ABSTRACT: A paver for depositing paving material into a mat along a roadway. The crown of the mat is automatically varied through operation of a control system sensing a preestablished crown reference. Different forms of the invention provide either mechanical or electrical feedback to null out crown control signals.
AUTOMATIC CROWNING SYSTEM FOR PAVERS

SUMMARY OF THE INVENTION

This invention relates to construction equipment and more particularly relates to road pavers having an adjustable surface template for varying pavement crown.

Conventional road pavers of the type described incorporate a surface template, such as a strike-off blade or screed, and means for adjusting the lateral profile or configuration of the template and thereby vary the pavement crown or lateral convex profile of the finished pavement. Crown adjustment is desirable as the paving operation progresses through different portions of the roadway. For example, when moving from a straight course into an intersection it is essential to reduce the crown and feather the two road surfaces together. Also, it is desirable to flatten the crown when moving into a curve where the surface will slope towards the inside. At other times the crown will be flattened when entering a road portion where the entire surface slope is to one side or the other.

With existing paving equipment crown is adjusted manually by an operator turning a crank. This introduces the effect of human judgement in changing the crown during transition can be uneven and rough, will vary between different operators, or even will vary with the same operator whose judgement may not be consistent on different courses.

The human factor in crown adjustment also produces unpredictable depth control when making a crowning transition. If the crown is as much as one-quarter inch too high then a considerable amount of material may be wasted, and likewise if the crown is too low the contractor may be subjected to penalties for not meeting contract specifications. It is therefore desirable to accurately control the crowning operation so that the depth of material deposited stays within predetermined limits.

Present paving equipment also requires the need for an additional operator to adjust the crown during a transition along the roadway. A system eliminating this operator would greatly increase the efficiency of the paving operation.

Accordingly, it is an object of the invention to provide a paving system with automatic crown control which eliminates human judgement in making a crowning transition and which is productive of a smoother road surface.

Another object is to provide a crown control system for a road paver which insures that the depth of paving material is within predetermined limits during a crowning transition.

A further object is an automatic crowning system which eliminates the requirement for an operator to adjust the surface template during a crowning transition.

Another important object is a crown control system for a road paver in which a crown reference datum is sensed to produce control signals which in turn actuate adjustment of the surface template, and in which the control signals are utilized following an adjusting movement of the template to vary pavement crown as a function of a change in said datum.

Another object is to provide a crown control system for a road paver in which a sensing element produces control signals responsive to variations in a reference datum, the control signals actuate vertical adjustment of the surface template profile, and a mechanical feedback system is provided to null out the control signals responsive to vertical movement of the template.

Another object is to provide a crown control system for a paver in which a sensor produces control signals responsive to variation in a reference datum, the control signals actuate adjustment of a surface template profile, and an electrical feedback system is provided to null out the control signals as the template is adjusted to the desired profile.

The above and other objects and advantages of the present invention will become apparent to those skilled in the art when the following specification is read in conjunction with the accompanying drawings.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of a portion of a road paver incorporating features of the invention;

FIG. 2 is a schematic diagram of the crown control system for FIG. 1;

FIG. 3 is a perspective view of a modified form of the invention;

FIG. 4 is a schematic diagram for the crown control system for the modified form of FIG. 3;

FIG. 5 is a schematic diagram of a modified crown control system for the invention;

FIG. 6 is a partial elevation view of another modified form of the invention;

FIG. 7 is an elevation view of a preferred crown reference datum illustrating the operation thereof; and,

FIG. 8 is a partial elevation view similar to FIG. 6 illustrating a mechanical feedback arrangement.

DETAILED DESCRIPTIONS

Referring to the drawings and particularly FIG. 1, a preferred paving template apparatus for attaching to the rear of a paver tractor is indicated generally at 10. The paver tractor, not shown, may be of conventional design for travel over prepared roadbed 12 where it receives raw paving material, such as asphalt and the like, and conveys the material rearwardly for deposit in front of the surface template of apparatus 10. The surface template in turn levels and smooths the raw material into a mat 14 of the desired depth, grade, slope and crown.

The term crown in this application has reference to the degree of convex profile of the surface of mat 14 when viewed in lateral cross section. As used herein, crown adjustment means a change in this profile to increase or decrease the height of the midpoint of the pavement surface with respect to the outer edges. The crown adjustment may vary from a maximum such as a flat surface in a curve where the entire surface slopes to one side or the other.

Surface template apparatus 10 is illustrated in the preferred form as incorporating a floating screed assembly 16 mounted behind the paver tractor by a pair of support beams 18. Screed 16 functions to level and smooth the raw material deposited on the roadbed by the paver as it advances. The screed additionally heats or irons the material to improve surface texture.

