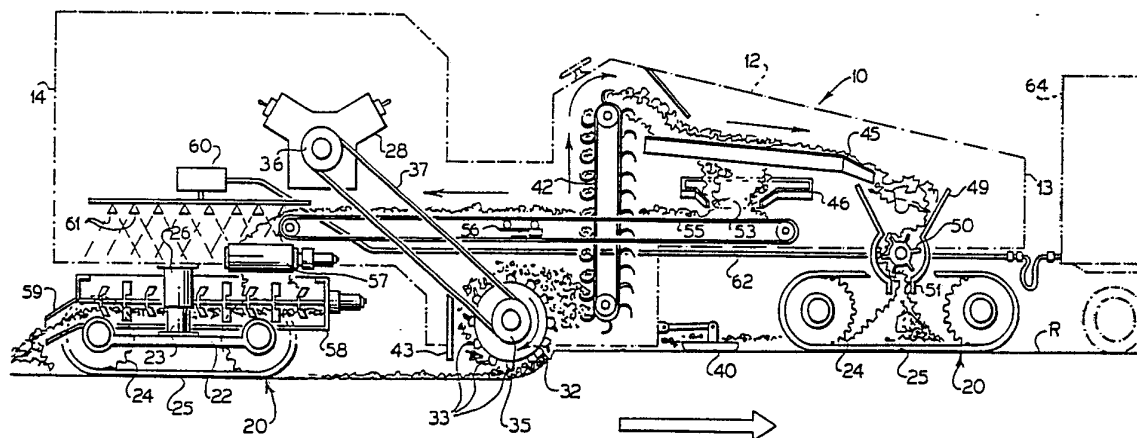




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(21) International Application Number: PCT/US90/04399 (22) International Filing Date: 6 August 1990 (06.08.90) (30) Priority data: 394,373 15 August 1989 (15.08.89) US (71) Applicant: ASTEC INDUSTRIES, INC. [US/US]; 4101 Jerome Avenue, Chattanooga, TN 37407 (US). (72) Inventor: JAKOB, Herbert, E. ; Box 924, Taylors, SC 29687 (US). (74) Agents: ELDERKIN, Charles, B. et al.; Bell, Seltzer, Park & Gibson, P.O. Drawer 34009, Charlotte, NC 28234 (US).		(81) Designated States: AT (European patent), AU, BE (European patent), CA, CH (European patent), DE (European patent)*, DK (European patent), ES (European patent), FR (European patent), GB (European patent), IT (European patent), JP, LU (European patent), NL (European patent), SE (European patent). Published <i>With international search report.</i>

(54) Title: ASPHALT PAVEMENT RECYCLING APPARATUS



(57) Abstract

An apparatus (10) is disclosed for the cold, in-place recycling of asphalt paving of an asphalt roadway. The apparatus (10) is self-propelled, and it includes a cylindrical milling drum (32) mounted at a medial location along its longitudinal length and which serves to remove a thickness of the asphalt paving and break the same into particles as the apparatus (10) moves forwardly along the roadway. The particles are lifted (42) to a separating screen (45) which is positioned forwardly of the drum (32), and the particles are thereby separated into a first portion of relatively small particles suitable for recycling and a second portion of oversized particles. The first portion is delivered to the rear end (14) of the apparatus (10) where it is mixed with a suitable liquid additive, and then discharged onto the roadway. A following paver then forms the discharged material into new paving. The second portion of oversized particles is discharged onto the roadway at a location in front of the milling drum (32). Thus the milling drum (32) again contacts the second portion upon forward movement of the apparatus (10), and the drum (32) acts to further crush the particles and cause them to be recycled through the apparatus (10).

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ASPHALT PAVEMENT RECYCLING APPARATUS

Background of the Invention

The present invention relates to a self-propelled apparatus for removing a thickness of asphalt paving from an asphalt roadway and for reprocessing the removed asphalt so as to permit the recycling thereof.

5 Deteriorating asphalt roadways have in the past been rehabilitated by a process wherein the top layer of the asphalt roadway is removed by a drum type milling machine which is advanced along the roadway. The removed asphalt is then trucked to a reprocessing
10 plant where the removed asphalt is usually blended with new aggregate and hot liquid asphalt in a rotary heater, to form a new asphalt paving material. This new material is then trucked back to the roadway while hot and laid on the roadway by a conventional paver.

