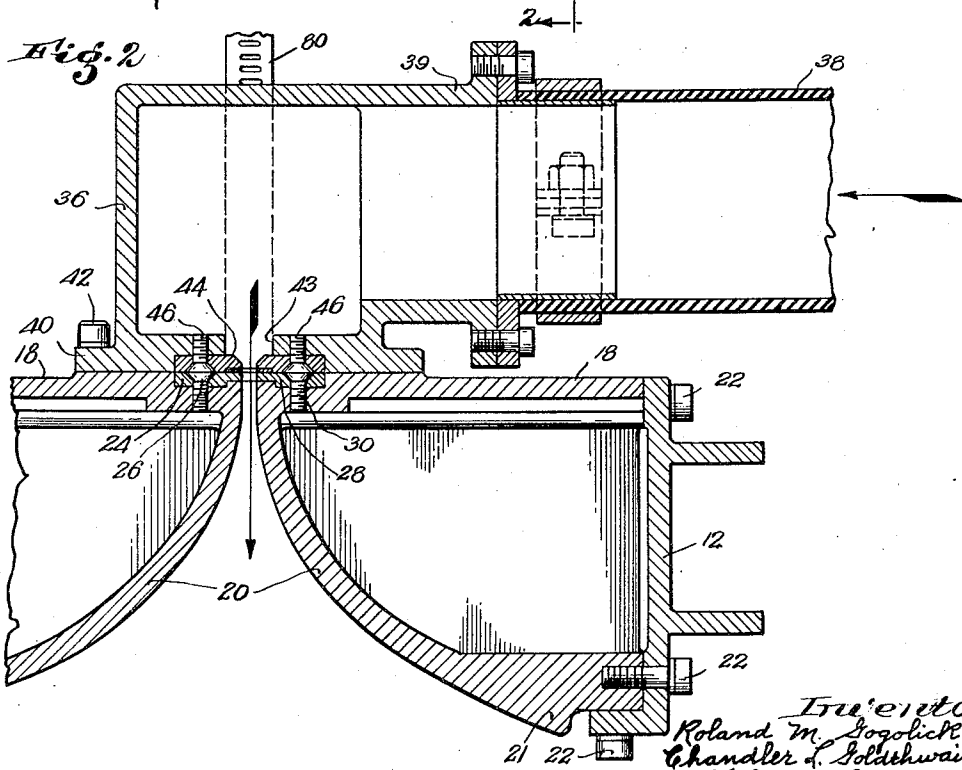
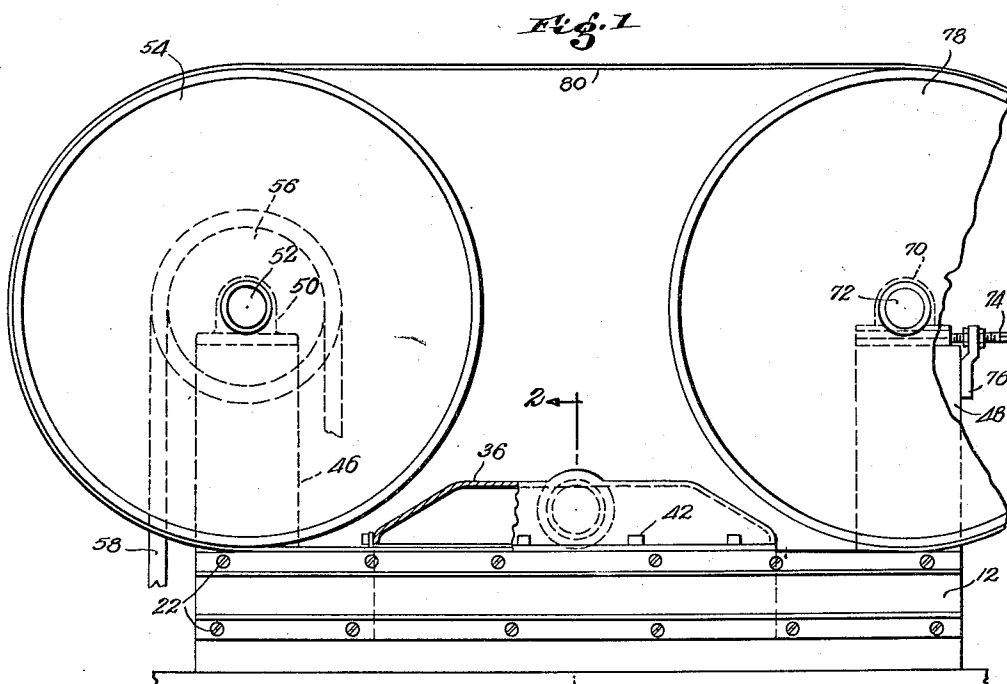