While a screed-type surface template is shown as preferred, it is understood that the invention has application to other templates, such as a strike-off blade, adapted to level a pavement surface with a crown profile.

Screed or template 16 comprises a flat, transversely extending bottom plate 20 extending from a pair of sideplates 22 and spaced above the prepared roadbed. A pair of suitable adjusting devices 24, 26 are provided to selectively vary the pitch angle or forward rake of screed plate 20. As is well known, this pitch adjustment operates to vary the thickness of mat 14 during a paving operation.

A pair of rear support members 28, 30 are secured to the upper edge of screed plate 20 with their inner ends spaced apart to define a gap 32. A pair of top plates 32, 34 extend from the rear plates forwardly to a pair of spaced front members 36, 38 which in turn are secured at their lower ends to screed plate 20 and extend upwardly for attachment at their outer edges with sideplates 22. A pair of gas burners 40, 42 are mounted above respective openings in top plates 32, 34 for heating screed plate 20 to iron the mat surface.

The crown of mat 14 is determined by the lateral profile of screed plate 20. This profile is preferably adjusted to vary crown through operation of crown-adjusting actuator 44. Actuator 44, which may be any suitable hydraulic or electric motor, drives an endless chain or belt 46 which is trained over a pair of sprocket wheels 48, 50, to extend and retract turnbuckle assemblies 52, 54. Turnbuckle 52 is attached at either
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end to arms 56, 58 which in turn are secured to respective front members 36, 38. Turnbuckle 54 is secured at either end to arms 60, 62 secured to screed plate 20 and respective rear plates 28, 30. As the two turnbuckles extend upon rotation of the sprocket wheels in one direction, the arms will operate to warp or bend screed plate 20 to increase the crown profile, and similarly retraction of the turnbuckles will operate to decrease the crown profile. Guide bars 64 and 65 are mounted at one end to respective arms 62 and 58, and are slidably connected at their other end to respective arms 60 and 56 to maintain alignment of the arms. As the crown is changed, screed plate 20 will effectively pivot at either side about the outer edges 66, 68 of the mat so that the midpoint of plate 20 varies in elevation with respect to these edges. During the paving operation the upper surface of the mat conforms to the profile of the screed or template.

Referring now to FIG. 2, the crown control circuit utilizing mechanical feedback is indicated generally at 69. Control circuit 69 is adapted to sense a preestablished crown reference datum and direct control signals to actuator 44 for adjusting the crown in response to variations in the datum. In the preferred form of this circuit, a direct signal to actuator 44 results in a respective front member 120, 122, a pair of top plates 124, 126, and a pair of heaters 128, 130 are provided as described above. The crown of member 132 is varied through lateral adjustment of the profile of plate 20 through operation of actuator 134. This actuator extends and retracts a pair of turnbuckle assemblies 136, 138 which in turn are connected to arms 140, 142 at the screed rear edge and arms 144, 146 at the front edge. A horizontal beam 148 is rigidly mounted below support beams 110, 112. The rear end of end plate 114 is supported from beam 148 by means of rod 150 while the end of end plate 112 is supported from this beam by rod 152. The upper end of rod 152 is secured to the beam through a sliding connection to accommodate pivotal movement of the end plate as the crown changes.

Turning to FIG. 4, the electrical crowning control circuit for the modification of FIG. 3 is illustrated generally at 155. This circuit includes crowning sensor 156 mounted at the overboard end of beam 148 above the crown reference datum, which may be the wire 76 of FIG. 7. Wand 158 is pivotally connected to the sensor as the elevation of the datum changes. Sensor 156 operates as a position transducer to produce a command signal at 160. This position transducer may comprise a rotary potentiometer in a conventional bridge circuit. Pivotal movement of the wand unbalances the bridge with a voltage having a polarity dependent upon the change in wand elevation. This electrical voltage is amplified at 162 to actuate hydraulic servo valve 164 which in turn directs pressurized fluid through conduit 166 into hydraulic motor 168 of actuator 134. Actuator 134 adjusts the profile of screed plate 110, and this adjustment is represented schematically as output position 170.

The command signals are nullled out in the modification of FIG. 3 by means of signals from feedback sensor 172. This sensor is mounted for a vertical movement with front screed member 122 as the crown varies. A pivoting wand 174 is biased for contact with the upper edge of beam 148. During crown adjustment sensor 172 moves either up or down relative to beam 148 thereby pivoting the wand. In the diagram of FIG. 4 feedback sensor 172 is represented as a position transducer producing a feedback signal at 176 equal in magnitude, but opposite in polarity, to command signal 160 to thereby null out the control circuit. When this occurs the screed plate has assumed a new profile which is maintained until the reference datum again changes to produce a new command signal.

