Nov. 19, 1963 H. C. POLLITZ 3,111,070

PAVING MACHINE WITH AUTOMATICALLY CONTROLLED SCREED

Filed Dec. 8, 1961 6 Sheets-Sheet 1

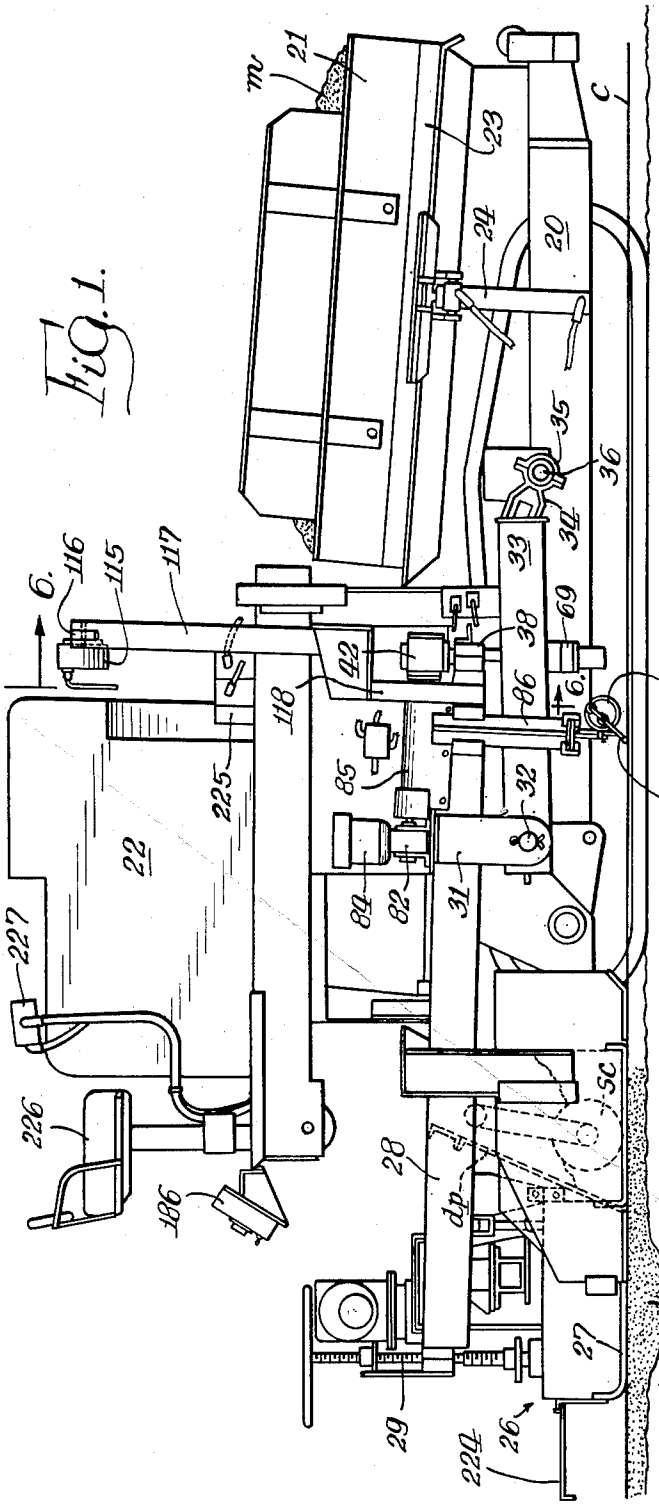


FIG. 1.

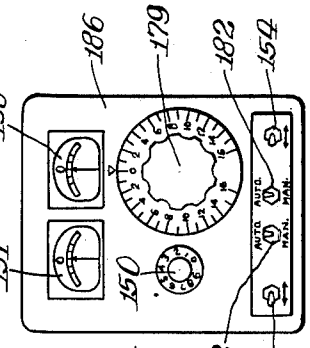


FIG. 15.