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AGITATING APPARATUS

3 Sheets--Sheet 1




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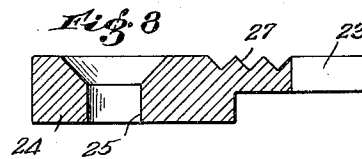
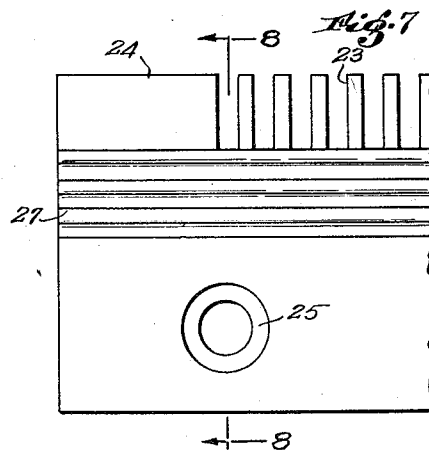
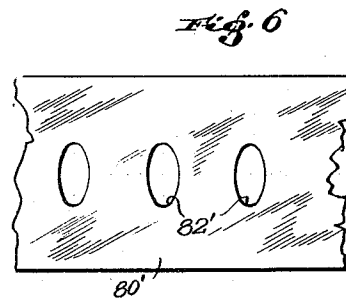
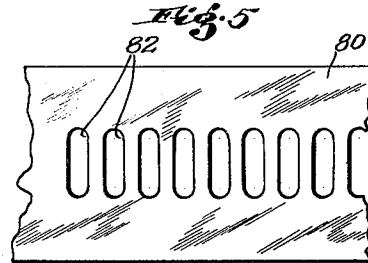
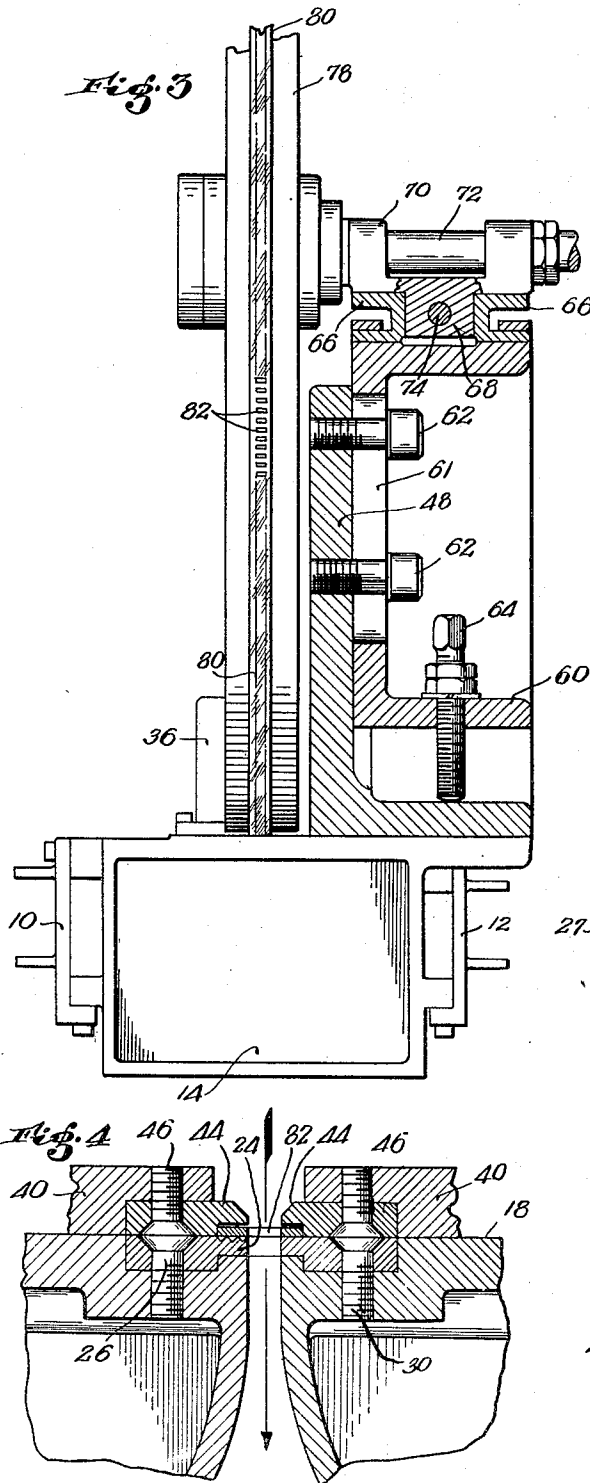
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AGITATING APPARATUS