15 As an alternative to the above process, a process has recently been developed which involves the cold, in-place recycling of asphalt, and which substantially reduces the transportation and heat energy costs associated with the above described
20 process. This cold process has heretofore been carried out by a complex apparatus composed of a train of three separate roadway units positioned in tandem. The first unit includes a drum milling cutter for removing the top layer of the asphalt surface. The second unit
25 receives the removed material on an inlet conveyor and has a vibratory screen for separating the material by

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size, with the relative fine portion dropping onto a discharge conveyor and the oversize portion being directed into a crusher and returned by a conveyor back to the inlet conveyor for recirculation through the vibratory screen. The final unit receives the proper, i.e. fine, material on a weigh conveyor, and a controlled amount of liquid asphalt or asphalt emulsion is added based upon the weight of the material. The mixture then passes through a pugmill type mixer and is discharged onto the roadway. A conventional paver follows the train, and forms the discharged material into pavement.

As will be apparent, the above described apparatus for the cold, in-place recycling of asphalt is structurally complex and expensive. More particularly, the train of roadway units incorporates a large number of separate conveyors, which are expensive and require separate maintenance. Also, the train of roadway units is large and cumbersome, and it cannot back up.

It is accordingly an object of the present invention to provide an apparatus for performing the cold, in place recycling of asphalt pavement which substantially avoids the limitations and disadvantages of the presently employed apparatus as described above.

It is a more specific object of the present invention to provide an apparatus of the described type which comprises a single roadway unit, and which is designed to efficiently perform all of the functions of the presently employed train of roadway units.

Summary of the Invention

These and other objects and advantages of the present invention are achieved in the embodiment illustrated herein by the provision of a self-propelled roadway apparatus which comprises a frame having longitudinally separated front and rear ends, roadway engaging wheel means mounted to said front and rear

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ends of the frame, and power means mounted to the frame and operatively connected to the wheel means for propelling the apparatus along the roadway. A cylindrical milling drum having spaced cutting elements thereon is mounted to the frame at a medial location along the longitudinal length thereof and for rotation about a transverse axis, and drive means is provided for rotating the milling drum to remove a thickness of the asphalt paving and break the same into particles as the apparatus moves forwardly along the roadway. Particle processing means is mounted to the frame for receiving the asphalt particles removed by said milling drum and separating the same into a first portion of relatively small particles suitable for recycling and a second portion of oversized particles. The first portion is delivered to a rear discharge outlet located adjacent the rear end of the frame and the second portion is delivered to a forward discharge outlet which is located adjacent the front end of the frame. The second portion is thereby delivered onto the roadway forwardly of and in alignment with said milling drum, such that the milling drum again contacts the second portion upon forward movement of the apparatus and the second portion is thus again subjected to the processing of the apparatus.

Brief Description of the Drawings

Some of the objects and advantages of the present invention having been stated, others will appear as the description proceeds, when taken in conjunction with the accompanying somewhat schematic drawings, in which

Figure 1 is a side elevation view of an apparatus which embodies the features of the present invention; and

Figure 2 is a top plan view of the apparatus shown in Figure 1.

Brief Description of the Preferred Embodiment

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Referring more particularly to the drawings, an apparatus embodying the features of the present invention is indicated generally at 10. The apparatus 10 comprises a central frame 12 which is indicated by the dash dot lines. The frame is generally rectangular in outline, and it defines a front end 13, a rear end 14, and four corners 15, 16, 17 and 18. A wheel member 20 is positioned at each of the four corners for moveably supporting the apparatus upon a roadway R.

The wheel members 20 are of generally conventional construction, and each comprises a frame 22 supporting a lower sleeve 23, spaced sprockets 24 carrying an endless trackway 25, and a hydraulic motor (not shown) which serves to rotate the sprockets and the trackway to thereby propel the apparatus in either direction along the roadway. The sleeve 23 of each wheel is slidably received in an upper sleeve 26 which is fixedly mounted to the frame 12 of the apparatus, and means are provided for adjustably interconnecting each lower sleeve 23 with its upper sleeve 26 such that each wheel member 20 may be independently raised or lowered with respect to the frame 12. This interconnecting means is conventional and is thus not illustrated herein, and it may for example include a hydraulic cylinder mounted inside the two sleeves.

