

June 18, 1946.

R. G. ROWE ET AL

2,402,183

COATING APPARATUS

Filed April 13, 1944

4 Sheets-Sheet 1

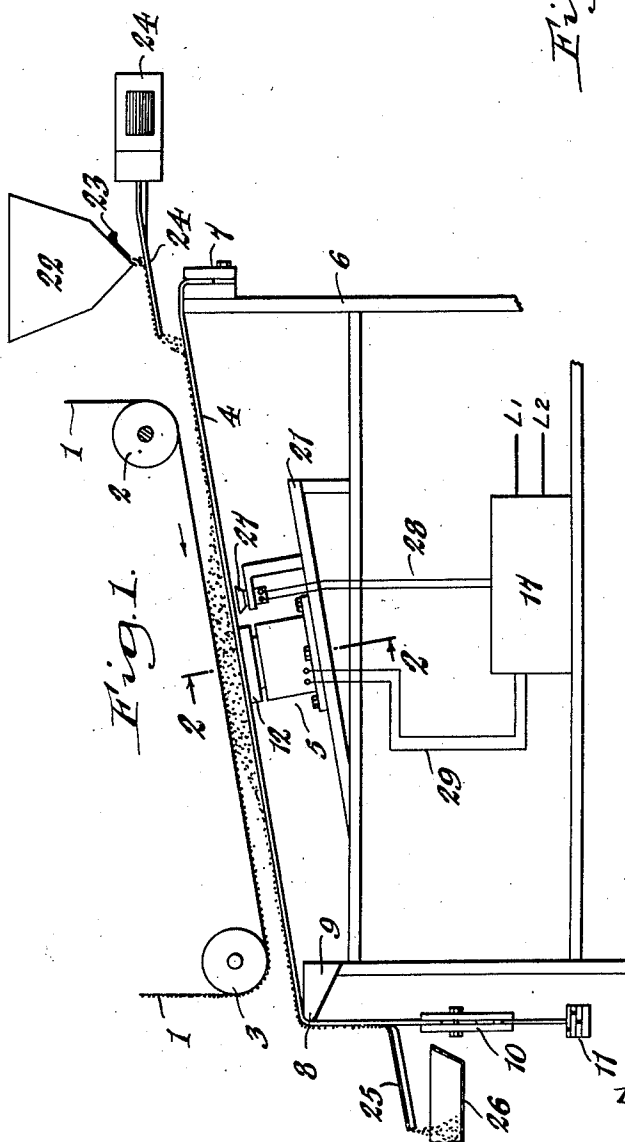
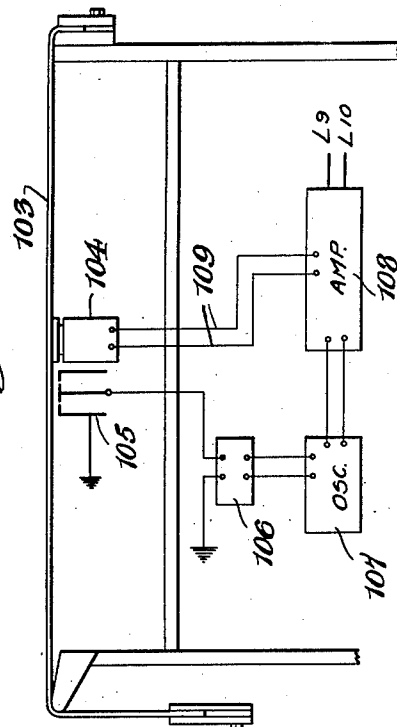


Fig. 6.



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Fig. 2.

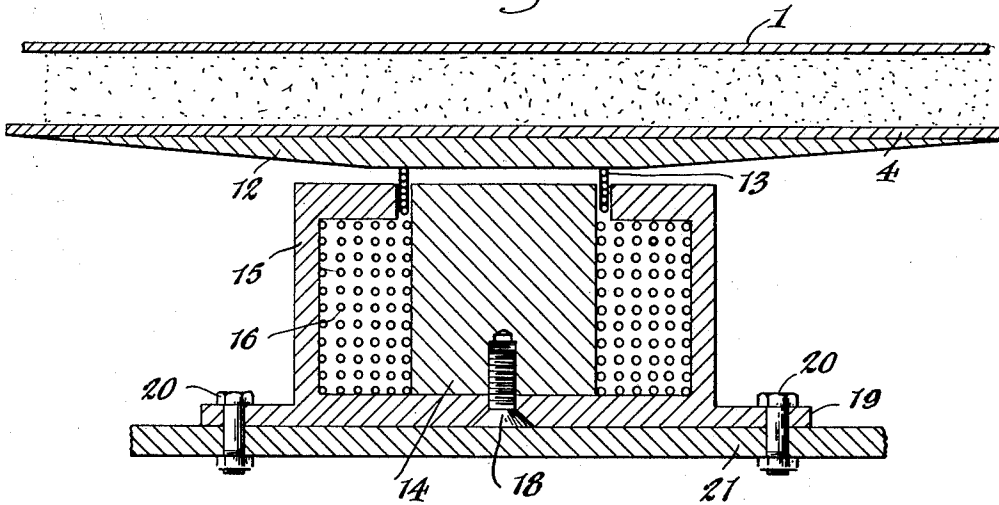
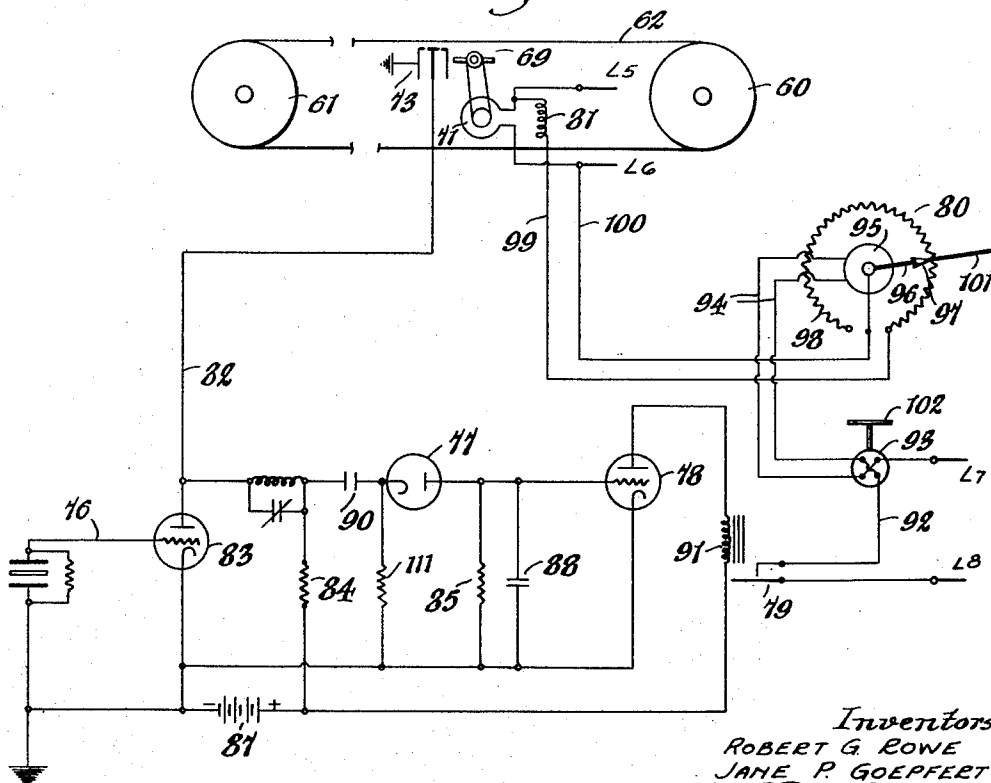