An alternate mounting for the crowning sensor is indicated at 156' in FIG. 3. In this modification the sensor is mounted forwardly on arm 178 secured to support beam 110. A wand 158' depending from the sensor is biased for contact with a reference wire similar to that illustrated in FIG. 7.

Referring to FIG. 5, a modified control circuit indicated generally at 180 is provided for the modification of FIG. 3 embodying an electrical actuator for crown change. Circuit 180 includes a crowning sensor or position transducer 182 directing a command signal 184 into amplifier 186, as explained above. The amplified command signal operates electric motor 188 of actuator 134 which in turn drives the control 190 to adjust the crown. A change in crown is indicated as a screed output position at 192. A feedback from this output position operates position transducer 194, such a rotary potentiometer, which directs an electrical signal at 196 to null out the command signal. The screed plate has now assumed a new profile which is maintained until the reference datum again changes.

Referring to FIG. 6, a modified crown control mechanism for a solid frame or nonfloating screed type of template is illustrated in partial rear elevation view at 198. Mechanism 198 includes a U-shaped screed frame 200 mounted to the rear of the paver tractor, not shown. The screed includes a pair of screed plates 202, 204 articulated at 206 and secured at their outer ends to the lower end of frame 200 in datums 208, 210. These connections may be slotted or the like to accommodate lateral movement of the end plates as the crown changes. A suitable actuator, shown as hydraulic cylinder 212, is mounted at its upper end to the midpoint of frame 200 and at its lower end to the articulated connection 206 of the screed plates.
The surface crown of mat 214 is controlled through extension and retraction of actuator 212 by means of a suitable control circuit, not shown, incorporating crowning sensor 216 and feedback sensor 218. Retraction of the actuator will raise the crown and extension will lower it. The control circuit for the modification of FIG. 6 may be similar to that of FIGS. 4 and 5. A wand 220 biased to contact crown reference wire 222 pivots as the wire elevation changes, and sensor 216 in turn produces a command signal operating actuator 212 to change crown in the required direction. Feedback sensor wand 224 is biased to contact the top of scrived plate 202 so that crowning adjustment pivots the wand and operates feedback sensor 218 to null out the command signal. The scrived profile remains at its new position until the reference wire again changes elevation.

Referring to FIG. 8, a modified form of the invention of FIG. 6 is illustrated generally at 226. In this modification a mechanical feedback arrangement is provided to null out the command signal from crowning sensor 216'. This crowning sensor is mounted on an arm 228 pivoted to the lower leg of scrived frame 200. The inner end of arm 228 is connected by rod 230 to level 232 which in turn is pivoted to bracket 234 on the frame. Lever 232 in turn is connected through rod 236 for movement with scrived plate 204'.

In the operation of the modification of FIG. 8 a change in elevation of reference wire 222' pivots wand 220'. This in turn actuates sensor 216' to direct the electrical command signal for operating the crowning actuator, not shown, to raise or lower the crown plates in the desired direction. The feedback device follows this crowning movement by pivoting level 232 and arm 228 to null out the command signal. For example, assuming that reference wire 222' raises and moves closer to sensor 216', a command signal is produced to increase crown and raise scrived plate 204'. This in turn pivots level 232 clockwise and arm 228 counterclockwise to elevate sensor 216' until the wand returns to its original position and deactivates the command signal.

What is claimed is:

1. In a paving machine comprising a surface template and crown control means to effect a crown adjustment of said template by varying the spacing of intermediate points thereof with respect to a lateral plane passing through the end points thereof, the improvement which comprises:
   a. reversible motor means for operating said crown control means in either direction, to increase or decrease the crown contour of the template,
   b. sensing means responsive in part to an external crown reference datum and responsive in part to the magnitude of crown adjustment in said template, and
   c. control circuit means functionally effective to compare the responses of said sensing means and to energize said motor means in response thereto.

2. A paving machine according to claim 1, further characterized by:
   a. said sensing means comprising a sensing element and a support therefor for carried by said template,
   b. said sensing element being movable relative to its support in response to changes in said reference datum relative to the template,
   c. said support being movable relative to the reference datum in response to changes in the crown adjustment of said template, to effect a null of the sensing element response.

3. A paving machine according to claim 2, further characterized by:
   a. a support carried by the template at one side and extending laterally outward beyond the outer edge of said template,
   b. said sensing means comprising a sensing element carried by said support and movable thereby relative to said lateral plane in opposite relation to crown adjusting movements of intermediate portions of said template.

