ABSTRACT

A single transversely aligned floor conditioning plate or a group of transversely aligned floor conditioning plates are mounted on a tubular support which in turn is carried by an appropriate vehicle. For vibrating the plates at or near one of their modes of natural frequency, a single source of sinusoidal energy vibrating in the low sonic range is mounted midway between opposite ends of a resonant tubular support, at an antinodal point. When more than one resonant plate is employed, the other plates are also mounted at antinodal points by means of pedestal supports. A work shoe below each plate has an accumulator chamber for reception of cleaning liquid located above the work shoe and separated from the work shoe by a series of resilient spring mounts located at antinodal points which alone and/or in combination with the liquid transfer the sinusoidal acoustic resonant energy from the source through the tubular support and plate thereon into the conditioning fluid. The fluid medium is transformed into a state of cavitation and continues after it leaves the chamber. Subsequently a suction apparatus draws the spent and soiled conditioning fluid away from the conditioning operation.

12 Claims, 25 Drawing Figures
INDUSTRIAL CARPET AND FLOOR CONDITIONER

This application is a division of copending application Ser. No. 150,075, filed June 4, 1971, now U.S. Pat. No. 3,739,417.

Although there have been devised a variety of mechanical devices for conditioning purposes such, for example, as stripping wax, re waxing, polishing of hard surfaced floors, and the cleaning of soft floor surfaces such as, for example, rugs and carpets, a great number of such devices and particularly those more currently devised, have consisted of one or more rotating discs wherein the plane of the disc is parallel to the plane of the surface to be conditioned. Machines of such character have been used for cleaning rugs and carpets. Rotating discs and comparable equipment have been used for the stripping, cleaning, and polishing of hard surfaced floors. Other types of motorized equipment have often employed one or more brushes of a cylindrical type rotating on axes parallel to the plane of the surface to be cleaned, such brushes often being counterrotating so as to brush dirt upwardly between them. Industrial sweeping equipment employs numerous variations of the rotating brush principle herein made reference to. In virtually all instances, both those specifically made reference to and other equipment heretofore available, rely upon some type of scrubbing action.

Although a degree of cleaning is possible with equipment of the type described, a common defect in the continued use of such equipment is a progressive wearing down of the hard surfaces and a wearing out of soft surfaces such, for example, as rugs and carpets. The very agitating action depended upon for cleaning results in a wearing and physically disintegrating action of the material itself. Further still, equipment of the brushing and scrubbing type requires an appreciable amount of energy to overcome the friction depended upon for cleaning and such means accordingly have been heavy, expensive to build, and difficult to use without the expenditure of excessive amounts of power.

It is therefore among the objects of the invention to provide a new and improved floor conditioning device which cleans by the principle of cavitation without dependence upon a physical rubbing or scrubbing action.

Another object of the invention is to provide a new and improved surface conditioning device which is of such design and construction that cleaning can be accomplished by merely bringing a resonant work shoe into contact with the surface to be cleaned without depending upon the work shoe itself for mechanical cleaning action on the surface, and virtually without wear on the shoe.

Still another object of the invention is to provide a new and improved surface conditioning device which makes use of a sonic energy sinusoidal frequency generator operating in the low sonic range which can be applied to one or a plurality of resonant work shoes advantageously spaced in line so that a relatively broad path of cleaning can be accomplished with one pass of the device.

Still another object of the invention is to provide a new and improved surface conditioner making use of a source of sonic energy in the low sonic range which is of such character that it can be readily mounted upon a vehicle for cleaning large surfaces with modest effort, the application of sonic energy being transmitted through an elongated member such as a beam whereby to spread over an appreciable distance, the work shoes of the device being so designed as to vibrate at or near their resonant or natural frequency modes thereby creating cavitation at the surfaces to be cleaned and making possible effective cleaning by use of a relatively minimum amount of power.

Still further among the objects of the invention is to provide a new and improved mobile surface conditioning device operating by use of sonic energy in the low sonic range applied through a fluid medium wherein individual work shoes may be mounted in line for movement transverse to their structural arrangement and overlapping to an extent such that upon a single passage of the equipment a broad uninterrupted path of cleaning can be accomplished.

