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Davin

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[54] **REFERENCE BEAM GRADE CONTROL FOR ASPHALT PAVERS**

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[52] **U.S. Cl.** **404/84**
[51] **Int. Cl.** **E01c 19/00**
[58] **Field of Search** 404/83, 84; 37/DIG. 20

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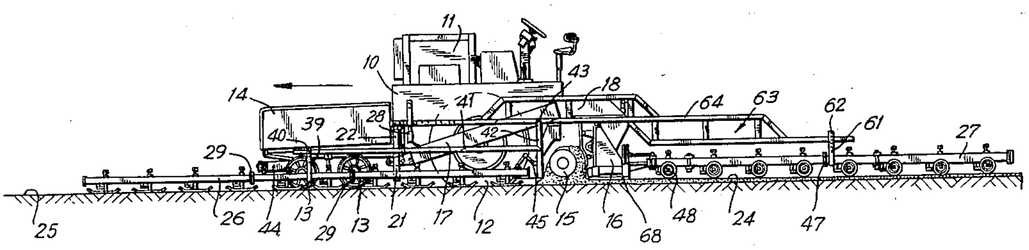
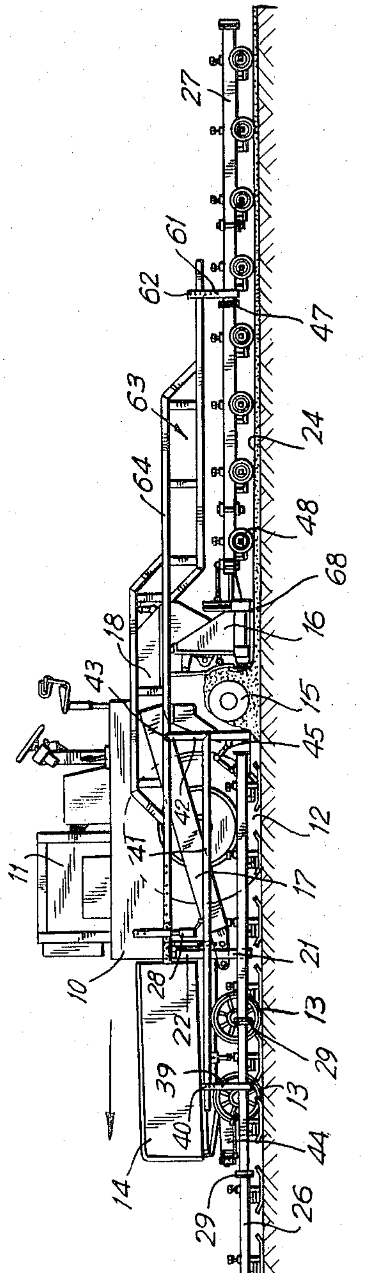
[57] **ABSTRACT**

The disclosure relates to an improved type of grade control for an asphalt paver utilizing reference members positioned in leading and trailing relation to the pavement-forming screed. Control over the grade of the asphalt mat laid down by a floating screed is controlled by the combined action of the reference members moving along with the paving apparatus and sensing the average grade conditions of the base in front of the screed as well as the average grade conditions of the newly laid pavement mat. The new control provides for exceptional smoothness and uniformity of the pavement mat, and also greatly facilitates the use of mobile grade reference controls when laying extremely wide pavement mats.

17 Claims, 5 Drawing Figures

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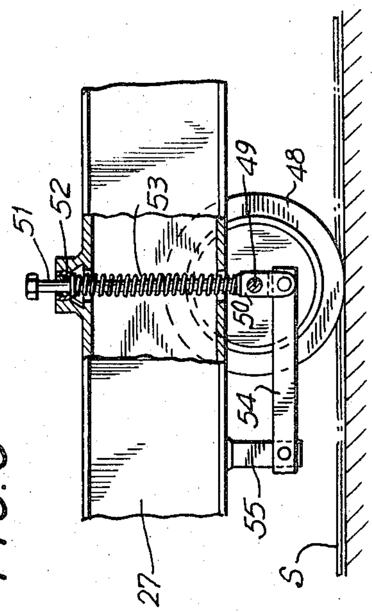
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FIG. 3