Fig. 5.



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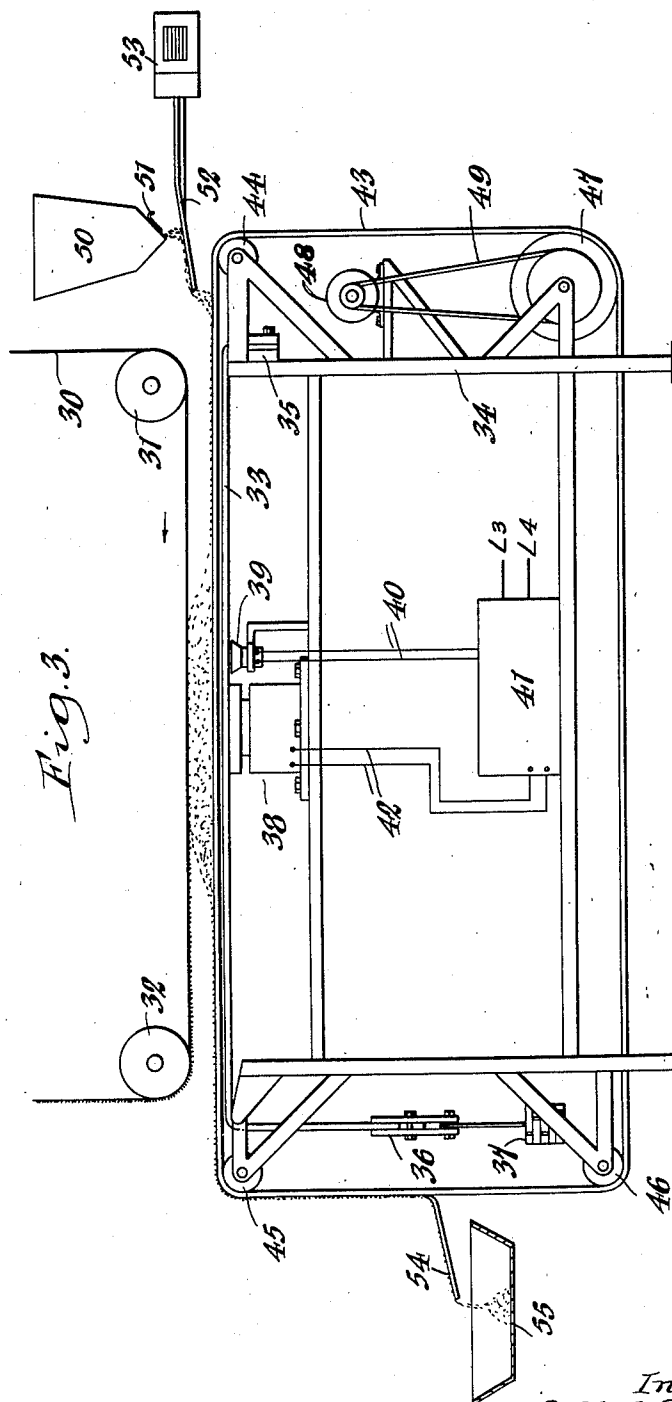
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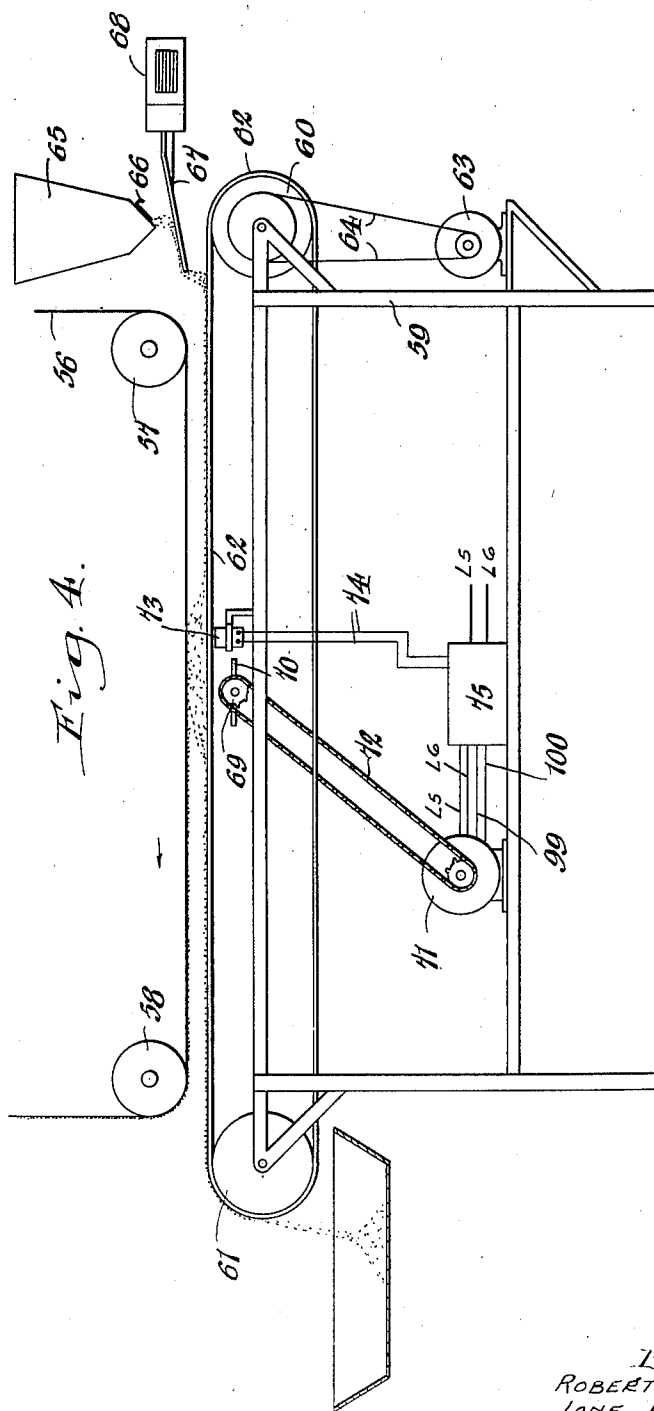
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COATING APPARATUS