Also included among the objects of the invention is to provide a new and improved vehicle mounted surface conditioner which makes use of energy in the low sonic range, transported to individual work shoes through a vibrating tubular or channel beam designed to operate at one of the modes of natural frequency and from which energy is applied to the work shoe through pedestal mountings, the operation being such that fluid is set in a state of cavitation by the plate and shoe assemblies and continues in a state of cavitation after leaving the work shoes and while in contact with the surface to be conditioned and which thereafter can be repeatedly worked in engagement with the surface to be conditioned and subsequently the residue can be vacuum removed by a further passage of the vehicle mounted machine.

With these and other objects in view, the invention consists of the construction, arrangement, and combination of the various parts of the device, whereby the objects contemplated are attained, as hereinafter set forth, pointed out in the appended claims and illustrated in the accompanying drawings.

In the drawings:

FIG. 1 is a front perspective view of the floor conditioner device showing the device in a mounted position on a vehicle.

FIG. 2 is a front schematic view of the device.

FIG. 3 is a fragmentary elevational view of one end of the device.

FIG. 4 is a fragmentary elevational view of an opposite end of the device.

FIG. 5 is a plan view of a second form of energy source usable with the device partially broken away.

FIG. 6 is a side elevational view taken along the lines 6—6 of FIG. 5.

FIG. 7 is a longitudinal sectional view through a typical work shoe usable with the device with a portion broken away.

FIG. 8 is a cross-sectional view on the line 8—8 of FIG. 7.

FIG. 9 is a fragmentary bottom view taken on the line 9—9 of FIG. 7.

FIG. 10 is a fragmentary longitudinal sectional view of another form of the device.

FIG. 11 is a cross-sectional view on the line 11—11 of FIG. 10.

FIG. 12 is a fragmentary bottom view taken on the line 12—12 of FIG. 10.
FIG. 13 is a fragmentary bottom view taken on the line 13—13 of FIG. 10. FIG. 14 is a foreshortened longitudinal sectional view of still another form of the device. FIG. 15 is a cross-sectional view on the line 15—15 of FIG. 14. FIG. 16 is a cross-sectional view on the line 16—16 of FIG. 14. FIG. 17 is a side elevational view of another form of energy source. FIG. 18 is an end elevational view taken on the line 18—18 of FIG. 17. FIGS. 19, 20 and 21 are respectively plan, side elevational and front elevational views respectively of another form of the invention. FIG. 22 is a fragmentary front elevational view of a different type of work shoe. FIG. 23 is a longitudinal sectional view of the device equipped with a wet vacuum pick-up. FIG. 24 is a bottom view on the line 24—24 of FIG. 23. FIG. 25 is a cross-sectional view on the line 25—25 of FIG. 23. In an embodiment of the invention chosen for the purpose of illustration the general setup as illustrated in FIGS. 1 and 2 show a vehicle 10 having a frame 11 supported by wheels, other details of the vehicle being omitted, but it being understood that the vehicle is customarily a power operated vehicle upon which a driver sits, in order to move the vehicle over a broad extent of surface to be conditioned such, for example as a stadium, convention hall, long corridors of an industrial or office building or virtually any surface of appreciable extent which is in the need of cleaning or conditioning. The vehicle is self powered and provides auxiliary equipment for the cleaning system such as power, a fluid system, a vacuum system, etc.

On a forward bar 15 of the vehicle is a bracket 16, a vertical revolving portion 17 of which supports a twin lever frames 18 at opposite ends as shown in FIGS. 1, 5 and 6. On the frames 18 is mounted a support mount base 19 for motor 19 which may be electrically, hydraulically or pneumatically operated, depending to a degree on the type of power made use of by the vehicle. The motor 19 is speed controlled to maintain a constant or desired frequency. The twin frames 18 connected to the vertical portions 17 at opposite ends is by pivot shaft bearings 13 and with suitable stops (not shown) provided to limit tilting of the platform 18 as it adjusts to unevenness in the surface on which the device operates. Isolation channel shear mount connections 14, interconnect the frames 18 and mounting supports 20 at opposite ends. An additional resilient isolation channel mount 18' is provided between the opposite ends of frames 18 and the base 19 of the motor 19.