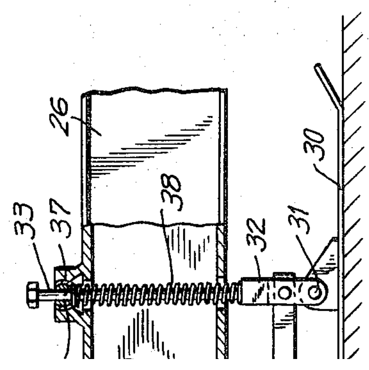
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FIG. 4

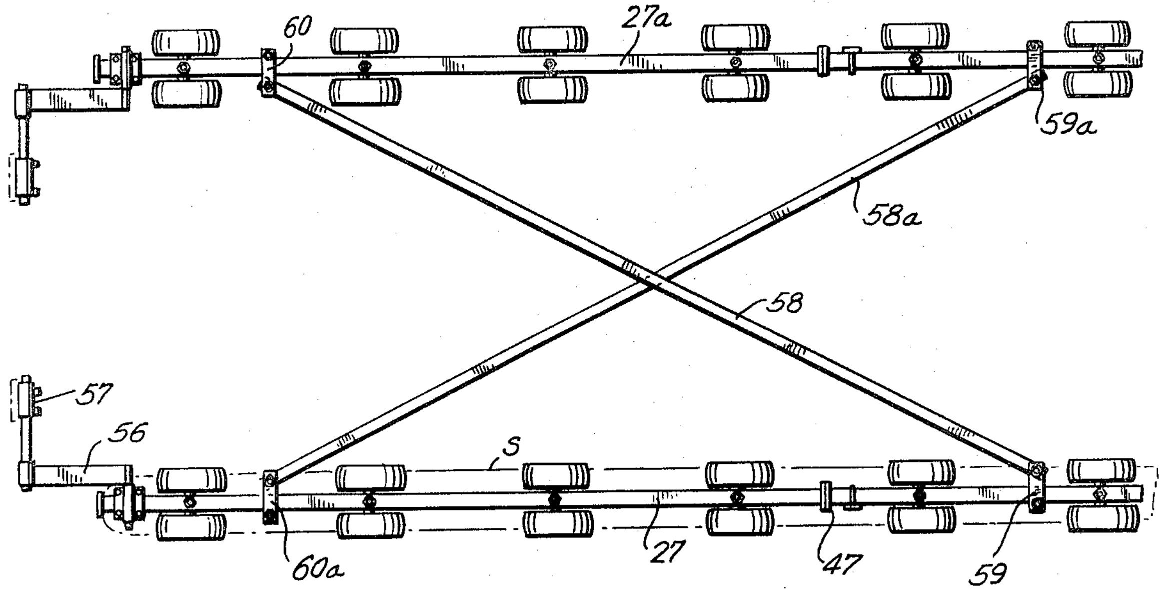
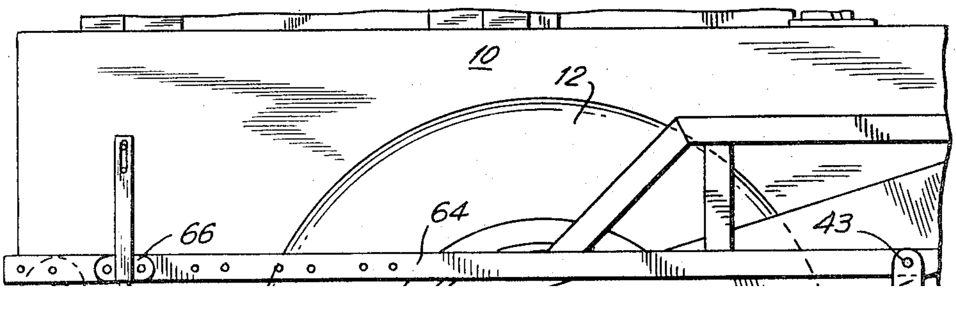