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3 Sheets-Sheet 2



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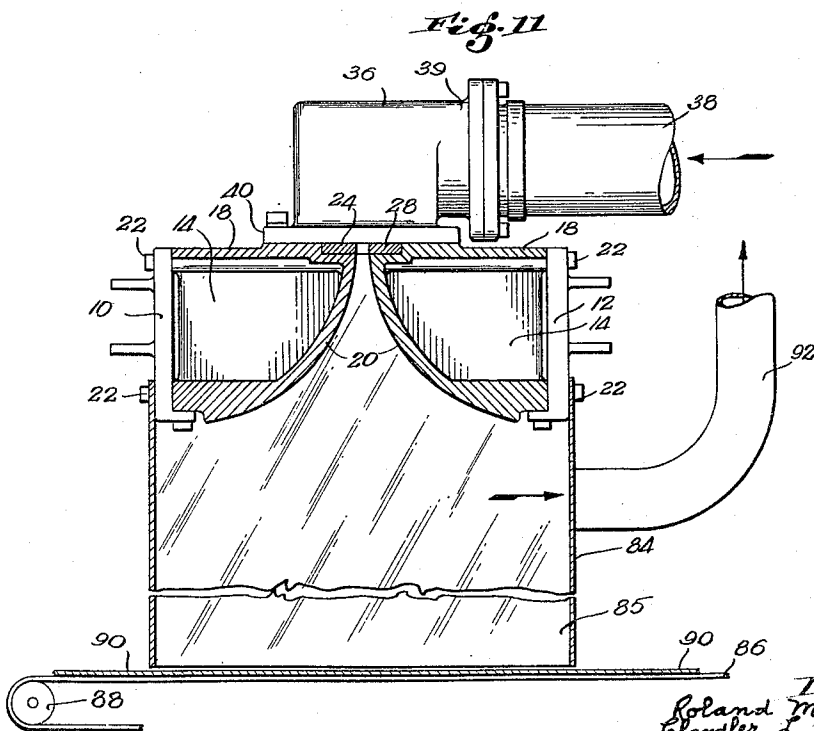
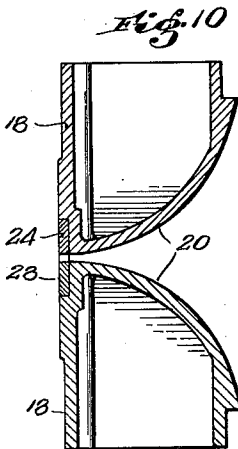
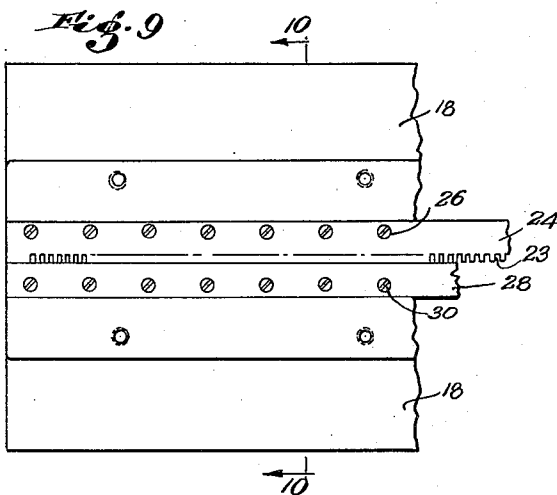
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AGITATING APPARATUS