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Application April 13, 1944, Serial No. 530,798

12 Claims. (Cl. 91—18)

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This invention relates to improved apparatus for the manufacture of granular coated webs.

The invention has, as one object thereof, the provision of apparatus for mechanically projecting particles against a web and orienting them with respect thereto, such apparatus being so constructed that it is maintained automatically in its optimum operating condition. Another object of the invention is the provision of a mechanical particle projecting apparatus so constructed that the granular coated web resulting therefrom is uniform throughout its extent. These and further objects of the invention will more fully appear as the description proceeds.

Granular coated webs of material such as paper and cloth have been made in the past by dropping the granular particles upon an adhesively coated surface of the web. The product resulting from such gravity coating process, when the granular particles are abrasive grains, is in general inferior in cutting ability since the particles for the most part tend to lie on the web with their broad surface parallel to the surface of the web. Because of this, in the making of abrasive coated paper and cloth "electrocoating" has largely supplanted the gravity coating method in the finer grit sizes, that is to say, 24 grit and finer. By "electrocoating" is meant the projection and/or orientation of particles with respect to the web by means of electrostatic fields, electromagnetic fields, or a combination of the two.

Considerable difficulty has been experienced in electrocoating webs with granular material larger than 24 grit, and in fact the process does not work in an entirely satisfactory manner with grains which are larger than 36 grit. This is due to the fact that with the larger particles the field strength must be raised tremendously to effect their projection and/or orientation, and that the practical limit of field strength is reached when the particles are 24 grit size. Because of this, mechanical grain projection or the combination of mechanical grain projection with electrical or electromagnetic grain projection is employed in the coating of webs with grains of 24 grit size and larger. Such mechanical grain projectors, of which the present invention is an improvement, may employ rotary beaters beneath a continuously driven conveyor belt, the belt carrying the granular particles beneath an adhesively coated web which travels roughly parallel to the conveyor belt with the adhesive coated side confronting the grain projector. The arms of the beater intermittently contact the under surface

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of the conveyor belt thereby causing the belt to vibrate and to project the granular particles against the adhesively coated side of the web. In their travel through the air the particles tend to align themselves with their long dimensions parallel to the line of flight, and thus such mechanical projection produces an oriented coated product.

In place of the rotary beater for the purpose of vibrating the conveyor belt, other types of vibrators have been employed, such as reciprocating, rocking and/or electromagnetic vibrators. Such devices, besides being used by themselves for the purpose of projecting and orienting the particles by purely mechanical means, have been employed to supplement the effects of electrostatic or electromagnetic fields in the projection and orientation of particles. It is to be understood that the present invention, which relates to an improvement in the mechanical projection of particles, even though shown as used by itself for the purely mechanical projection of particles may be used in combination with electrostatic and/or electromagnetic fields for the purpose of supplementing their effect in the projection and orientation of particles.

Briefly, the present invention resides in the provision of the combination of a vibrating grain projector with means for controlling the frequency of vibration of such projector whereby it vibrates at its optimum frequency at all times. By "optimum frequency" is meant that frequency at which the projector imparts to the particles the maximum projective effect.

The invention will be more readily understood by reference to the accompanying drawings in which:

Figure 1 is a side elevation of one modification of apparatus constructed in accordance with the present invention,

Figure 2 is a view in cross-section taken along the line 2—2 of Figure 1,

Figure 3 is a side elevation of a second modification of apparatus made in accordance with the present invention,

Figure 4 is a side elevation of a third modification of apparatus made in accordance with the present invention,

Figure 5 shows a control circuit for the beater in the apparatus shown in Figure 4, and

Figure 6 is a schematic drawing showing an alternative control circuit for the apparatus of Figures 1 and 3.