FIG. 5



REFERENCE BEAM GRADE CONTROL FOR ASPHALT PAVERS

BACKGROUND AND SUMMARY OF INVENTION

In the laying of asphalt pavement roadways and the like, it is widespread practice to employ so-called floating screed paving machines. These machines include a tractor-like main frame having an engine for propulsion and for material distributing functions. Typically, there is a material receiving hopper at the front of the paver arranged to receive hot asphalt material from a truck, as the paving machine advances along the roadbed. Slat conveyors or the like are provided to convey the material from the hopper, at the front of the machine, toward the floating screed, at the back of the machine. Immediately in front of the screed, there is typically provided a distributing auger, which receives the raw asphalt material from the slat conveyor and conveys it laterally so as to distribute the material along the front edge of the screed. As the machine advances along the prepared roadbed, the raw asphalt material flows under the screed, which levels, smooths and compacts it to provide a continuous, level pavement mat.

In a typical floating screed asphalt paver, the screed is attached to a pair of forwardly extending tow arms which engage the paver frame at their forward extremities. These tow arms are also connected to the paver frame by hydraulic or other actuators arranged to adjust the vertical position of the tow arm extremities in relation to the paver frame. By effecting proper control over the position of the tow arm forward extremities in relation to a reference plane or a reference element, substantially independent of the irregular vertical motions of the paver frame itself, it is possible to cause the floating screed to lay a pavement mat which is smooth and level in relation to the underlying base surface.

Effective control of the screed tow point adjustment may be achieved by means of suitable feeler device, for example, which is carried by one or both of the tow arms and arranged for contact with a predetermined reference surface. When the tow point becomes either higher or lower than is indicated by the reference surface, as with changing loads upon paver frame and/or irregularities in the roadbed surface, the tow point is caused to be controllably raised or lowered relative to the paver frame to maintain a constant relationship with the reference. Such an arrangement is shown in the Ackerman, et al. U.S. Pat. No. 3,236,163 for ex- tained in a constant relationship to the reference wire.

In some instances, it is undesirable or inconvenient to utilize a reference wire or a previously laid pavement surface as a grade reference. For such occasions, it has proven advantageous to utilize a mobile reference beam, which is carried along with the paver as it moves over the roadway base surface. An arrangement of this type is described and claimed in the D. R. Davin U.S. Pat. No. 3,259,034. In the arrangement of the Davin patent, an elongated beam structure is provided with a substantial plurality (e.g., ten) of independent supports, advantageously arranged on individual springs. The arrangement is such that, as the reference beam is carried along the base surface, it is supported by the combined action of the multiple, yieldable supports. The individual supports are enabled to follow the minor deviations in base contour without significantly affecting the position of the reference beam as a whole, and the mobile reference beam thus provides a suitably accurate, averaged reference plane representing the grade to which the pavement mat is to be applied. A sensing device carried by the screed tow arms engages the reference beam near its center, to enable the tow points to be maintained in a predetermined relationship to the moving reference beam.

While the arrangement illustrated in the D. R. Davin U.S. Pat. No. 3,259,034 constituted an important advance, certain problems were encountered in using the specific apparatus of that patent with conventional paving machinery when laying extremely wide mats of paving material, as is becoming increasingly prevalent with the availability of larger and more powerful paving machines. In part, these problems derive from the fact that, in order to be suitably accurate, a moving reference beam must have substantial length, typically greater than that of the paving machine itself. When paving narrow widths, this presents no problem, as the beam may extend slightly ahead of and slightly in back of the paving machine, while being towed alongside of it by a suitable tow bracket extending laterally from the frame of the paver. However, where the floating screed and the associated material distributing augers are substantially wider than the paver frame, it becomes extremely difficult, if not impossible, to effectively tow the reference beam and to derive an accurate reference signal from a location outwardly of the lateral extremities of the screed and auger. Merely moving the reference beam forward, so as to be entirely in front of the auger and screed is not entirely satisfactory; moreover creased length and enables the laying of a mat of increased smoothness and accuracy in comparison to prior arrangements.