A rotary bearing coupling 16' connects bracket 16 to the vertical portion 17 and thus permits 17 to revolve in a transverse angular manner to provide leveling of the structure to the floor surface the extent of which is limited by suitable stops, not shown. A sinusoidal force frequency generator is shown in FIGS. 5 and 6. The function of the generator is to generate and transmit sinusoidal force energy at a desired frequency in the low sonic range and to direct said energy to excite and resonate a longitudinal tubular beam structure into an elastic wave force motion at frequency mode by design at or near its natural modal frequency and at a desired amplitude. The generator 21 consists in part of a fixed cylindrical mass 22, and an adjustable cylindrical mass 22'; an eccentric bearing 41 with a concentric stub shaft 40, the structure of which is supported horizontally at one end at its centerline by a ball bearing 43 with its housing mounted within a pedestal or bracket 45, and at the other end by a resilient isolation mount 27 mounted within a supporting pedestal 20. Mounted within a concentric bore of the mass 22 and in line with the centerline of the cylindrical mass 22 is a rotatable shaft 35 which is positioned by means of ball bearings 36, 36' the housings of which are fastened around the bore of mass 22 at opposite ends of said bore, the shaft 35 being secured in position by means of thrust bearings 38, 38' at opposite ends and retaining rings 37, 37'. The left hand end of the driver shaft 35 as viewed in FIGS. 5 and 6, is mounted eccentrically of means of a bore within the face of the eccentric bearing 41 and secured by a set screw 42. On an extension of the eccentric bearing 41, on its center line is a stub shaft 40 which extends through its supporting ball bearing 43 within a vertical leg 44 of the supporting pedestal 45. An externally driven timing belt pulley 46 is mounted on the stub shaft 40. Over the shaft 40 travels a timing belt 47, the belt also engaging a timing belt pulley 48 which is on a drive shaft 49 of the motor 19. The pulleys may be of the same diameter as shown in FIGS. 5 and 6 or the relative diameters may be varied in order to select the speed of rotation of the revolving mass 22, namely faster or slower than the speed of the motor, in order to develop a desired generation value of output frequency. The right hand end of mass 22 as viewed in FIGS. 5 and 6 is supported by means of a stub shaft 26 which is centrally located with respect to the centerline of mass 22. The extension of stub shaft 26 passes through and is anchored in a fixed position within a resilient isolation tubular mount 27 of commercial design which in turn is supported and anchored in a fixed position within a bore of the supporting pedestal 20. The resilient isolation mount is of special construction wherein an outer annular collar 29 is separated from the extension shaft 26' of the stub shaft 26 by means of an annular cylindrical section 30 of resilient isolation material. The purpose of the resilient mount of this description is to provide a resilient isolation mount connection between the vibration energy produced by the revolving masses 22 and 21 and a platform 18 so that the energy will not be passed to and be absorbed by the platform 18 and its supporting structure. The resilient mount also provides a freedom of pivotal motion of the supported mass 22 at its terminal support location of shaft 26' within the resilient mount 27.

Accordingly, when a timing belt pulley 46 on the stub shaft 40 is driven in rotation by its timing belt 47 the shaft 35 is in turn caused to rotate at one end about its eccentric bearing 41 by means of its eccentric shaft location in said bearing. The rotation generates a conical circulatory shaft movement about its longitudinal axis with the base of the cone being at the eccentrically mounted end, the apex of the cone being on the center line of the resilient mount bearing 27. The shaft 35 thus rotates about an axis substantially coincident with the stub shaft 40 within the bearings 43 and the axis of the opposite end of the mass at the isolation mount 27.
Since the housings of the ball bearings 36, 36' of shaft 35 are rigidly connected to the centerline bore structure of the mass 22, the motion of the cylindrical mass 22 and its adjustable split ring cylindrical mass 22', secured as shown by threaded bolts 25, are caused to move in circulatory fashion about said axis and likewise in conical fashion.