Figure 1 shows one typical apparatus, constructed in accordance with the present inven-

tion, for projecting and orienting particles. As shown in this figure, a web 1, which may be of paper, cloth, or the like, is caused to travel by means (not shown) in the direction of the arrows around pulleys 2 and 3, whence it travels to suitable drying racks (not shown). Such web has a layer of suitable adhesive applied to that face which is on the underside in its travel between pulleys 2 and 3, the adhesive being in optimum condition for the reception and retention of particles projected against it. Lying at least substantially parallel with the portion of the web between pulleys 2 and 3, and at an appreciable angle to the horizontal, is a particle conveying and projecting member 4 which, in this instance, is vibrated by the electromagnetic vibrating means designated generally by the reference numeral 5. Member 4, which is of a width somewhat greater than that of the web to be coated, is supported on the top of a frame 6 which may be constructed of an angle iron bolted or welded together. One end of member 4 which may be made, for example, of leather, is held to the frame by means of a clamping mechanism shown at 7, and the other end of member 4 runs over the rounded edge 8 of the projecting member 9 at the other end of the frame. The portion of particle carrying and projecting member 4 between opposite ends of the frame is maintained taut by means of a clamping mechanism 10 secured to the lower left hand end thereof. The clamping mechanism having provision for attaching to the bottom end thereof weights 11 of varying mass. As will be evident, the greater the tension upon member 4 the higher will be the natural frequency of vibration of such member. Such frequency may also be changed by changing the length of member 4 between the supports at the end of the frame. This may be accomplished by providing an adjustment for one or both of the supports for member 4, whereby the length of the vibrating portion thereof may be readily changed if desired. Although member 4 has been described as being of leather, it may be made of other strong durable flexible substances such as vulcanized fiber, strong canvas, a composite sheet of vulcanized fiber and cloth adhesively secured together, canvas, rubberized fabric, a thin sheet of metal, and the like.

The electromagnetic means 5 for vibrating member 4, which is shown in more detail in Figure 2, resembles in general the driving mechanism of a dynamic loud speaker. Attached to the central portion of the member 4, in the modification shown, by means such as a layer of hardened adhesive, is a laterally extending member 12 which imparts uniform vibration to the entire central section of member 4. Centrally attached to the bottom of member 12 is a coil of wire 13 which may be of one or two wires in thickness and which corresponds to the voice coil in a dynamic speaker. Such coil is free to reciprocate in the space between the central magnetic core 14 and the outer magnetic shell 15 of the field coil 16. The clearance between coil 13 and the core 14 and shell 15 is made as small as feasible in order to utilize maximum field strength. The windings of coil 16, which surround the lower part of core 14, are excited by a constant voltage D. C. source whereby a very strong magnetic field exists in the gap between the upper portion of the core and the shell of the field coil. Coil 13 is supplied, by means of flexible leads (not shown) running from wires 29 which deliver the output of an amplifier shown generally

as 17 in Figure 1, and vibrates axially at the frequency of alternation of the voltage supplied it by the amplifier, thereby imparting such frequency of vibration to member 4 in a direction transverse to its length.

The bottom portion of shell 15 of electromagnetic driving means 5, to the central portion of which core 14 is attached by means of bolt 18, is provided with an external flange 19 through which project bolts 20 to secure it to supporting plate 21. Supporting plate 21 is mounted on cross members of frame 6 as shown, so that it lies parallel to member 4.

Granular particles are supplied to the mechanical projector from hopper 22 which feeds the particles downwardly at a predetermined rate depending upon the adjustment of sliding gate 23. The particles fall from the hopper onto the feeding member 24 of a conventional electromagnetically vibrated feeding device 24', from which they are fed in a substantially uniform and controlled manner onto the upper end of vibrating projecting means 4. The angle at which means 4 is disposed to the horizontal, together with its vibration in a direction transverse to its broad extent, serves to feed the particles downwardly on member 4 onto the portion opposite the adhesively coated web and to the zone where member 4 vibrates with sufficient amplitude to project the particles upwardly into contact with the web. Such projecting portion of member 4 extends for a substantial distance on either side of the point of attachment of the electromagnetic vibrating means 5. After the web 1 is pulled past such zone of projection, it is "close coated," or completely covered with particles, if a sufficient quantity of particles, or an excess thereover, is fed onto member 4. An "open coated" web may be produced by feeding a predetermined amount of particles onto the projector, said particles being insufficient to completely cover the adhesive coated web. An "open coat" may also be produced by cutting down on the gain of amplifier 17, thereby imparting less amplitude of vibration to the projecting member. In order to recover those particles which do not become fastened to the web, a conveyor 25 is provided in contact with the vertical portion of member 4 at the lower end thereof for conducting such unprojected grains into a container or bin 26.

As has been indicated above, member 4 projects the grain thereon most strongly and efficiently when it is vibrating at its maximum amplitude, or, more correctly, when the system consisting of member 4 and the grain load thereon is vibrating at its fundamental or harmonic frequencies. It is to be understood that in order to project the particles against the web such frequencies must be sufficiently high to impart adequate velocity to the particles.

It can readily be seen that such fundamental and harmonic frequencies for the system vary with the amount and distribution of grain on member 4, and that, even though the frequency of vibration of means 5 is initially adjusted so that the system vibrates in resonance, a change in the amount of grain fed onto the projector or a change in its distribution on member 4, which will inevitably occur with any commercial feeder, will result in a loss of efficiency of the mechanical projector, if the frequency of vibration of the driving means is allowed to remain constant.

The present invention overcomes this difficulty by providing means which automatically main-

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tain the vibrating means substantially in resonance with the projecting member regardless of variations in the rate of feed or distribution of particles onto the projector. In the modification shown in Figure 1 this is accomplished by providing a means 27 responsive to the frequency of vibration of the projector member 4 for exciting amplifier 17 in a regenerative fashion, the thus modified output of the amplifier being fed to the vibrating means 5. As shown in this modification, means 27 consists of a microphone mounted under projector 4 in a position as near as possible to its longitudinal center. Voltages produced by the microphone are led by means of wires 28 into the amplifier, and impressed upon the grid of the first tube thereof. The amplifier 17, which is a conventional multi-tube radio amplifier, is supplied with power from lines L₁ and L₂. The modified output of amplifier 17 is fed to the moving coil of vibrator means 5 by wires 29.

The system shown in Figure 1 operates as follows: It is well known in the radio art that when a conventional microphone and loudspeaker are placed near each other and suitably coupled, for instance, to a public address amplifier, regenerative feed-back occurs. The frequency of these regenerative oscillations is determined by the frequency response characteristics of the microphone, the amplifier, and the loudspeaker, as well as the characteristics of the medium interposed between the microphone and the loudspeaker. By employing a microphone and amplifier of uniform frequency response characteristics, the feed-back frequency is then determined largely by the response characteristics of the loudspeaker.