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3 Sheets-Sheet 3



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UNITED STATES PATENT OFFICE

2,562,545

AGITATING APPARATUS

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9 Claims. (Cl. 259—1)

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Our invention relates to apparatus for agitating materials to change their condition or character. In particular, the invention comprises apparatus for generating compression waves (sonic energy) in a long narrow beam well adapted to operate with uniform effect across moving sheets, webs or material riding on a conveyor.

Others have recognized phenomena resulting from the subjection of various materials to compression wave agitation. For example, sonic energy has been known to effect the homogenization of milk, the killing of bacteria, emulsification of liquids, the flocculation and deflocculation of solid particles, and rapid dyeing of textiles. Difficulties attendant upon the generation of sonic energy in liquids has led to the development of apparatus for generating compression waves in a gaseous medium and applying the waves to the materials undergoing treatment. However, conventional sound generators of the siren type produce conical beams which decrease in intensity as the distance from the center increases.

The most important object of our invention is to produce sound waves of uniform intensity throughout a narrow linear zone and thereby make it possible to subject a moving band of material to compression wave agitation having identical effect throughout the width of the band.

Another object of the invention is to provide a compression wave generating and radiating system applicable for the establishment of a long narrow sound field of high intensity.

An important feature of the invention resides in the combination of a long flat slotted stator coupled at one side to an acoustic horn having a long narrow mouth, and provided on the other side with a shutter controlling the stator slots. Means are also provided for supplying fluid under pressure to the shutter-stator combination.

Another feature of the invention comprises a resonant chamber coupled to the acoustic horn and furnished with means for the continuous passage of material through the chamber.

These and other objects and features of the invention will be best understood and appreciated from the following description of a preferred embodiment thereof selected for purposes of illustration and shown in the accompanying drawings in which:

Fig. 1 is a view in side elevation of agitating apparatus constructed in accordance with the invention,

Fig. 2 is a view in cross-section along the line 2—2 of Fig. 1,

Fig. 3 is a view in end elevation of the apparatus, portions thereof appearing in cross section,

Fig. 4 is a view in cross section on an enlarged scale showing the relation of the stator, the endless belt, and the horn,

Fig. 5 is a plan view of a portion of the endless belt,

2

Fig. 6 is a plan view of an alternative form of belt,

Fig. 7 is a plan view, much enlarged, of a portion of the stator,

Fig. 8 is a view in cross-section along the line 8—8 of Fig. 7,

Fig. 9 is a plan view of the stator and bed plates,

Fig. 10 is a view in cross section along the line 10—10 of Fig. 9, and

Fig. 11 is a view in end elevation of the apparatus as coupled to a resonant chamber and material conveyor.

In the particular embodiment of our invention shown in the drawings we organize the compression wave producing apparatus about an opposed pair of heavy hollow iron side frames 10 and 12 disposed in parallel relation and each closed at its ends by a pair of plates 14 to define, in effect, a long, narrow rectangular box structure open at the top and bottom. Secured to the inside of each side frame by screws 22 is a long hollow casting having a flat top 18, a curved inner face 20, and a thickened base 21 merging smoothly into the curving side. The two castings together form a long flat bed 18 and an exponential acoustic horn 20 having a long narrow mouth running the length of the bed plate, the horn being closed at its ends by the plates 14.