A prime mover, such as an internal combustion engine 28, is mounted to the frame 12 of the apparatus 10. The engine powers one or more hydraulic pumps 30 which are part of a central hydraulic system and which in turn power the hydraulic motors associated with the wheel members 20 so as to propel the apparatus along the roadway and raise and lower the frame 12 with respect to the wheel members 20. The central hydraulic system also powers several other powered components of the apparatus as described below.

The apparatus 10 mounts a cylindrical milling drum 32 having spaced cutting elements 33 thereon, with

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the drum 32 being mounted to the frame 12 at a medial location along the longitudinal length thereof and for rotation about a transverse horizontal axis. The drum 32 is of a type well known in the art, such as disclosed in the applicant's prior U.S. Patent No. 4,193,636. The drum 32 is rotatably driven by a drive system which includes a pulley 35 coaxially mounted to the drum 32, an aligned pulley 36 mounted to the output of the engine 28, and a multiple drive belt transmission 37 interconnecting the two pulleys 35, 36. As illustrated, the engine 28 acts to rotate the drum 32 in a forward direction with respect the forward movement of the apparatus. Thus the milling drum cuts downwardly onto the surface of the roadway, which has been found to provide better control of the resulting particle size of the asphalt.

The elevation of the milling drum 32, and thus the depth of its cut, are controlled by a conventional elevation and slope control system, which includes a ski 40 which is pivotably mounted to each side of the frame 12 immediately ahead of the milling drum 32. Each ski 40 thus rides on the original roadway surface, ahead of the drum 32, and its pivotal movements activate a valve (not shown) which in turn controls the elevation of the wheel members 20 with respect to the frame 12.

A vertical bucket type conveyor 42 is positioned forwardly of the milling drum 32, for receiving the asphalt particles which are removed by the drum. The frame 12 of the apparatus may also include a suitable guide plate 43 which partially encloses the drum 32 for directing the removed particles onto the conveyor 42. The conveyor 42 is powered by the central hydraulic system, and it serves to lift the particles upwardly onto a vibrating screen 45. The screen 45 is mounted to the frame 12 by means of springs (not shown) so as to permit vibrating

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movement, and it is also powered by the central hydraulic system. The screen 45 has openings of predetermined size, which by design permit a first portion of the particles, and which are of a relatively fine size suitable for recycling, to drop therethrough onto an underlying tray member 46. Also, the screen 45 is inclined downwardly in the forward direction, and so that a second portion of the particles, i.e. the oversized particles which are too large to pass through the openings, move forwardly to the forward lowermost end 48 of the screen where they are discharged downwardly into a guide passageway 49 which includes a rotary crusher 50. The crusher 50 is powered by the central hydraulic system, and it acts to reduce the size of the particles and to then discharge the crushed particles onto the roadway R through a forward discharge outlet 51 of the guide passageway 49. The forward discharge outlet 51 is located adjacent the front end 13 of the frame 12 and so as to deliver the second portion of the particles onto the roadway R forwardly of and in alignment with the milling drum 32, and such that the milling drum again contacts the second portion upon forward movement of the apparatus.

The tray member 46 which underlies the screen 45 and which receives the first portion of the particles, is laterally inclined so as to define a lower discharge end 53. A longitudinal conveyor 55, which is powered by the central hydraulic system, is positioned to receive the first portion of the particles from the discharge end 53 of the tray member 46 and to convey the same rearwardly along a path which extends above and rearwardly beyond the milling drum 32. A load cell 56 is operatively connected to the conveyor 55 for the purposes described below.