To advantage, the trailing reference beam, which is towed by the paver frame behind the auger and screed is supported by one or more wheels or in some cases by an elongated flexible slide strip. Moreover, notwithstanding that the trailing reference beam rides upon the just-laid mat, it is desirable in many cases that the trailing reference beam be supported by a large plurality of wheels arranged for independent movement, such that the trailing reference reflects an averaged reference position. In the case of either the leading or trailing reference beams, or both, it is considered preferable to utilize a rigid beam with independently yieldably movable supports. However, it is within the purview of the invention to utilize reference beam structures comprising articulated pairs of supports (e.g., see DeLeuze, French Pat. No. 1,056,865).

In its most advantageous form, the system of the invention includes leading and trailing reference beams of rigid structure, independently supported by a plurality of yieldable supports. The leading reference beam is supported by a plurality of shoes or plates, while the trailing beam is supported by a plurality of wheels. Elongated reference arms extend rearward from the leading beam and forward from the trailing beam and are pivotally connected to a screed tow arm, advantageously at a point forward of the screed itself but well behind the tow point. Thus, the reference arm pivot point is in a position to reflect deviations from the reference level of both the tow point and the screed itself.

For a better understanding of the invention and its various features and advantages, reference should be made to the following detailed description and to the accompanying drawings, with further reference to the appended claims.

DESCRIPTION OF THE DRAWING

FIG. 1 is an elevational view of a floating screed type asphalt paver illustrated as in operation laying a pavement mat and utilizing a dual mobile reference beam arrangement according to the invention.

FIG. 2 is an enlarged, fragmentary elevational view, with parts broken away, illustrating an advantageous form of individual yieldable support for a forward reference beam.

FIG. 3 is an enlarged elevational view, similar to FIG. 2 illustrating a preferred form of yieldable support for

a source of tractive power and also provides power for the various material conveying and distributing functions of the machine. In the illustrated apparatus, a pair of large, pneumatic tires 12 at the back of the paver provide the necessary forward traction, with steerage and support for the front of the paver being provided by pairs of smaller wheels 13.

In front of the paver 10, there is conventionally provided a hopper 14 arranged to receive paving material, which may be aggregate, asphalt, and the like, from the tilted body of a truck (not shown). In accordance with conventional practice, the truck is brought into contact with the front of the paver, and then is pushed along by the paver, continuously discharging its contents into the hopper 14 during the progress of the paving operation, until the complete truckload is exhausted. Thereafter, the empty truck is replaced by a new, fully loaded truck, with the paving operation continuing from the hopper supply during the changeover interval.

By means of a suitable slat conveyor (not shown) the paving material is conveyed from the hopper 14 to the back of the machine and deposited in front of a controllably rotated auger 15. The auger is pitched oppositely from the center, so as to convey the conveyor-discharged paving material laterally outward and distribute it more or less evenly along the full length of the auger. In this respect, it will be understood that the basic body of the paver frame 10 may have an overall width of 10 or 12 feet, for example, to accommodate its over-the-road transportation from place to place. At the same time, the paver may be and often is set up in a configuration to lay paving mats in an uninterrupted width of 20 to as much as 40 feet on occasion. In such cases, the overall width of the auger 15 is substantially equal to the full paving width.

Disposed immediately behind the auger 15 is a strike-off and screed structure generally designated by the numeral 16, which is carried by a pair of forwardly extending tow arms 17. The screed assembly 16, like the auger 15, has a width corresponding to the desired paving width, and thus may be substantially wider than the width of the paver frame 10. The tow arms 17, are spaced so as to be closely adjacent to sides of the paver frame. Accordingly, the tow arm 17 may engage the screed assembly 16 well inboard of its lateral extremities. Intermediate portions 18 of the tow arms extend upward and over the top of the area occupied by the auger 15.