In the modification of the present invention shown in Figure 1 the loudspeaker is replaced by a grain projecting member 4 which has a definite fundamental period of vibration. When coupled as shown, the feed-back frequency of the entire system is determined largely by the fundamental period of the grain projecting member. The fundamental period of the grain projecting member is modified by the grain load and distribution, but when a variation in either or both of these occurs the feed-back frequency or period of oscillation of the system automatically readjusts itself to these new conditions in such as fashion as to maintain optimum projection of grain, because the new frequency of vibration of driven 5 will be at or very near the new natural period of the system consisting of the projecting member and the grain load.

In practice it has been found that other modes of vibration than the fundamental may be excited in the projecting member. Other modes of vibration are often preferable to distribute the areas of maximum projection more uniformly over the surface of the projecting member. Further, it has been found that an optimum frequency exists for optimum projection, and that an optimum frequency range exists for optimum projection of grain under the conditions of varying grain load and distribution found in practice. When such a frequency range has been determined, it is preferable to install narrow band-pass filters in the circuit to substantially restrict the amplifier output to this range of frequencies. This enables the system to follow the variations caused by changes in grain load and distribution, but prevents it from slipping into another mode of vibration.

Although the driving means 5 has been shown

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as located at the center of the projecting member 4, additional amplitude may be secured by positioning it nearer to either end of the projecting member. Further, by varying the location of the driver, many different modes of vibration may be produced in the projecting member.

Although the means responsive to the frequency of vibration of member 4 has been shown and described as a microphone, it is obvious that there may be substituted therefor a vibration pick-up in contact with the projecting member 4. Furthermore, suitable control of the driver can be effected by means of a condenser formed by an insulated metal plate fastened to the frame of the machine or to a stationary portion of the vibrating means 4, and another plate in confronting relationship therewith fastened to the projector means 4 or to a moving portion of the vibrator. The capacity of the condenser so formed varies as the projecting member is vibrated, and may be readily employed to control the output of the amplifier feeding the electromagnetic vibrator in such manner as to maintain the projecting member vibrating at optimum frequency. Such condenser control is preferable in some instances to the use of a microphone because it is responsive only to varying displacement of the parts and not to external noise.

The modification of the apparatus shown in Figure 3 comprises in the main the same essential components as the apparatus shown in Figure 1, with the exception that the grain projecting member is not relied upon to convey the grain into the zone of projection opposite the web. An adhesive coated web 30 is run in the direction of the arrows around pulleys 31 and 32 with the adhesive coated side facing downwardly in the portion between the pulleys. After leaving pulley 32 the particle surfaced web is pulled by means not shown to drying racks to allow setting of the adhesive. The device comprises a vibrating grain projector means 33 similar to means 4 in Figure 1. Means 33 is stretched over the top of frame 34 and is held at one end by clamping means 35 and at the other end by clamping means 36 and adjustable weight 37. Means 33 is vibrated by an electromagnetic vibrating means indicated generally by the character 38, which in this instance is identical with the vibrating means 5 in Figure 1. Vibrations of projecting means 33 are picked up by vibration responsive device 39, which may be a microphone. The output of microphone 39 is lead by wires 40 into the amplifier 41 which is fed by power leads L₃ and L₄. The output of amplifier 41, modified regeneratively, as explained in connection with Figure 1, by the output of microphone 39, is fed to the moving coil of vibrator means 38 by wires 42.

Particles are carried into the projecting zone of the vibrating member 33, in this instance, by means of continuous conveyor belt 43 which is supported for travel across the top of frame 34 on idler pulleys 44 and 45, and which then travels down and through the bottom portion of the frame on idler pulley 46 and driven pulley 47. Pulley 47, which serves to drive belt 43 at a suitable speed, is driven by means of motor 48, mounted on a sub-frame attached to frame 34, by means of belt or chain 49. Conveyor belt 43 is so mounted in its upper horizontal run that when the parts are at rest it just clears the top of projector member 33. Particles are fed onto the top portion of the conveyor belt by means of a hopper 50 having an opening in the bottom thereof controlled by slide 51. The grain fed

from hopper 50 falls upon conveyor surface 52 of a conventional electromagnetically driven feeder 53 and thence is fed in a controlled and substantially uniform manner onto the top of the conveyor belt 43.

When vibrator 38 is set in motion it will, by reason of pickup 39 and amplifier 41, tend to vibrate the system composed of member 33, the upper horizontal portion of belt 43, and the load of particles on belt 43, at its natural frequency. The upper horizontal portion of conveyor belt 43 will follow closely member 33 in its vibration since member 33 will carry conveyor belt 43 upwardly in its upward travel, and, because of the small clearance initially present between the two members, and the difficulty of ingress of air between the broad vibrating surfaces of belt 43 and member 33, they will tend to adhere together during downward travel regardless of the longitudinal motion of the conveyor belt relative to the projector member 33. Thus the horizontal portions of conveyor belt 43 and projector member 33 tend to vibrate as a unit, and variations in the weight of grain and its manner of distribution on the conveyor belt change the natural frequency of vibration of the system.

The system is maintained in its optimum vibrating condition, however, by means of pickup 39 and amplifier 41 which maintain projector member 33 vibrating with maximum amplitude regardless of changes in the particle load on belt 43. The apparatus of Figure 3 may, as in the case of the apparatus shown in Figure 1, be used to make "open-coat" as well as "close-coat" particle surfaced webs by suitable choice of the quantity of particles fed to the projector, or of the power supplied to the projecting member. Any particles remaining on conveyor belt 43, after it has progressed through the projecting zone and traveled over pulley 45, fall onto conveyor 54 and thence are led to container 55 for re-use.

In Figures 1 and 3 vibration of the grain projecting member has been accomplished by means of an electromagnetic vibrator, the moving coil of which is attached to the projecting member. It is obvious that if the projecting member is itself magnetic in character as, for instance, thin sheet steel, a moving coil need not be employed. Instead, an electromagnet acting directly upon the projecting member and fed by a voltage of the desired controlled frequency may be employed.