The discharge end of the conveyor 55 is positioned above a short transverse conveyor 57, and the transverse conveyor is positioned to drop the

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material into a pugmill type mixer 58. The mixer 58 is positioned adjacent the rear end 14 of the apparatus, and the rear end of the mixer includes a rear discharge outlet 59 through which the mixed material is deposited onto the roadway. A liquid metering system 60 which comprises a plurality of outlets 61 is also provided for metering a predetermined quantity of a liquid additive onto the first portion in an amount proportional to the mass flow rate thereof. More particularly, the output of the load cell 56 is fed to a metering control system, by which the mass flow rate of the particles on the conveyor is calculated, and the amount of liquid additive which is metered onto the first portion is controlled so as to be proportional to the mass flow rate. The liquid additive may be piped to the apparatus through a line 62 which may be coupled to a separate vehicle 64 as indicated in the drawings, and the additive typically comprises heated liquid asphalt or an asphalt emulsion.

In operation, the apparatus 10 is moved along the roadway R under its own power and at a predetermined speed, with the milling drum 32 being forwardly rotated so as to remove a predetermined and controlled thickness of the asphalt paving and to break the removed asphalt into relatively small particles. The thickness and slope of the cut is controlled by the setting of the two skis 40.

The removed asphalt particles are delivered into the bucket conveyor 42 which conveys the material upwardly and onto the vibrating screen 45. The relatively fine portion of the material is separated by the screen and drops through the screen and onto the inclined tray member 46, and it then slides laterally across the tray member until it drops from the discharge end 53 of the tray member onto the longitudinal conveyor 55. The load cell 56 weighs the material as it is carried rearwardly over the milling

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drum 32, and the material is delivered into the mixer 58 at the rear end 14 of the apparatus. The metering outlets 61 which are positioned above the mixer 58 add an appropriate quantity of liquid additive to the material, and after mixing, the mixer discharges the mixed material onto the surface of the roadway through the rear discharge outlet 59. This material may then be formed into pavement by a conventional paver which follows the apparatus.

The oversized portion of the removed asphalt particles is directed forwardly from the screen 45 so as to be discharged into the crusher 50, and the crushed material is then discharged onto the roadway surface through the forward discharge outlet 51 so as to be in front of the milling drum 32. As the apparatus moves forwardly, the milling drum 32 acts to further crush the material and to return it for reprocessing in the apparatus. Also, since the drum again crushes the material, it may be possible in some applications to eliminate the separate crusher 50 as illustrated, since the action of the milling drum 32 will be sufficient to adequately reduce the particles to the desired size.

It will be noted that the size separation and crushing operations are both conducted in front of the milling drum 32, which permits the oversized portion to be simply dropped onto the roadway for reprocessing by the milling drum as the apparatus moves along the roadway. Also, any spillage is automatically picked up and reprocessed by the drum.

In the drawings and specification, there has been set forth a preferred embodiment of the invention, and although specific terms are employed, they are used in a generic and descriptive sense only and not for purposes of limitation.

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THAT WHICH IS CLAIMED IS:

1. A self-propelled apparatus for removing a thickness of asphalt paving from an asphalt roadway and reprocessing the removed asphalt so as to permit the recycling thereof, and comprising
 - 5 a frame having longitudinally separated front and rear ends,
roadway engaging wheel means mounted to said front and rear ends of said frame,
power means mounted to said frame and
10 operatively connected to said wheel means for propelling the apparatus along the roadway,
pavement milling means mounted to said frame at a medial location along the longitudinal length thereof and for rotation about a transverse axis, and
15 drive means for rotating said milling means to remove a thickness of the asphalt paving and break the same into particles as the apparatus moves forwardly along the roadway,
particle processing means mounted to said
20 frame for receiving the asphalt particles removed by said milling means and separating the same into a first portion of relatively small particles suitable for recycling and a second portion of oversized particles, and for delivering said first portion to a rear
25 discharge outlet located adjacent said rear end of said frame and delivering said second portion to a forward discharge outlet located adjacent said front end of said frame and so that said second portion is delivered onto the roadway forwardly of and in alignment with
30 said milling means and the milling means again contacts said second portion upon forward movement of the apparatus.
 2. The apparatus as defined in Claim 1 wherein said particle processing means further

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comprises means for determining the mass flow weight of the first portion of the particles,

5 means for metering a quantity of liquid additive onto the first portion in an amount proportional to the mass flow rate thereof, and

10 mixer means for mixing said first portion and said liquid additive and then discharging the mixture onto the roadway through said rear discharge outlet.