In accordance with conventional practice, the tow arms 17 may be connected to the paver frame by means ations in the base roadbed 25 and also more or less independently of changes in the suspension of the paver frame 10 itself resulting from changing loads in the hopper 14, for example, or movement of the wheels into or over minor discontinuities or obstructions in the roadway. This is realized in part by providing a so-called grade reference level, which is independent of the paver frame 10, and by maintaining the tow point of at least one of the arms 17, at a predetermined height in relation to that reference. The other tow arm likewise may be controlled by a similar reference means, although it is usually more common to control one of the arms from a grade reference extending longitudinally of the roadway while controlling the other tow arm by means of a so-called slope control. If the slope angle is zero, both tow arms will automatically be adjusted to maintain an equal uniform height in relation to a single grade reference. Frequently, however, a predetermined cross slope is built into the pavement surface, to facilitate drainage and/or for banking at turns. In the latter case, both tow arms can be adjusted in accordance with a single grade reference means, but the two tow arms will be maintained in an unequally spaced relation to that grade reference to provide the desired cross slope.

In accordance with the teachings of the beforementioned Davin U.S. Pat. No. 3,259,034, a suitable artificial grade reference frequently may be derived from the base roadbed itself, by means of an elongated reference beam individually supported by a large plurality of independently yieldable supporting elements. The base road mat 25 may be a prepared but unpaved base, or may even be a previously laid asphalt course, where the finished pavement mat consists of more than one asphalt course. The present invention utilizes to a large extent some of the important principles of the beforementioned Davin patent, while at the same time providing a greatly improved mobile reference beam arrangement which is suitable for pavement configurations in which the screed and auger are of substantially greater overall width than the paver frame itself—and which, at the same time, provide for an exceptionally high degree of accuracy in the control of the level and smoothness of the resultant pavement mat.

In accordance with the invention, the paving machine is provided with dual mobile reference beams 26, 27, carried alongside and closely adjacent to the paver frame 10, with one reference beam 26 being carried in leading relationship to the auger-screed area and the second reference beam 27 being carried in trailing relationship to the auger-screed area, preferably riding on the newly laid mat, immediately behind the screed assembly 16. By an advantageous arrangement of reference arms or levers, reference data information from the respective beams 26, 27 is combined and made available to a sensing device 28 to effect controlled movement of the actuator 22 and thereby maintain a constant relationship between the screed assembly 16 and the respective leading and trailing reference beams 26, 27.

In the illustrated form of the apparatus, the moving reference beam 26 is in the form of a three-piece lightweight tubular beam joined at flanges 29 into a unitary assembly. The segmented construction permits dismantling for transportation, as will be understood. In its assembled form, the leading reference beam 26 may have a length on the order of 30 feet and is supported at uniformly spaced intervals by a large plurality (10 in the illustration) of yieldably mounted shoes 30 (FIG. 2). To advantage, the shoes 30, may be made of flat sheet metal, pivotally connected at 31 to a yoke bracket 32 carried at the end of a guide bolt 33. A stabilizing link 34 is pivotally connected to the yoke 32 and extends forward to a lug bracket 35, to which it is pivotally connected at 36. The bolt 33 is slidably guided in a spherical bearing 37 received in a boss 38 formed on the reference beam 26. A spring 38 extends between the spherical bearing 37 and the top of the yoke 32, and is arranged to be compressed as a function of upward movement of the shoe 30 relative to the reference beam 26.

The arrangement of the several supporting shoe assemblies for the leading reference beam is such that, when the beam is resting on the base surface 25, in its normal operating arrangement, the springs 38 of all of the shoe assemblies are partially compressed. And, although the base surface 25 may not be precisely level throughout the length of the reference beam, and may contain minor aberrations in the form of small rises or depressions, the beam itself and particularly its midpoint, will tend to maintain an averaged position above the roadway, reflecting the average condition of the surface. As will be understood, individual shoe assemblies may rise or fall relative to the beam in following anomalies in the road surface. The reference beam itself will be influenced only to a minor extent by individual movements of the shoe assemblies, but will reflect an average condition. The geometric center of the beam, in terms of the location of the supports therefor, reflects most precisely the average reference condition sought to be determined.