The sinusoidal force thus generated by rotation of the mass of the generator is passed through its pedestal mount 45 to the resonant structure. It is significant to note that the source of external power provided by the motor 19 is separately mounted on its support base 19' and completely isolated from the resonant structure by means of the resilient isolation mount connections 14, and resilient isolation mount 27.

The pedestal 20 of the generator is also anchored to platform 18 at one end and completely isolated from its support base 19' by means of a resilient isolation mount 27 shown in FIG. 1 so that the energy will not be passed to and absorbed by the frames 18 and support 20 of the supporting structure. The frames 18 are therefore completely isolated from the resonant structure and from the vertical supporting structure, and the entire structure therefore takes the form of a spring-mass structure.

The frequency output of the sinusoidal generator heretofore described is identical to the speed of the driven pulley 46. The transmitted sinusoidal force released by the generator is understood to be a force resulting from the calculation: \[ F = \frac{E(\text{degree of eccentricity}) \times M(\text{mass})}{\pi R(\text{P.M.})} \]

The output force of the sinusoidal wave energy is a function of the amplitude of the wave energy released. The most economical way to increase the amplitude and resulting force output is to increase the mass. This may be accomplished by adjusting the position of the split ring auxiliary adjustable mass 22' over the periphery of the mass 22 or to alter the mass weight of 21 to the desired value.

The frequency output of the generator may be altered by means of a pulley diameter change of either the driven pulley 46 or the driver pulley 48.

The structure of the generator is significant to the invention since its frequency mass and output amplitude is adjustable over wide ranges as required by design parameters. For example, vehicle powered industrial floor cleaners are designed in many different sizes to meet requirements and the generator heretofore described as driven by an external power source may be altered to its output requirements to satisfy all of the necessary known power and energy requirements.

The demands made reference to are satisfied by structures depicted in the drawing where the energy source is operatively attached to a tubular member 60.

Horizontal leg 50 of the bracket 45 is secured through a plate 51 by cap screws 52 to an upper section 53 of a flanged mount indicated generally by the reference character 54, there being a lower section 55 with the same flanged mount. The upper and lower sections are secured together by means of screws 56. Anchoring bolts 58 secure the flanged mount 54 non-rotatably to the tubular member 60. For additional support of the tubular member 60 there is provided an arm 61 extending in a direction toward the vehicle 10, the arm being connected by the pivot shaft 13 to the vertical portions 17 which are anchored as previously described to the bracket 16 and in that way to the vehicle. Although partly supported by the bracket 16 the tubular member has a certain freedom to move up and down as occasion may require.

On those occasions where the tubular member 60 is designed to vibrate in the third mode, of its natural frequency, as illustrated in FIG. 2, the flanged mount is attached to the tubular member midway between opposite ends and at an antinode. As the rotating mass is set in motion by the motor, a sinusoidal force motion excitation is set by the revolving mass in the low sonic range preferably at a chosen frequency between 50–500 cycles per second and such sinusoidal energy is transmitted through the bracket 45 to the flanged mount 54 and from there to the tubular member midway between its opposite ends. The sinusoidal vibration energy thus created excites an elastic wave motion within and throughout the tubular beam at its selected mode of natural frequency by design. The elastic energy waves pass outwardly to opposite ends of the tubular member setting up nodal points at 64, 65, 66 and 67 and antinodes at 68, 69 and 70. This is the condition for vibration in the third mode. Clearly, by design, higher modes of natural frequency could be chosen wherein a large number of respective node and antinode sections would be set up throughout the length of the tubular member. Further still, since the tubular member is vibrating at or near its resonant frequency, ellipsoid force patterns are released by the member alternately in 3 planes as illustrated schematically in FIG. 4.