Each plate 18 is recessed adjacent the mouth of the horn to receive members comprising a stator. One member 24 consists of a long rectangular metal strip milled along one margin to produce a series of teeth 23 forming a series of uniformly spaced rectangular slots, clearly shown in Fig. 7. The strip 24 is also provided with a series of counterbored screw holes 25 by means of which it is held flat upon the plate 18 by a number of screws 26. Adjacent the roots of the teeth 23 are three parallel grooves 27 running throughout the length of the member 24 to form a labyrinth seal as will hereafter be discussed. The member 24 is so placed on the plate 18 that the alternate teeth and slots overlie the mouth of the horn 20.

The second stator piece consists simply of a flat strip 28 held on the plate 18 in abutting relation with the member 24 by means of a series of screws 30. The two pieces 24 and 28 may thus be regarded as a long flat member having a series of uniformly spaced slots or apertures communicating with the mouth of the horn 20.

Secured to the bed plates 18 over the stator is a hood or box 36 provided with a base flange 40 receiving a plurality of bolts for holding the hood in position. The hood 36 is fluid tight except for the stator, which in effect serves as a portion of a wall of the hood; a rubber hose 38 is secured to an appropriate fitting 39 formed in the hood 36 and serves to supply air or other fluid to the hood, the latter being employed as a pressure chamber from which fluid is periodically discharged through the slotted stator.

The bottom wall of the hood 36 is provided with a narrow longitudinal slot 43 overlying the slotted stator; the bottom wall is also recessed adjacent the slot to receive an opposed pair of guide strips 44 each provided with an upwardly offset overhanging inner margin. The strips 44 are secured to the bottom of the hood 36 by means of a series of screws 46.

At one end of the side frame 10 there is secured a vertical standard 46, while a similar standard 48 is mounted at the opposite end. At the top of the standard 46 there is secured a yoked bearing member 50 in which is journaled a stub shaft 52 carrying a pulley 56 at one end and a large wheel 54 at the other end. A V-belt 58 is looped over the pulley 56 and driven by a motor (not shown).

A heavy bracket 60 is secured to the standard 46 by a pair of bolts 62 working in an elongated slot 61 cut in the side of the bracket which is outwardly flanged at its bottom to receive an adjusted bolt 64 which bears on the base of the standard 48. The top of the bracket 60 is also outwardly flanged to provide support for an opposed pair of guide rails 66 between which slides a carriage 68 carrying a yoked bearing housing 70 in which a stub shaft 72 is journaled. An adjusting bolt 74 works in a lug 76 mounted on the side of the bracket and operates to slide the carriage 68 horizontally. A large wheel 78 is fixed to one end of the stub shaft 72 and may be adjusted horizontally and vertically by manipulation of the bolts 64 and 74.

An endless steel belt 80, similar to a band saw blade, is looped over the wheels 54 and 78; its bottom run being substantially straight and passing over the slotted stator members 24 and 28 and beneath the guides 44 which serve as edge guides keeping the belt confined to a linear path. The tension of the belt may be adjusted by moving the wheel 78 bodily by means of the bolts 64 and 74.

The belt 80 is provided throughout its length with a plurality of uniformly spaced slots corresponding to but slightly smaller than the slots in the stator. The slots 82, as shown, are rectangular, although circles, ellipses, etc. may be employed as suggested at 82' in Fig. 6. Stator openings of similar geometry may also be employed.