In the system illustrated in the Davin U.S. Pat. No.

Desirably, the pivot point **43** connecting the reference arm **41** to screed tow arm is located rearward of the tow bracket **21** and at the same time well forward of the screed assembly **16**. A point approximately midway between these areas is advantageous, inasmuch as vertical movement relative to the desired reference of either the screed assembly **16** or its tow point will be reflected in vertical movement of the pivot point **43** and a corresponding vertical movement of the reference arm **41**.

The reference beam **26** is carried along with the paver frame **10** by means of a forward tow linkage **44**, by which the beam is attached to the front of the paver. An articulated stabilizing linkage **45** connects the back of the reference beam **26** to a portion **46** of the paver frame (FIG. **5**) to provide lateral stability.

The trailing reference beam **27** typically may be somewhat shorter in length than the leading beam **26**. For example, a beam length of 20 feet for the trailing beam may be suitable, while a 30 foot length on the leading beam would be preferable. In the illustrated arrangement, the trailing beam is constructed in two sections, bolted together at a center flange **47**. To greatest advantage, the trailing reference beam **27** is supported by a large plurality of uniformly spaced sets of elements, there being eight such sets in the specific illustration. Under some conditions, a single support element might suffice for the rear reference, but a plurality is required and/or desired in most instances. Wheels are used rather than flat shoe plates, as in the case of the leading reference beam, because the newly laid asphalt mat **24** is still in a soft condition when traversed by the reference beam and could be scraped or marred by individual sliding shoes. Most advantageously, the wheels **48** are arranged in pairs for increased flotation on the soft mat surface, and also to impart stability to the beam to facilitate its handling when detached from the paver.

Notwithstanding that the newly laid pavement mat **24** may have a high degree of smoothness and levelness, it is advantageous in most cases that the plurality of wheel pairs **48** for the trailing reference beam be independently supported, so that the position of the beam reflects an average position of the multiplicity of wheel pairs. To this end, the wheel pairs may be supported much in the same manner as the shoes **30** of leading reference beam. Thus, an axle **49** connecting the two wheels of a pair is journalled in a yoke bracket **50** carried at the end of a guide bolt **51** slidably received in a spherical bearing **52**. A coil spring **53** urges the yoke

slide strip is suitably secured at its front end to the reference beam or to the paver itself, so as to be towed along with the beam. The strip readily flexes to accommodate the desired independent movement of the beam supports.

The trailing beam advantageously is towed from the screed assembly **16**, by means of a pivoted tow link **56** (FIG. **4**) extending rearward from a bracket **57** suitably attached to the screed. For lateral stabilization of the back of the trailing beam **27**, there is provided a diagonal stabilizing linkage consisting of a tie rod **58** secured to the beam by a clamp **59** and extending forwardly to a connection point at the opposite side of the machine. In the arrangement shown in FIG. **4** of the drawings, the equipment is set up to employ reference beam systems on both sides of the paving machine. In that case, the stabilizing bar **58** for the reference beam **27** may be secured by a clamp **60** to the forward portion of the opposite side trailing reference beam ***27a***. Likewise, the beam ***27a*** will be stabilized by a tie bar ***58a*** secured by clamps ***59a*** and ***60a***. Where only a single trailing reference beam is utilized, the stabilizing bar **58** can be connected more directly to the screed assembly **16**.

In the effective center region of the beam **27**, in terms of the location of the uniformly spaced supports, there is provided a vertically disposed extension bracket **61** which pivotally engages at **62** the trailing end of a reference arm structure **63**. The reference arm structure **63** desirably is constructed in the form of a truss arranged to support an elongated, forwardly extending reference arm element **64**. The specific configuration of the truss **63** is unimportant, apart from the fact that it must be consistent with its passing over the top of the screed and auger structures at the back of the paver.