In order to put the sinusoidal resonant energy thus created to work there are provided three work shoes 70, 71 and 72, the work shoe 70 being located at a point midway between opposite ends of the tubular member and the work shoes 71 and 72 being adjacent opposite ends. To be sure that the work is performed in an uninterrupted fashion throughout a path equal to the area covered by the three work shoes, adjacent sides 73, 74, for example, of the respective work shoes 70 and 71 extend on the bias so that the forward corner of the work shoe 70 overlaps in its operation, the rearward corner of the work shoe 71 on the same relative side. Similarly, adjacent sides 75 and 76 of the respective work shoes 70 and 72 extend diagonally so that there is a corresponding overlapping on that side of the mid-section of the tubular member.

Extending downwardly from the tubular member 60 at its midpoint is a cylindrical mounting pedestal block 77 for mounting the work shoe 70, some details of which are illustrated in FIG. 7. The mounting block 70 is bolted to a plate beam 78 which, in the embodiment of FIG. 7, comprises the back plate of the work shoe, bolting being accomplished by means of bolts 79. A working plate 80 is spaced from the resonant plate beam 78 by means of resilient pads 81, 82, 83 and 84 equally spaced around the central resilient pad 85 and located at antinodal points. Spaced as described the plates define between them an accumulator chamber 86. A resilient band 87 of soft resilient vulcanized rubber material encloses outside edges of the accumulator chamber.

Below and vulcanized to the working plate 80 is a grooved work shoe 88 which may be rubber of a character exemplified by the tread on conventional rubber tires. Open channels 89 on the lower face of the work shoe communicate with the accumulator chamber 86.
through expansion holes 90. A seal 87 extends around the perimeter.

The material of the resilient pads by design is such that they are soft in a vertical direction as viewed in FIG. 7 but relatively stiff in a plane parallel to horizontal. The spring rates of the resilient pads 81, 82, 83, 84, and 85 are designed to match the natural frequency of the resonant plate beam 78.

In order to supply the accumulator chamber with whatever fluid might be needed for conditioning an appropriate surface, there is a fluid feed line 91 in communication with a fitting 92 on the cylindrical mounting pedestal block 77, the fitting being in communication with a supply bore 93 through the mounting block 77 and the central resilient flaw divider pad 85, there being provided lateral bores 94 by means of which fluid is able to find its way evenly into the accumulator chamber 86.

The work shoe assembly may take various forms as illustrated, for example, in FIGS. 10, 11, 12 and 13. In this form of the work shoe a resilient divider 95 of vulcanized rubber material separates the accumulator chamber into chambers 86 and 86' one of which is supplied with fluid through a supply bore 96 and the other of which is a chamber without a fluid supply. The accumulator chamber 86 of FIG. 10 is supplied in a manner similar to that already described, namely, through the supply bore 96 in a cylindrical mounting block 102, offset slightly from the divider 95. A pressurized fluid supply line 103 attached to a fitting 104 serves as a source of supply of cleaning liquid, to chamber 86 where it is transformed into a field of cavitation energy and then passing through expansion holes 101 to the surface to be cleaned where cavitation continues to take place. Grooves 100 are located at the bottom of work plate 80' of chamber 86 to increase the scrubbing action by friction and to entrap the fluid released from chamber 86 and to further excite its field of cavitation.