When the wheel 54 is driven, the belt 80 slides across the flat stator members 24 and 28 and thus alternately opens and closes the slots in the stator. In effect, the belt serves as a shutter; when the belt slots 82 are registered with the slots in the stator, air or other fluid in the hood 36 is discharged through the belt slots; the stator slots, and into the long acoustic horn 20. The intensity of the sound waves generated depends upon the pressure of the fluid forced into the hood 36; while the frequency is a function of the speed at which the belt is driven. It is extremely important that the slots in the stator and in the belt be uniformly spaced in both instances, since otherwise some of the stator slots will be open while others are closed or partially closed. The result then is that fluid is continuously discharged from the hood rather than emitted only in short bursts. Inasmuch as the intensity of the waves generated by the apparatus is a function of the fluid pressure in the hood, it follows that the hood must be airtight and fitted in airtight sealing relation upon the bed plates 18. Leakage of fluid is minimized by the position of the grooves 27 which form, in effect, a labyrinth seal which

tends to eliminate the lateral emission of fluid. It should further be pointed out that the pressurized fluid bears against the inner surface of the belt 80 and tends to hold it against the upper surface of the stator, thereby further reducing leakage.

Apparatus of the type shown may be used to generate compression waves at frequencies at least as high as 5,000 cycles per second and at an intensity of at least 160 db. (better than a sound pressure of 10^4 dynes per square centimeter).

Sonic energy of these proportions may effectively be used for many industrial purposes. For example, in the manufacture of paper the wet pulp is spread upon a traveling screen conveyor where it is dried. It has long been recognized that the fibers of the pulp tend to lie parallel to each other with the result that the finished paper is much less resistant to shearing stresses in one direction than in another. Various attempts have been made to deflocculate or disorient the pulp fibers so that they will lie completely at random. We have found that sound waves may be employed for this purpose with a considerable degree of success. However, conventional sources of sound waves are not suitable because the intensity varies radically from point to point in the sound field. Apparatus of the type herein shown, however, is distinguished for the production of a long narrow sound field and thus lends itself admirably to the treatment of paper pulp.

In Fig. 11 there is shown, somewhat diagrammatically, an arrangement in which the compression wave agitator of our invention may usefully be applied for the deflocculation of paper pulp fibers. A long narrow rectangular chamber is formed by metal sheets 84 bolted to the side frames 10 and 12 of the generating apparatus and by suitable end walls 85. The apparatus with the chamber beneath it is poised transversely over a conveyor belt 86 passing over a driven roller 88. The paper pulp 90 is carried on the belt across the bottom of the chamber and thus subjected to the compression waves radiated by the acoustic horn 20. As before stated, the sound waves act to shake the fibers of the paper pulp and distribute them at random so that when the pulp has dried, the resulting paper will be uniformly strong in all directions.

In designing the hood and the treating chamber it is important to choose dimensions which will minimize out of phase reflections. That is to say if a sound wave reflected from the pulp on the belt 86 returns to the interface of the stator and belt slots in proper phase relation, the second reflection will tend to augment the newly generated wave. If the phase is displaced, the returning wave will tend to buck and diminish the wave being generated. Similarly every time a wave is propagated through the horn 20 another wave is propagated back up into the hood. Consequently it is desirable so to design the hood that back reflected waves will return to the stator in proper phase relation. Naturally, the frequency at which the apparatus is to be operated will largely determine the selection of the proper dimensions. In general it may be stated that the distance from the interface or upper surface of the stator, to the reflecting surface should be an uneven multiple of a quarter wavelength.

To give an example of a unit constructed in accordance with the invention and which has been successfully operated, a belt 208.1' long is provided with 1664 slots, each .051' wide and

$\frac{3}{32}$ " long. The effective length of the stator was 30" and it was provided with 240 slots each .059" wide and $\frac{1}{4}$ " long. The practical upper limit of the frequency of the waves generated is about 15 kc., but this may be greatly increased by using a double stator and two endless belts driven in opposite directions. It is to be emphasized that these figures are by no means critical and are inserted here merely to give an idea of the order of magnitude of a satisfactory device constructed in accordance with the invention.