3. The apparatus as defined in Claim 1 wherein said milling means comprises a cylindrical milling drum having spaced cutting elements thereon, and said drive means is operatively connected to said power means and acts to rotate said drum in a forward direction with respect to the forward movement of said apparatus.

4. The apparatus as defined in Claim 1 wherein said frame is generally rectangular in outline to define four corners, and wherein said roadway engaging wheel means comprises a supporting wheel member positioned at each of said four corners, and means for adjustably interconnecting each of the supporting wheel members to said frame such that each wheel member may be selectively and independently raised or lowered with respect to said frame.

5. The apparatus as defined in Claim 1 wherein said particle processing means comprises a bucket elevator positioned forwardly of said milling means for receiving the asphalt particles removed by said milling means and conveying the same upwardly, and a vibrating screen positioned to receive the particles from said bucket conveyor, with said vibrating screen having openings therein of a size for permitting said first portion of said particles to pass downwardly

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10 therethrough, while said second portion of said
particles does not pass through said openings.

6. The apparatus as defined in Claim 5
wherein said vibrating screen is inclined so as to
define a lower end, and so that the second portion of
said particles moves along said screen and is
5 discharged from said lower end.

7. The apparatus as defined in Claim 6
wherein said particle processing means further
comprises a tray member positioned below said screen
for receiving said first portion, with said tray member
5 being inclined so as to define a lower end, and so that
the first portion moves along said tray member and is
discharged from said lower end of said tray member.

8. The apparatus as defined in Claim 7
wherein said particle processing means further
comprises a longitudinal conveyor positioned to receive
the first portion from said lower end of said tray
5 member and with said longitudinal conveyor extending
rearwardly above said milling means.

9. The apparatus as defined in Claim 8
further comprising passageway means for permitting the
second portion of said particles to pass from said
lower end of said screen to said forward discharge
5 outlet, and wherein said passageway means includes
means positioned between said lower end of said screen
and said forward discharge outlet for crushing the
second portion of said particles prior to being
deposited on said roadway.

10. A self-propelled apparatus for removing
a thickness of asphalt paving from an asphalt roadway

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and reprocessing the removed asphalt so as to permit the recycling thereof, and comprising

5 a frame having longitudinally separated front and rear ends,

roadway engaging wheel means mounted to said front and rear ends of said frame,

10 power means mounted to said frame and operatively connected to said wheel means for propelling the apparatus along the roadway,

pavement milling means comprising a cylindrical milling drum having spaced cutting elements thereon and mounted to said frame at a medial location
15 along the longitudinal length thereof and for rotation about a transverse axis, and drive means for rotating said milling drum to remove a thickness of the asphalt paving and break the same into particles as the apparatus moves forwardly along the roadway,

20 bucket elevator means positioned forwardly of said drum for receiving the asphalt particles removed by said drum and conveying the same upwardly,

a vibrating screen positioned forwardly of said bucket elevator means for receiving the particles
25 from said bucket elevator means, and with said vibrating screen being inclined so that the most forward end of said screen is lower than the remainder of said screen, and with said vibrating screen having openings therein of a size for permitting a first
30 portion of said particles of relatively small size to pass downwardly therethrough, while a second portion of said particles of relatively large size moves longitudinally along said screen and is discharged from said forward end thereof,

35 a tray member positioned below said screen for receiving said first portion of said particles, with said tray member being laterally inclined so that one lateral side edge portion of said tray member is