In the illustrated arrangement, the reference arm **64** is attached by the pivot pin **43** to the forward reference arm **41** and to the screed tow arm **17**. Within the purview of this invention, the forward and rearward reference arms **41, 64** could be separately pivoted to the tow arms **17**, or they could be pivotally connected together and pivoted to the tow arm **17** at a different axis. However, a common pivot point at the pin **43** is simple and advantageous.

As is reflected in FIGS. **1** and **5**, the rearward reference arm **64** extends forwardly well beyond the pivot pin **43**, to a region located approximately over the center of the forward reference arm **41**. The sensing device **28**, typically in the form of a potentiometer actuated by a feeler element **65**, is secured to the upper reference which are well known and need not be repeated here, movement of the potentiometer feeler element **65** away from its neutral position can be utilized to effect energization of the actuator **22** in a direction that will tend to restore the feeler to its neutral position by appropriate upward or downward movement of the tow arm **17**, as may be necessary.

In typical operation, the reference arms **41, 64** are arranged to be more or less horizontal and parallel when the respective leading and trailing reference beams are in a desired, predetermined relationship and the tow arms **17** are properly positioned. To this end, the vertical supports **39, 61** may be provided with a plurality of openings or other adjustment facilities for establishing a desired level for the pivot points **40, 62** of the respective reference arms.

When the system is in operation, the paver frame **10** advances forwardly (to the left in FIG. **1**) carrying with it the reference beams **26, 27**, the former riding on the roadway base surface and the latter riding on the just laid pavement mat. Assuming, for example, that the level of the paver frame **10** were to drop, relative to the reference, as by reason of an increased load in the hopper and/or one or more of the wheels moving into a minor depression in the roadway, the forward extremity of the tow arm **17**, being attached to the paver frame through the hydraulic actuator **22**, would be correspondingly lowered relative to the reference beams **26, 27**. This would in turn cause a lowering of the pivot point **43** and a resulting relative closing of the distance between the reference arms **41, 64** in the region of the sensor **28**. Immediately, the actuator **22** would be energized to raise the forward end of the tow arm **17** sufficiently to re-establish proper spacing between the reference arms. As a result, the orientation of the tow arms **17** to the roadway base surface **25** and to the pavement surface **24** is retained substantially constant, notwithstanding vertical deviations of the paver frame itself.

As will be appreciated, the screed assembly **16** is supported by flotation on the viscous asphalt paving material as the paver is advanced on the roadway. The viscosity and other characteristic nature of this material ideally should be constant at all times. As a practical matter, however, the consistency of the mixture may vary from truckload to truck load, and the viscosity characteristic of even the same mixture may vary somewhat as a function of temperature, for example. Accordingly, assuming the paving frame **10** itself is traveling a perfectly level course, there may be some ten- plate **68** with respect to the pavement mat, tending to cause the screed assembly **16** to seek a higher level and thereby re-establish the desired level of the pavement surface.

The dual reference beam system of the invention results in an exceptionally high degree of accuracy and smoothness in the laying of an asphalt paving mat, because the level of the screed plate is controlled as a combined function of the roadway base surface **25** and the just-laid pavement surface **24**. Moreover, the extreme overall length of the dual reference beam system provides for exceptional overall responsiveness of the control to deviations from a desired level surface.

In addition to the foregoing advantages, the system of the invention provides a rather simplified and wholly practical arrangement for utilizing a mobile reference means in conjunction with heavy duty asphalt pavers having the capacity to lay a pavement mat of far greater width than that of the paver frame itself. This is of particular importance in view of current trends toward the paving of 30 and 40 foot mat widths in a single pass with the paving machine.

In a most advantageous form of the invention it is provided that the trailing reference beam, although riding on an essentially smooth and level, just-laid pavement surface, is supported by a large plurality of elements, preferably wheels, each being independently supported. In this respect, notwithstanding the essentially smooth, flat characteristic of the newly laid pavement surface, wheels can, in continued operation, become rather irregular through non-uniform pickup of adherent asphalt material. By reason of the multiple, independent support of the plurality of wheels, the trailing reference beam can be supported in an appropriately averaged position notwithstanding a degree of out-of-roundness of the individual wheels during normal operations.