Although an endless belt has been shown as the element controlling the opening and shutting of the stator ports, the invention is not limited to an embodiment in this form. For example, a reciprocating strip or shutter provided with suitable slots may be mounted above the stator and used to generate sound waves. It will be found in practice that the reciprocating shutter is less desirable for the generation of waves at relatively high frequencies, since the rate of reciprocation becomes impractically great. For relatively low frequencies the reciprocating gate or shutter may well offer advantages. Those skilled in the art will readily appreciate the possibility of wide variations in the design of the unit, but the scope of the invention is to be measured in terms of the appended claims rather than in the detailed description above.

Having thus disclosed our invention what we claim as new and desire to secure by Letters Patent of the United States is:

1. Apparatus for agitating materials with compression waves comprising a pair of wheels mounted for rotation on spaced parallel axes, means for driving one of said wheels, an endless belt looped over said wheels and having one run disposed along a straight path, said belt being provided throughout its length with uniformly spaced apertures, an elongated bed plate disposed beneath the straight run of said belt, opposed guides disposed to engage said belt and confine it to close juxtaposition with said bed plate, said bed plate having a plurality of uniformly spaced apertures disposed in a line parallel to said belt in position to be opened and closed as said apertured belt passes over the bed plate, an acoustic horn communicating with the side of the bed plate opposite the belt, and walls forming a resonant chamber communicating with said horn.

2. Apparatus for agitating materials with compression waves, comprising a long substantially flat member provided with a series of aligned uniformly spaced apertures extending along the long dimension of said member, an endless belt provided with a series of aligned uniformly spaced apertures, means for driving the belt through a path including a section in close proximity to and in parallel relationship with said member and with the direction of said series of apertures, and walls forming a chamber communicating with said belt and member, whereby fluid may be introduced to said chamber under pressure and discharged therefrom in repeated bursts as the movement of the belt alternately opens and interrupts the apertures in said member.

3. Apparatus for agitating materials with compression waves, comprising an endless belt provided with a series of apertures, an elongated member also provided with a series of apertures extending longitudinally along said member, means for driving the belt through a path including a section in close proximity to and in parallel relationship with the member and to the direction of said series of apertures, and means for

supplying fluid under pressure to an area overlying said belt and member.

4. Apparatus for agitating materials with compression waves, comprising walls forming a chamber, a substantially flat elongated member serving as a portion of a wall of said chamber and provided with a plurality of aligned apertures, an endless belt provided with a plurality of aligned apertures, and means mounting said belt for movement through a path traversing said chamber in close juxtaposition to and in parallel relationship with said member and with the direction of alignment of said series of apertures, whereby the apertures of said member are alternately closed and opened by said belt to generate a band of compression waves.

5. Apparatus for agitating materials with compression waves, comprising an elongated substantially flat member provided with a plurality of aligned apertures, walls forming a chamber including said member as part of a wall, and a shutter mounted for movement in close proximity to and in a path parallel to said apertures in position alternately to open and close said apertures, thereby forming agitating compression waves.

6. Apparatus for agitating materials with compression waves comprising walls forming a chamber, a flat elongated member forming a portion of one of said walls and provided with a series of aligned apertures, a long shutter disposed in close proximity to said member in position alternately to open and close said apertures, said elongated member being parallel to the direction of movement of the shutter and means for admitting fluid under pressure to said chamber.

7. Apparatus for agitating materials by compression waves comprising walls forming a chamber, a long flat member serving as a portion of one of said walls and provided with a plurality of uniformly spaced aligned apertures, an endless belt having a plurality of aligned apertures and mounted for movement along a path parallel to said member and to the direction of alignment of said apertures including a section in close juxtaposition to said member, and an acoustic horn having a long narrow mouth coupled to said member on the side opposite said chamber.

8. The structure defined in claim 7 wherein are provided walls forming a resonant chamber coupled to said horn.

9. Apparatus for agitating materials by compression waves, comprising a conveyor belt, a narrow elongated acoustic horn mounted transversely above said belt, said horn having a long narrow mouth, a long flat apertured stator, and a long shutter, said stator and shutter being mounted at the mouth of the horn in operative combination, said stator and shutter being parallel with the long mouth of the horn and walls forming a pressure chamber communicating with said horn through said stator and shutter combination.

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