Although in both the modifications shown in Figures 1 and 3, and also in that discussed immediately above, vibration of the grain projecting means is accomplished by electromagnetic vibrating means, the present invention includes mechanical particle projectors in which vibration of the projecting member is accomplished by other means such as motor driven beaters. Such a device is shown in Figure 4. In this modification an adhesive coated web 56, travelling in the direction of the arrow, passes around pulleys 57 and 58 in such manner that the adhesive coated face lies in the underside. Supported on frame 59 are driven and idler pulleys 60 and 61, respectively, so arranged that the upper portion of continuous conveyor belt 62 which runs over them is approximately parallel to the portion of the web between pulleys 57 and 58. Conveyor belt 62 is driven at a desired speed by means of motor 63, which drives pulley 60 by means of belt or chain 64. Particles are fed onto the upper surface of the conveyor belt from a conventional hopper 65 having a controllable slidable gate 66, the par-

ticles from the hopper dropping onto the feeding member 67 of a conventional electro-magnetic feeding device 68, and thence to the top surface of the conveyor belt, as shown. The top grain carrying portion of conveyor belt 62 is vibrated in a conventional manner by means of rotary beater 69 having a plurality of belt contacting arms 70. The rotary beater is driven by means of variable speed shunt D. C. motor 71 through the intermediary of chain 72, so that the speed of the beater bears a fixed relationship to the speed of the motor.

In this type of vibration grain projection specific rotational beater speeds project the particles with a maximum effectiveness. These speeds, which are determined by observation and experiment, bear a direct relationship with the natural period of vibration of the loaded projecting member. When beater blades 70 strike particle projecting conveyor belt 62 with a periodicity corresponding to a natural period of vibration of the loaded projecting member, or, in other words, when the periods of the driving means and the projecting means are at or near resonance, the maximum projective effect is noted.

However, variations in the grain load and distribution on projecting member 62 produce variations in the natural period of this member. Thus, a constant beater speed (driving frequency) cannot follow the shifted period of the projecting member and resonance is not maintained. By readjustment of the beater speed and hence the driving period through motor 71, resonance and maximum amplitude of the particle projecting member can be reproduced.

Figure 5 is a disclosure of one modification of the invention to automatically maintain the maximum projective effect by maintaining resonance or near-resonance conditions between the driving and projecting means.

Coaxial condenser 73 is so positioned near projecting member 62 that the displacement of member 62 produces capacitance variations in condenser 73. The magnitude of the capacitance variation is proportional to the magnitude of displacement of member 62. Such capacitance variations in condenser 73 are coupled through lead 82 to the plate tank circuit of crystal oscillator 76, in a manner such that capacitance variations in condenser 73 are manifested as current changes through resistor 84, and such that the magnitude of current variation through resistor 84 is proportional to the magnitude of capacitance variation in condenser 73. By this means, through the IR drop through resistor 84, a varying voltage is subtended across resistor 84 which is proportional to the magnitude of capacitance variation in condenser 73 and hence to the displacement amplitude of projecting means 62.

This variable voltage is coupled through condenser 90, A. C. load resistor 111 and diode rectifier 77 to D. C. load resistor 85 and filter condenser 88 to provide a direct current grid bias for amplifier tube 78, such direct current grid bias being directly proportional to the displacement amplitude of projecting member 62. Circuit components are so chosen that relay 91 closes contacts 79 when the grid bias on tube 78 is low and opens contacts 79 when the grid bias is high. The grid bias of tube 78 is directly proportional to the amplitude of vibration of projecting means 62, hence contacts 79 will close when the amplitude of projecting means 62 is small and open when the amplitude is large.

Interposed in the shunt field of motor 71 is a

speed controlling rheostat 80. Rheostat 80 is provided with a small direct current rheostat operating motor 95, the field of which is supplied by permanent magnets. The rotor of motor 95 is supplied with direct current from lines L₁ and L₂, line L₂ leading to one of the relay contacts 79, and line L₁ leading to reversing switch 93. From the other one of the contacts 79 line 92 leads to reversing switch 93. Wires 94 lead out of switch 93 to feed the rotor of motor 95. Thus the closing of contacts 79 of relay 91 causes motor 95 to operate, and the throwing of switch 93 from one position to another causes reversal of current in wires 94 and thus reversal of motor 95.

Motor 95 drives contacting arm 96 which is provided with means 97 making contact with the circular winding 98 of rheostat 80. Line 99, leading to shunt winding 81 of motor 71, is connected to one end of the circular resistance. Line 100, by which the resistance 98 is fed from D. C. supply line L₂, is connected to contact arm 96 by means such as a brush on the hub of the arm. Contact arm 96 is extended to provide an outer portion 101 which contacts operating arm 102 of reversing switch 93 when the contact arm has reached either end of its travel about the resistance 98. This effects reversal of motor 95, thus causing arm 96 to reverse each time it reaches the end of the circular resistance.

The amount of correction necessary to be effected in the speed of rotation of motor 71 to compensate for varying grain loads on the belt lies within fairly close limits. Therefore it is necessary to make resistance 98 only of such value as to compensate for such relatively small speed changes in motor 71. Motor 95 may be made to rotate at an appreciable speed and thus the motor driven rheostat, once a condition is reached whereby belt 62 no longer vibrates in resonance, will quickly hunt over the extent of rheostat 98 to restore the system to resonance, at which point the plate current of tube 78, which is inversely proportional to the amplitude of vibration of the belt, will reach a minimum. Relay 79 will thus be opened and rheostat motor 95 will stop. Thus the beater speed will automatically be adjusted, whenever the particle load and distribution on the feed belt are changed appreciably, to maintain the belt at its optimum vibration frequency.