4. A paving machine according to claim 1, further characterized by:
   a. said sensing means comprising first and second sensing elements,
   b. the first sensing element being responsive to the external reference datum,
   c. the second sensing element being responsive to the magnitude of crown adjustment in said template, and
   d. said control circuit means being operative to energize said motor in a direction to move said second sensing element toward a null relation with respect to said first sensing element.

5. The invention of claim 1 wherein:
   a. the surface template comprises a bottom plate secured at its sides to side support members,
   b. said crown adjusting means comprises means to raise and lower the midpoint of said plate with respect to the plate sides,
   c. said external reference datum comprises a reference structure extending along a side of the path followed by the paving machine,
   d. said sensing means includes a sensing element in registry with the reference structure and mounted for movement with one side support member responsive to vertical crowning adjusting of the bottom plate,
   e. the control means actuating the crown adjustment means in response to the sensing element detecting change in elevation of the reference structure, and
   f. the adjusting means operating to vertically adjust the mid-point of the template in a direction to pivot the sensing element and restore its position relative to the reference structure.

6. The invention of claim 1 wherein:
   a. the template comprises a bottom plate with its midpoint adapted to be elevated and depressed relative to its side edges,
   b. the crown adjusting means operates to elevate and depress the template midpoint relative to said lateral plane,
   c. the control circuit means comprising circuit means generating control signals responsive to the reference datum indicating a crown change,
   d. the control signals actuating the adjusting means to change template midpoint elevation relative to said lateral plane in a direction corresponding to reference datum change, and
   e. a feedback circuit to balance said control signals responsive to the indicated respective elevation or depression of the template midpoint.

7. The invention of claim 6 wherein:
   a. the reference datum comprises a reference structure extending along the roadway course and varying in elevation in accordance with a predetermined crowning program,
   b. said control circuit including a sensing element detecting variation in reference structure elevation to generate said control signals, and
   c. said feedback signals including a second sensing element sensing elevation or depression of the template to generate feedback signals which balance the control signals.

8. The invention of claim 7 wherein:
   a. the second sensing element is mounted for movement with the template at a position between its side edges,
   b. the element being biased against the main frame to detect relative movement between the frame and template midpoint to generate said control signals.

9. The invention of claim 6 wherein:
   a. the crown adjusting means includes a motor to vary template midpoint elevation, and
   b. said control signals operate to actuate said motor to elevate or depress said midpoint relative to said lateral plane until the feedback signals balance said control signals.

10. The invention of claim 1 wherein:
   a. the template comprises a bottom plate articulated at its midpoint and mounted to the main frame at respective sides thereof, and
b. the adjusting means comprising an actuator connected between the frame and said articulated midpoint to elevate and depress said midpoint relative to said lateral plane for changing the crown.

11. The invention of claim 10 wherein
a. the control means includes a crowning sensor mounted on said frame and extending in registry with said reference datum,
b. said sensor generating control signals to operate the actuator in response to a crowning change reflected in the reference datum, and
c. feedback sensor means generating feedback signals to balance said control signals in response to elevation or depression of intermediate points of the template relative to said lateral plane for adjusting template profile to a position corresponding to said reference datum.

12. The invention of claim 10 wherein
a. the control means includes a support arm pivotally mounted to the frame,
b. a crowning sensor element mounted on one end of the support arm and positioned in registry with said reference datum to generate control signals for operating the adjusting means in response to crowning changes in the reference datum, and
c. feedback linkage means connected between the template and the support arm to pivot said support arm for cancelling said control signals responsive to indicated elevation or depression of intermediate portions of the template relative to said lateral plane.

13. The method of crown control in a paving system having a surface template for smoothing paving material into a finished mat comprising the steps of:
a. sensing a crowning reference datum programmed to vary for a predetermined change in crown along the roadway to be paved,
b. generating control signals responsive to sensing a crowning change in the reference datum,
c. adjusting the lateral profile of the template to vary curvature of the mat crown as a function of the datum change, and

d. terminating crown adjustment in response to the template having assumed a profile contour corresponding to said changed datum.

14. The method of claim 13 wherein
a. the step of generating the control signals comprises producing first and second electrical signals responsive to datum changes of respective increasing or decreasing crown change, and

b. increasing or decreasing the elevation of the template midpoint, with respect to a lateral plane between its edges, in response to respective first or second signals.

15. The method of claim 14 wherein
a. the step of terminating crown adjustment comprises producing first and second electrical feedback signals responsive to respective elevation or depression of the template midpoint with respect to said lateral plane, and

b. balancing the first and second control signals by first and second feedback signals equal in magnitude thereto.