In the form invention of FIGS. 14, 15, and 16, a plate beam 110 is separated from work shoe assemblies 111 and 112 by means of a second resonant plate beam 114. A cylindrical mounting block 113, in the manner previously described, picks up resonant energy from the tubular member 60, the work shoe being excited into its own natural frequency at its mid-point as shown in FIG. 14. A single rear resonant plate beam 114 serves both of the separated work shoe assemblies shown and actually comprises the rear plate of both of the work shoes. One work plate 115 spaced as shown from the rear plate 114 provides an accumulator chamber 116, there being expansion holes 117 communicating between the accumulator chamber 116 and an area adjacent the pile 118 of a carpet 119. A frame 120 of resilient vulcanized rubber material interconnects and seals the work plate 115 with the rear plate 114 for each of the work shoe assemblies. Pads 121 and 122 interconnect the plate beam 110 with the rear plate 114, such pads being the only connection between the open plate beam and the open rear plate. These pads, by design are similar to those previously made reference to, and have a designed spring rate corresponding to plate 110 such that they yield freely in a direction between the plate beam and the rear plate but are resilient to flexible motion in a direction 90° with respect thereto. Vibrations set up in the plate 110 are in this fashion passed through the pads to the rear plate 114 and from the rear plate 114 to the work plate 115, the work plate being in contact with the surface to be conditioned exemplified by the carpet 119. In this form of the device the pads, rather than being contained within the accumulator chamber, exist on the exterior of the work shoe assemblies, the frame 120 being of resilient character similar to that of the pads for passing vibration energy from the rear plate to the work plate, and having a spring rate corresponding to pads 121 and 122.

In the example of FIGS. 14, 15 and 16, as previously described, a supply line 125 attached to a fitting 126 on a mounting block 127 supplies conditioning fluid to a bore 128 in the mounting block from which it passes through a bore 129 in the pad 122 and from there to the accumulator chamber 116. Work plate 112 below chamber 133 has grooves 133.

In FIGS. 17 and 18 is shown a second form for generating sinusoidal energy. In this arrangement the rotating mass is the mass of a motor 140, supplied by an electric line 141. A flanged mount 142 is adapted to be secured at the mid-point of either of a tubular member like the tubular member 60 or the mid-point of a plate beam. On the flanged mount is a bracket 143, a horizontal leg 144 of which is anchored to the flanged mount by means of bolts 145. The other leg 146 of the bracket serves to mount an eccentric bearing 147, there being provided a bearing 148 on a concentric stub shaft 149 of the eccentric bearing 147. A drive shaft 150 of the motor is anchored eccentrically in the eccentric bearing 147 by means of an appropriate set screw 151.

At the opposite end of the motor 140 there is a stub shaft 152 which is attached to the motor casing and unassociated with the drive shaft 150. A bracket 153 may serve as a connection between the motor casing and the stub shaft 152.

A supporting flange 154 firmly secured to the flanged mount 142 by appropriate bolts 155 serves as a support for the stub shaft 152. This is accomplished by employment of a resilient bearing 156 of a type similar to bearing 27 described in connection with FIGS. 5 and 6. Since vibrations generated by the eccentric mounting of the motor mass in FIG. 17 are isolated from the supporting flange 154, substantially no vibrations are set up in the supporting flange and only the sinusoidal force energy is transmitted through the bracket pedestal 143 to the mounting flange 142 and thence to the appropriate tubular member. This source of vibration energy is fully utilized in the form as shown.

In the form of invention of FIGS. 19, 20 and 21, a single work shoe assembly 160 taking the form of previous work assemblies, FIGS. 7 through 14 previously described, is shown attached to the tubular member 60 at three separate antinodal locations 161, 162 and 163. In this form the work shoe assembly may be as long or longer than the full length of the tubular member 60, and the tubular member may be designed at mode of natural frequency so as to generate more or less than three nodal points, as long as antinodal points coincide with the points of attachment between the work shoe assembly 160 and the tubular member 60. The generator 21 attaches to the tubular member 60 by means of the flanged mount 54 in a manner described for FIGS. 1, 5 and 6.

Although primary emphasis in the disclosure has been placed on developing cavitational energy for a cleaning operation, it should be kept in mind that basi-
cally the structure is for economical utilization of sound wave energy to perform work. To that end a work shoe assembly 160 consisting of a single resonant plate beam, can be provided with different tools such, for example, as chopping or scarifying bits 168, in line or at random, and sinusoidal force energy passed to the bits for the purpose of cutting lines in an existing surface, or performing other work on the surface or the structure of which the surface is a part.

In operation, the device whether it be by use of the sinusoidal energy source shown in FIGS. 1, 5 and 6 or the sinusoidal energy source shown in FIGS. 17 and 18, the structure is so designed that the tubular member 60, where a tubular member is used, and the plate beam and/or plate beams are designed to be a combined free-free spring mass structure and to resonate at or near its natural frequency. The general description also applies to FIGS. 19, 20 and 21.