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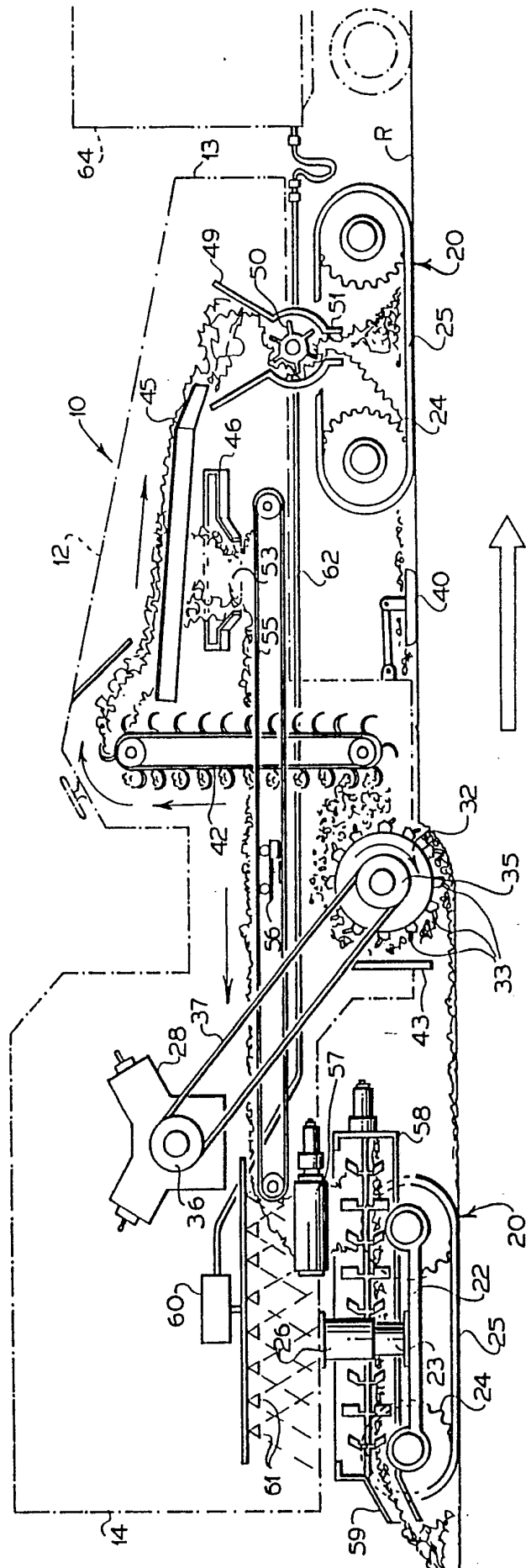
lower than the remainder of said tray member and
40 defines a lower discharge end,
a longitudinal conveyor positioned for
receiving said first portion from said discharge end of
said tray member and conveying the same rearwardly to a
discharge location adjacent said rear end of said
45 frame, with said longitudinal conveyor extending
rearwardly beyond and above said milling drum,
means for metering a liquid additive onto the
first portion in an amount proportional to the mass
flow rate thereof,
50 mixer means mounted to receive said first
portion from said longitudinal conveyor and to receive
the metered liquid additive for mixing the same and
then discharging the mixture onto the roadway at a rear
discharge outlet, and
55 passageway means for permitting the second
portion to drop from said forward end of said screen
onto the roadway at a forward discharge outlet located
forwardly of and in alignment with said milling drum,
whereby the milling drum again contacts said second
60 portion upon forward movement of the apparatus.

11. The apparatus as defined in Claim 10
wherein said passageway means includes means for
crushing the second portion of said particles passing
therethrough and prior to being dropped onto the
5 roadway.

12. The apparatus as defined in Claim 10
wherein said drive means comprises a power transmission
operatively connected between said power means and said
drum, and said drive means acts to rotate said drum in
5 a forward direction with respect to the forward
movement of said apparatus.

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FIG. 1.