It should be understood, of course, that the specific form of the invention herein illustrated and described is intended to be representative only, as certain changes may be made therein without departing from the clear teachings of the disclosure. Accordingly, reference should be made to the appended claims in determining the full scope of the invention.

I claim:

1. A dual reference beam grade control system for use in combination with an asphalt paver of the type having a transversely disposed material distributing auger, a floating screed positioned behind the auger, tow tending rearwardly toward and being pivotally connected to one tow arm,

e. a second reference member towed by the paver frame and being disposed entirely behind the screed,

f. support means for supporting said second reference member above an asphalt mat grade surface,

g. a second reference arm connected to the second reference member and extending forwardly toward and being pivotally connected to said one tow arm and/or said first reference arm, and

h. tow arm height reference control means associated with each of said reference arms and operatively associated with said tow arm suspension means for raising and lowering the tow point of said one tow arm relative to the paver frame in response to relative movements of one or both of said reference arms in relation to said one tow arm.

2. The grade control system of claim **1**, further characterized by

a. said reference control means including means engaging both of said reference arms and operative to detect relative movement therebetween.

3. The grade control system of claim **2**, further characterized by

a. said control means including a sensing potentiometer or the like carried by one of said reference arms and engageable with the other to detect relative movement.

4. The grade control system of claim **1**, further characterized by

a. said reference arms being pivotally connected to said one tow arm,

b. one of said reference arms having a portion extending longitudinally for a substantial distance beyond its pivot axis in the direction of the other reference arm, and

c. said reference control means being operatively associated between the extending portion of said one reference arm and a portion of said other reference arm.

5. The grade control system of claim **4**, further characterized by

a. said second reference arm having a portion extending longitudinally forward of said axis.

6. The grade control system of claim **5**, further characterized by

a. said reference arms being connected to said one

9. The grade control system of claim **1**, further characterized by

a. said first and second reference members comprising substantially rigid beam-like structural elements of substantial length in relation to the length of the paver, and

b. each of said beam-like structural elements being supported by a plurality of spaced independently movable supports,

c. the several support elements for each structural element being operative collectively to support the structural element in an averaged position over its length, in relation to the reference surface engaged by the support elements.

10. The grade control system of claim **9**, further characterized by

a. the support elements for said second reference member comprising wheels.

11. The grade control system of claim **10**, further characterized by

a. each of said support elements comprising a pair of axially spaced wheels, positioned on opposite sides of the reference member.

12. The grade control system of claim **10**, further characterized by

a. the support elements for the first reference beam comprising bearing plates slidably engageable with the base reference.

13. The grade control system of claim **9**, further characterized by

a. flexible slide strip means interposed between the asphalt mat surface and each of the support elements for the second reference member.

14. The grade control system of claim **1**, further characterized by

a. said first reference member being towed from the paver frame from a point substantially forward of the back end of the member,

b. stabilizing linkage means being connected between the paver frame and the back portion of the first reference member,

c. the second reference member being towed from the paver frame from a point in the forward region of the reference member, and

d. stabilizing linkage means being connected to the back portion of the second reference member and extending diagonally forwardly and toward the opposite side of the back portion of the paver frame.

15. The grade control system of claim **14**, further

b. an elongated reference control member supported by said plurality of wheels in an averaged position in relation to a surface,

c. resilient means mounting said wheels in a longitudinally aligned relationship along said reference control member for independent vertical movement in relation to said reference control member,

d. means for towing said reference control member directly behind a portion of said screed, whereby all of the said wheels engage the finished asphalt mat laid by said screed, and

e. means for actuating the screed control means in response to predetermined relative vertical movements between the paver frame and said reference control member.

17. A reference beam grade control system according to claim **16,** further characterized by

a. a reference arm being pivotally connected at one end to the mid-portion of said reference control member and connected at another portion for pivotal movement in relation to said screed and for vertical movement as a function of vertical screed movement with reference to the mat surface, and

b. said screed control means being actuated by movements of said reference arm.

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