It is significant to this disclosure that the purpose of the energy source and its combined structure by design, is to generate and produce acoustical cavitation at the surface to be cleaned and to thereby utilize the well known principles of cavitation for cleaning purposes.

Furthermore the simplest way of generating cavitation is by means of acoustical sinusoidal energy that has been generated within a resonant structure and which in turn directs and transmits its resonant acoustic sinusoidal energy thus developed to a liquid medium whereby it is transformed into an acoustic field of cavitational energy.

In this case, the cavitation energy thus released in the liquid medium at the surface is used to do work in the form of cleaning. A fluid field of resonant cavitation energy of sufficient amplitude has the phenomenon of breaking the surface tension of exposed surfaces within the liquid medium such as, for example, in this case carpet fibers or hard surfaces to be cleaned. The well known principles of cavitation are therefore developed and released within this device for cleaning purposes of exposed surfaces within this medium.

The cleaning that takes place is very fast because of the intense cavitational energy at resonance released at high amplitude energy with the liquid medium approaching the speed of sound and at life cycles of the minute energy particles thus developed approaching $10^{-8}$ of a second in three ellipsoid force planes.

Fluid which is passed through the supply passages to the work shoe and which finds its way from the accumulator chamber to the surface being conditioned is simultaneously set in a state of cavitation causing a foaming of the fluid, when released to the surface and being continually in a state of cavitation at its location within the carpet being cleaned or whatever other surfaces it may be which is being conditioned. Where a pickup of dirt laden fluid is needed the vacuum pickup portion of the machine can be passed over the surface. Occasions also may require several passes of the work shoe assemblies over the surface without the application of additional conditioning fluid where the dirt, soil and other condition on the surface is stubborn and additional application of cavitation is helpful. As a help in understanding the action which is made up of, FIG. 3 shows the ellipsoid elastic wave motions in three planes which is set up in the tubular member when operating at its natural frequency and the diagramatic representation of ellipsoid motions in the three planes of FIG. 1 is illustrative of the motion set up in the surface which is being conditioned within a cavitation field.

The device coupled with a wet vacuum pickup is shown in FIGS. 23, 24 and 25. In this structural association a plate beam 170 is attached to a mounting block 171 by means of of cap screws 172. A work shoe plate 173 is parallel to and separated from the plate beam 170, there being provided a series of resilient pads 174 interconnecting the plate beam and the work shoe plate with a resilient connection, the resilient pads being relatively soft in a vertical direction and relatively stiff in a horizontal direction. Perimetrical seal strips 175, 175', 175'' and 175''' enclose a closed chamber 176.

Similar perimetrical seal strips 177, 177', and 177'', with the aid of the perimetrical strip 175''' enclose a fluid chamber 178. Additional perimetrical seal strips 179, 179' and 179'' with the help of the seal strip 177'' enclose a vacuum chamber 180.

A resilient pad 181 has a vertical aperture 182 from which extend horizontal apertures 183, the latter being in communication with the fluid chamber 178. At its upper end the vertical aperture 182 communicates with a bore 184 which in turn is in communication with the nipple 185 to which a cleaning fluid line 186 is attached. A multiplicity of holes 187 extend through the work shoe plate 173, communicating with recesses 188 in a wear plate 189 anchored to the lower face of the work shoe plate 173.

A fitting 190 is adapted to have a vacuum hose (not shown) attached to it whereby when a vacuum or suction is applied the suction effect will communicate through a passage 191 in the plate beam 170, then with the vacuum chamber 180 and from there through a passage 192 in the work shoe plate and an aligned passage 193 in the wear plate 189.