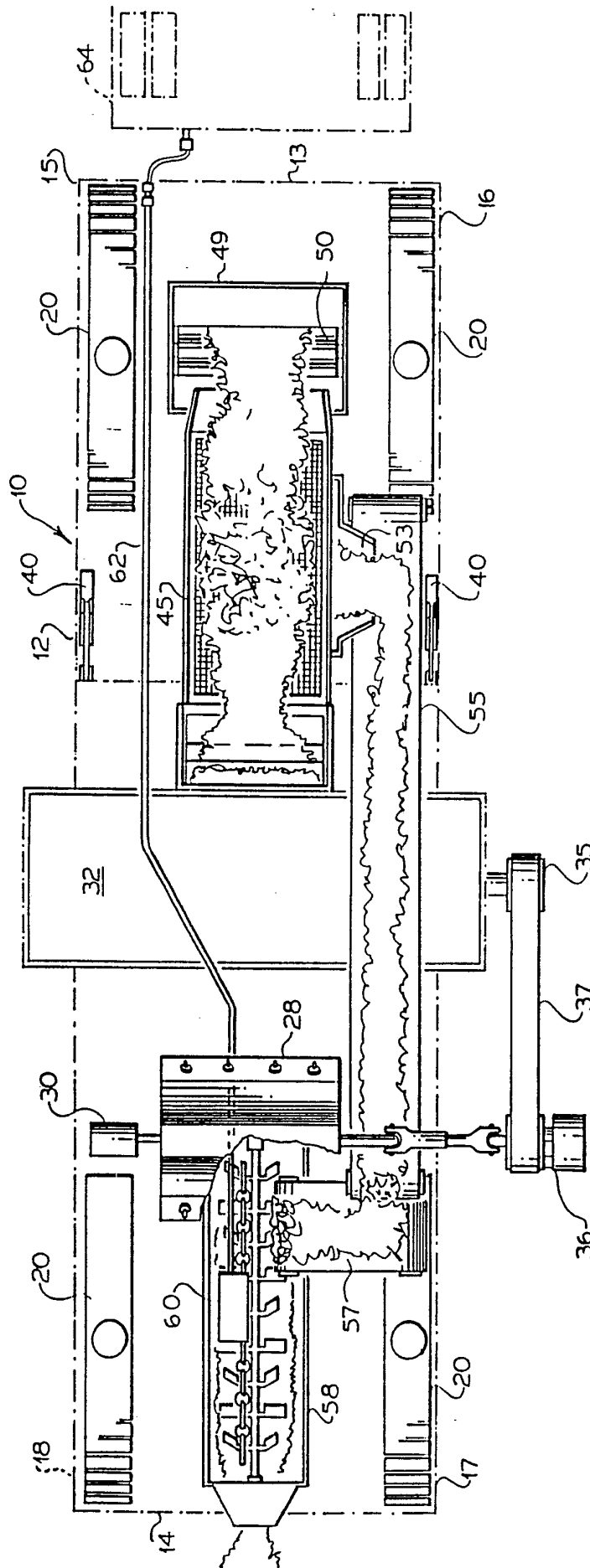


FIG. 2.

INTERNATIONAL SEARCH REPORT

International Application No

PCT/US 90/04399

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) *		
According to International Patent Classification (IPC) or to both National Classification and IPC		
IPC ⁵ : E 01 C 23/06, E 01 C 23/08		
II. FIELDS SEARCHED		
Minimum Documentation Searched ⁷		
Classification System	Classification Symbols	
IPC ⁵	E 01 C	
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched *		
III. DOCUMENTS CONSIDERED TO BE RELEVANT *		
Category *	Citation of Document, ¹¹ with indication, where appropriate, of the relevant passages ¹²	Relevant to Claim No. ¹³
A	EP, A, 0282381 (BEUGNET) 14 September 1988 see the whole document --	1, 2
A	US, A, 4325580 (SWISHER) 20 April 1982 see figures --	1, 4
A	EP, A, 0182748 (COLAS) 28 May 1986 see claims --	1, 2
A	CH, A, 387677 (NEUENBERG) 31 May 1965 see figure 12 --	3
A	US, A, 4619550 (JEPPSON) 28 October 1986 --	
A	FR, A, 2586435 (BEUGNET) 27 February 1987 ----	
* Special categories of cited documents: ¹⁰ "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art. "&" document member of the same patent family		
IV. CERTIFICATION		
Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report	
8th November 1990	21 NOV 1990	
International Searching Authority	Signature of Authorized Officer	
EUROPEAN PATENT OFFICE	MISS T. TAZELAR	

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO.

US 9004399
SA 40013

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on 14/11/90
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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP-A- 0282381	14-09-88	FR-A, B 2611767	09-09-88
US-A- 4325580	20-04-82	None	
EP-A- 0182748	28-05-86	CH-A- 661953	31-08-87
CH-A- 387677		None	
US-A- 4619550	28-10-86	None	
FR-A- 2586435	27-02-87	DE-A- 3632713	31-03-88