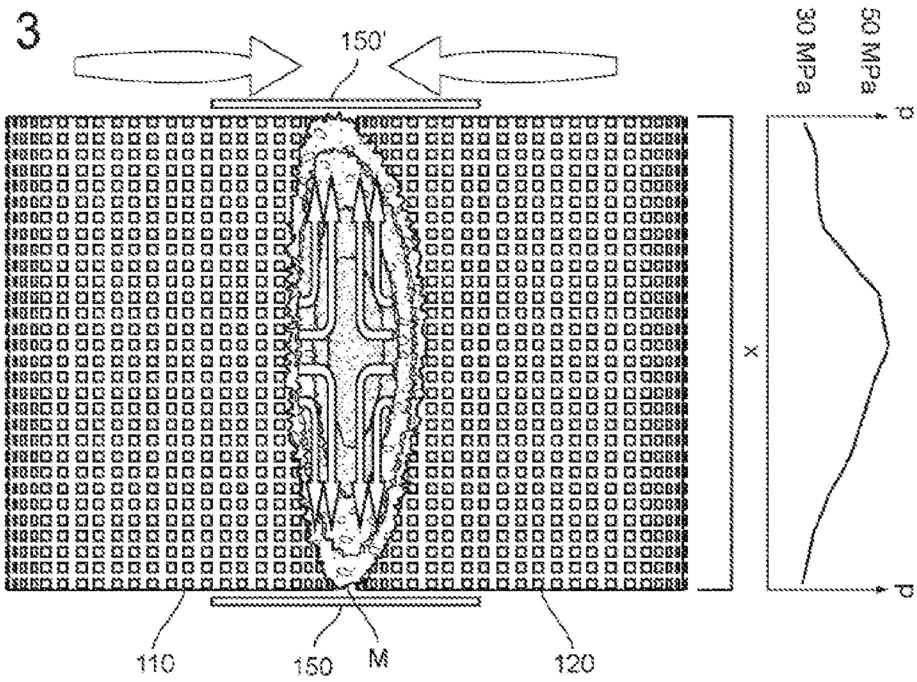


Fig. 3



PRIOR ART

Fig. 4