Operation of this structural arrangement is substantially the same as those heretofore described in that when cleaning fluid is passed through to the fluid chamber 178 and the mounting block 171 vibrated at the rates herein before described the cleaning fluid is set up in a resonating condition, passing outwardly as foam through the holes 187 and recesses 188 to the surface to be conditioned. When sufficient foam has thus been applied to the surface the supply can be cut off and the foam is additionally agitated when the portion of the wear plate 189 beneath the closed chamber 176 is passed into contact with it. This greatly amplifies the effect produced by the resonating foamed liquid cleaner. After there has been a sufficient amount of vibration applied to the foamed cleaning fluid, to clean the surface to which it has been applied, wet foam may be removed through the passages 191, 192 and 193 by application of the vacuum to the fitting 190 whereby the moistened foamed cleaning fluid can be substantially entirely removed from the surface after it has done its work.

Additional agitation is achieved by the provision of closed elongated recesses 195 in that portion of the wear plate 189 which lies beneath the closed chamber 176.

While the invention has been shown and described in a practical embodiment, it is recognized that departures may be made therefrom within the scope of the invention, which is not to be limited to the details dis-
closed herein, but is to be accorded the full scope of the claims embracing all equivalent devices.

Having described the invention, what is claimed as new in support of Letters Patent is:

1. A conditioner for surfaces adapted to be mounted on and carried by a vehicle, said conditioner comprising a resonant plate beam, a source of sinusoidal vibrating energy carried by the vehicle and having a location of application to said plate beam intermediate sides and ends thereof, the application of said energy being in a direction substantially perpendicular to the surface of the plate beam, a work shoe comparable in length and breadth to said plate beam, means forming a relatively closed shallow accumulator chamber therebetween, a multiplicity of passages through said work shoe comprising outlets from said accumulator chamber, a plurality of resilient mounts spaced throughout the area respectively of said plate beam and said work shoe, said mounts being relatively flexible in a direction perpendicular to the surface of the plate beam and relatively stiff in a direction parallel to the surface of said plate beam, and means for supplying conditioning fluid to said work shoe.

2. A conditioner as in claim 1 wherein said plate beam and said shoe and all portions of the device associated therewith at the locations of application of sinusoidal energy have masses and shapes selected to vibrate at or near their resonant frequency.

3. A conditioner as in claim 2 wherein the point of application of sinusoidal energy to the plate beam is located substantially centrally with respect to sides and ends of said plate beam.

4. A conditioner as in claim 2 wherein the plate beam and the work shoe form opposite sides of said accumulator chamber and the mounts are located in the accumulator chamber in engagement respectively with said plate beam and said work shoe.

5. A conditioner as in claim 4 wherein the work shoe has a conditioning face of flexible rubber-like material with a tread of alternately located high and low spots, said passages being in communication with said low spots.

6. A conditioner as in claim 2 wherein a portion of said accumulator chamber is isolated from the rest of the the accumulator chamber and the supply line thereto, there being a suction line in communication with said portion of the accumulator chamber.

7. A conditioner as in claim 2 wherein there is a back plate intermediate the plate beam and the work shoe, said back plate and said work plate forming opposite sides of said accumulator chamber, said mounts being located between and in engagement with the plate beam and the back plate, there being additional mounting means of corresponding character between the back plate and the work shoe.

8. A conditioner as in claim 7 wherein said additional mounting means form a lateral closure for said accumulator chamber.

9. A conditioner as in claim 2 wherein said source of sinusoidal energy comprises a base carried by the vehicle, a bracket on the plate beam, an eccentrically loaded mass rotatably mounted respectively on said base and said bracket, the mounting between the mass and the base being a resilient isolation mount and the mounting between the mass and the bracket being an eccentric bearing.

10. A conditioner as in claim 9 wherein the mass is an electric motor.

11. A conditioner as in claim 9 wherein the mass is an eccentrically mounted weight having a pulley on an axis of rotation thereof, a motor carried by said vehicle, a pulley in rotated engagement with said motor and a belt drive between said pulleys.

12. A conditioner as in claim 9 wherein there is a tubular longitudinal beam, and a plurality of plate beams connected at substantially central locations thereof to said longitudinal beam at antinodal points, said source of sinusoidal vibrating energy being located at one of said antinodal points.

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