In Fig. 6 there is shown a modification of the frequency control of the apparatus shown in Figs. 1 and 3. In this embodiment of the invention a variable frequency oscillator 107 drives projecting means 103 through amplifier 108 and the vibrating driver 104. The frequency of the oscillator 107 may be kept equal to the resonant frequency of the grain projecting member 103 by a voltage that will vary in magnitude with the amount the oscillator frequency deviates from the natural period of the projector, and will vary in polarity depending on whether the oscillator frequency is above or below the natural period of the projector. In the apparatus shown in Fig. 6 this varying voltage is produced by the coaxial condenser 105 cooperating with frequency control device 106. This frequency control device includes a discriminator circuit for developing a voltage the polarity of which depends upon whether the oscillator frequency is above or below the resonant frequency of the projector, and a reactor tube for changing the constants of the oscillator circuit in accordance with the magnitude and polarity of the voltage delivered by the discriminator.

Although the apparatus has been shown for the projecting and orienting of particles in the coating of webs, it will be evident that it may be employed for treating particle coated webs in which the adhesive is still fluid or plastic. In such case the particle coated web, with the uncoated surface facing downwardly, may be run over the vibrating member whereby the rapidly repeated impulses applied to it cause the particles to sink more deeply into the adhesive. Such web may be spaced only slightly from the vibrating member and thus travel with it. In such case the apparatus would be similar to that in Fig. 3, with, however, conveyor 43 and its driving means removed and with the coated web being run under tension over pulleys 44 and 45. It may be preferred to employ a rotary beater system for such treatment of coated webs. In this case the conveyor belt 62 and its driving means in the apparatus shown in Fig. 4 may be removed and the web, with its uncoated surface facing downwardly, is run over pulleys 60 and 61. In either of such modifications of the apparatus shown in Figs. 3 and 4 the means controlling the frequency of vibration of the vibrating driver insures that the vibrating system driven thereby is vibrated at maximum amplitude and that thus the web will be treated in such manner as to cause the coating particles to become further embedded in the adhesive layer most effectively.

Although the present invention has been found advantageous in the making of abrasive coated webs, it is obvious that it possesses broader utility. It may be used, for example, in coating webs with other types of granular particles such as roofing particles, or with decorative or reflective particles such as glass beads and the like.

The invention having thus been fully described, it is desired to claim as new the following:

1. Apparatus for the manufacture of particle coated webs comprising a particle projector which includes an elongated vibrating particle projecting member of substantial width, means for feeding particles into the particle projector in such relationship to the particle projecting member that they are projected thereby, means for vibrating the particle projecting member in a direction substantially at right angles to a line parallel to its greatest dimension, electrical means responsive to the frequency of vibration of the particle projecting member, said last named means being so constructed and arranged that it controls the frequency of vibration of the particle projecting member in such manner that the particle projecting member is caused to vibrate at maximum amplitude regardless of the changes in weight or distribution of the particles fed to the particle projector, and means for supporting a web with a particle receiving surface near and confronting the particle projector.

2. Apparatus for the manufacture of particle coated webs comprising a particle projector which includes an elongated vibrating particle projecting member having an upper surface of substantial extent, means for continuously feeding particles into the particle projector in such relationship to the particle projecting member as to be vibrated and projected thereby, means for vibrating the particle projecting member in a direction substantially at right angles to its upper surface, electrical means in proximity to the particle projecting members responsive to the frequency of vibration of the particle projecting member, a power source for the means for vibrating the projecting member, and means modifying the power

fed to the vibrating means in accordance with the response delivered by the frequency responsive means to maintain the particle projecting member vibrating at a maximum amplitude regardless of variations in weight and distributions of particles fed to the particle projector.

3. Apparatus for the manufacture of a particle coated webs comprising a particle projector which includes an elongated vibrating particle projecting member of substantial width, said particle projecting member consisting of a sheet of flexible material maintained under substantial tension in the direction of its length, means for vibrating the particle projecting member in a direction substantially at right angles to a line parallel to its greatest dimension, electrical means in proximity to the particle projecting member responsive to the frequency of vibration of the particle projecting member, a power source for the vibrating means, and means modifying the power fed to the vibrating means in accordance with the response from the frequency responsive means to maintain the particle projecting member vibrating at maximum amplitude regardless of variations in loads applied to the projecting member, means for feeding particles into the particle projector in such relationship to the particle projecting means that they are vibrated and projected thereby, and means for supporting a web with a particle receiving surface near and confronting the particle projector.

4. Apparatus for the manufacture of particle coated webs comprising a particle projector which includes a vibrating particle projecting member having an upper particle receiving surface of substantial extent, means for feeding particles onto the particle projecting member, means for vibrating the particle projecting member in a direction substantially at right angles to its upper surface, electrical means responsive to the frequency of vibration of the particle projecting member, said last named means being so constructed and arranged that it controls the frequency of vibration of the particle projecting member in such manner that the particle projecting member is caused to vibrate at maximum amplitude regardless of changes in the weight or distribution of the particles fed to the particle projector, and means for supporting a web with a particle receiving surface near and confronting the particle projector.

5. Apparatus for the manufacture of particle coated webs comprising a particle projector which includes an elongated vibrating particle projecting member of substantial width, means for feeding particles into the particle projector in such relationship to the projecting member as to be vibrated and projected thereby, means for vibrating the particle projecting member in a direction substantially at right angles to a line parallel to its greatest dimension, said vibrating means comprising an electromagnetic vibrating means, a source of pulsating voltage for driving the electromagnetic vibrating means, electrical means in proximity to the particle projecting member responsive to the frequency of vibration of the particle projecting member, means modifying the pulsating voltage fed to the vibrating means by the power source in accordance with the response from the frequency responsive means whereby the frequency of vibration of the particle projecting member is controlled in such manner that it vibrates at maximum amplitude regardless of the changes in the weight or distribution of the particles fed to the particle pro-

jector, and means for supporting a web with a particle receiving surface near and confronting the particle projector.

6. Apparatus for the manufacture of particle coated webs comprising a particle projector which includes an elongated vibrating particle projecting member of substantial width, means for feeding particles into the particle projector in such relationship to the projecting member as to be vibrated and projected thereby, means for vibrating the particle projecting member in a direction substantially at right angles to a line parallel to its greatest dimension, said vibrating means comprising an electromagnetic vibrating means, an audio frequency amplifier for driving the electromagnetic vibrating means, means in proximity to the particle projecting member responsive to the frequency of vibration of the particle projecting member, the response delivered by said frequency responsive device being delivered to the amplifier in a regenerative manner whereby the frequency of vibration of the particle projecting member is so controlled that its amplitude of vibration remains at maximum regardless of variations in the weight and distribution of the particles fed to the particle projector, and means for supporting a web with a particle receiving surface near and confronting the particle projector.

7. Apparatus for the manufacture of particle coated webs comprising a particle projector which includes an elongated vibrating particle projecting member of substantial width, means for feeding particles onto the particle projecting member, means for vibrating the particle projecting member in a direction substantially at right angles to a line parallel to its greatest dimension, said vibrating means comprising an electromagnetic vibrating means, an audio frequency amplifier for driving the electromagnetic vibrating means, means in proximity to the particle projecting member responsive to the frequency of vibration of the particle projecting member, the response delivered by said frequency responsive device being delivered to the amplifier in a regenerative manner whereby the frequency of vibration of the particle projecting member is so controlled that its amplitude of vibration remains at maximum regardless of variations in the weight and distribution of the particles fed onto the particle projecting member, and means for supporting a web with a particle receiving surface near and confronting the particle projector.

8. Apparatus for the manufacture of particle coated webs comprising a particle projector which includes a driven particle carrying conveyor belt, means for feeding particles onto the conveyor belt, means for vibrating the particle carrying portion of the conveyor belt in a direction substantially at right angles to a line parallel to its greatest dimension, said vibrating means including a vibrating driving means beneath the particle carrying portion of the conveyor belt, electrical means responsive to the frequency of vibration of the conveyor belt, means for supplying power to the vibrating driving means, means controlled by the frequency responsive means for varying the means for supplying power to the vibrating driving means, and means for supporting a web in proximity to the vibrating conveyor belt and with a particle receiving surface confronting said conveyor belt; the frequency responsive means, the means for supplying power to the vibrating driving means, and the means controlling the power supply being so constructed and arranged that the particle conveyor belt vibrates at maximum amplitude regardless of variations in the

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weight or distribution of the particles fed onto the conveyor belt.

9. Apparatus for the manufacture of particle coated webs comprising a particle projector which includes a driven particle carrying conveyor belt, means for vibrating the particle carrying portion of the conveyor belt in a direction substantially at right angles to a line parallel to its greatest dimension, said vibrating means including an elongated vibrating member parallel to and extending longitudinally of the particle carrying portion of the conveyor belt for substantially the entire length of such portion of the conveyor belt, said elongated vibrating means and the particle carrying portion of the conveyor belt being so spaced as to clear each other only slightly when the parts are not vibrating, vibrating driving means for vibrating the elongated vibrating member, and means for supporting a web in proximity to the vibrating conveyor belt and with a particle receiving surface confronting said conveyor belt; electrical means responsive to the frequency of vibration of the elongated vibrating means, means for supplying power to the vibrating driving means, means controlled by the frequency responsive means for varying the means for supplying power to the vibrating driving means, the frequency responsive means, the means for supplying power to the vibrating driving means, and the means controlling the power supply being so constructed and arranged that the system composed of the particle conveyor belt and the elongated vibrating means vibrates at maximum amplitude regardless of variations in the weight or distribution of the particles fed onto the conveyor belt.

10. Apparatus for the manufacture of particle coated webs comprising a particle projector which includes a driven particle carrying conveyor belt, means for feeding particles onto the conveyor belt, means for vibrating the particle carrying portion of the conveyor belt in a direction substantially at right angles to a line parallel to its greatest dimension, said vibrating means including a rotary beater beneath the particle carrying portion of the conveyor belt, a variable speed motor for driving the rotary beater, electrical means responsive to the frequency of vibration of the conveyor belt, means for supplying power to the motor for driving the beater, means controlled by the frequency responsive means for varying the speed of the beater motor, and means for supporting a web in proximity to the vibrating conveyor belt and with a particle receiving surface confronting said conveyor belt; the frequency responsive means, the means for supplying power to the beater motor and the means controlling the motor speed being so constructed and arranged that the particle conveyor belt vibrates at maximum amplitude regardless of variations in the weight or distribution of the particles fed onto the conveyor belt.

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11. Apparatus for the manufacture of particle coated webs comprising a particle projector which includes a driven particle carrying conveyor belt, means for feeding particles onto the conveyor belt, means for vibrating the particle carrying portion of the conveyor in a direction substantially at right angles to a line parallel to its greatest dimension, said vibrating means including a rotary beater beneath the particle carrying portion of the conveyor belt, a variable speed motor for driving the beater, electrical means responsive to the frequency of vibration of the conveyor belt, a source of power for the motor driving the beater, means controlled by the frequency responsive means for varying the speed of the beater driving motor, said last named means including an oscillator controlled by the frequency responsive means and a relay operated by the oscillator and controlling operation of the means for varying the speed of the beater motor, and means for supporting a web in proximity to the vibrating conveyor belt and with a particle receiving surface confronting said conveyor belt; the frequency responsive means, the means for supplying power to the beater driving motor, and the means for varying the speed of the beater motor being so constructed and arranged that the particle projector belt vibrates at maximum amplitude regardless of variations in the weight or distribution of the particles fed onto the conveyor belt.

12. Apparatus for the manufacture of particle coated webs comprising a particle projector which includes an elongated particle projecting member of substantial width, means for feeding particles into said particle projector in such relationship thereto that the particles are vibrated and projected by the particle projecting member, means for vibrating the particle projecting member in a direction substantially at right angles to a line parallel to its greatest dimension, electrical means responsive to the frequency of vibration of the particle projecting member, means for supplying power to the vibrating means, means controlled by the frequency responsive means for varying the means for supplying power to the vibrating means, and means for supporting a web in proximity to the particle projector and with a particle receiving surface confronting said projector; the frequency responsive means, the means for supplying power to the vibrating means, and the means controlling the power supply being so constructed and arranged that the particle projecting member vibrates at maximum amplitude regardless of variations in the weight or distribution of the particles fed to the particle projector.

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