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Filed Dec. 8, 1961 6 Sheets-Sheet 2

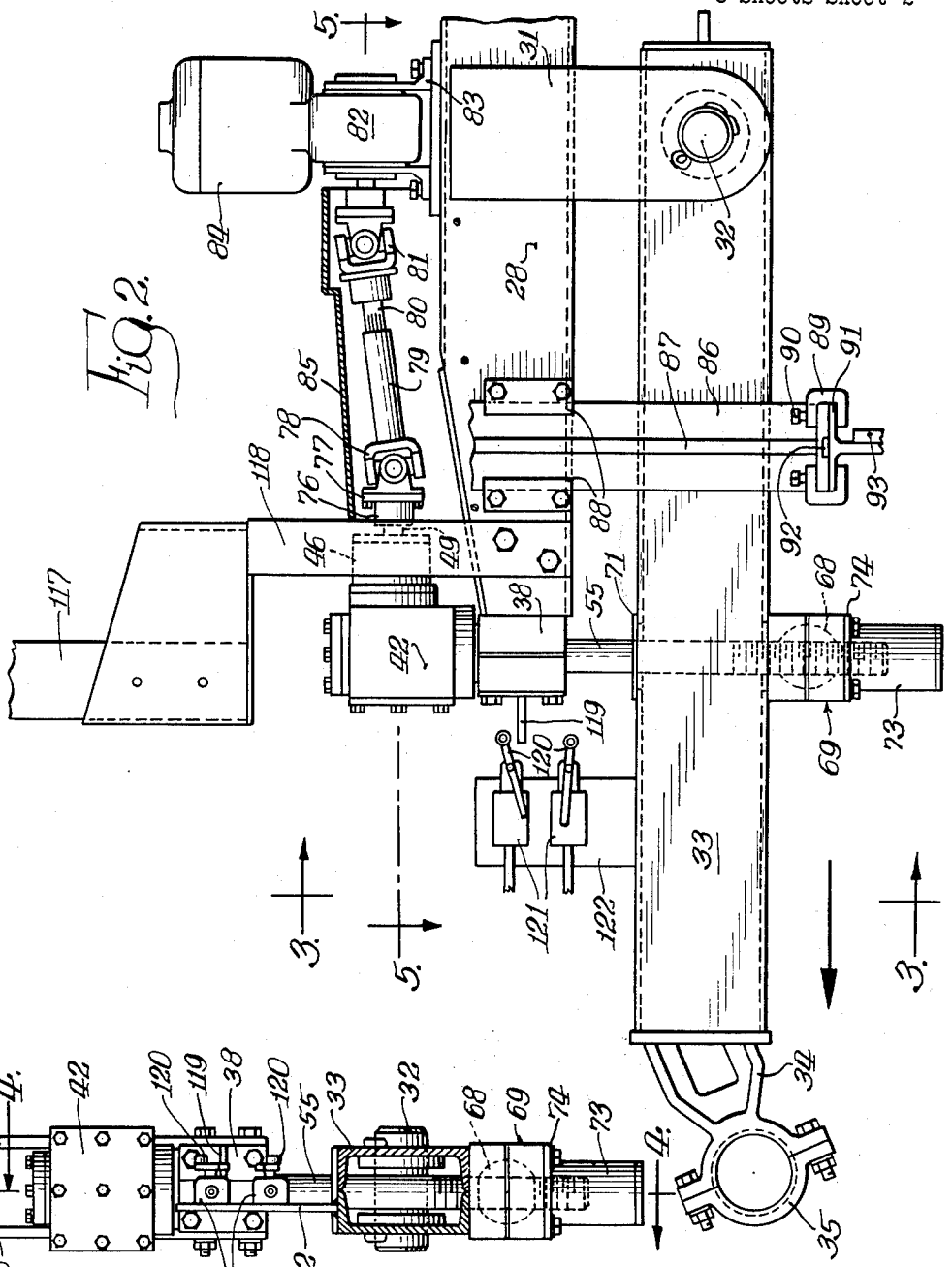


Fig. 2.

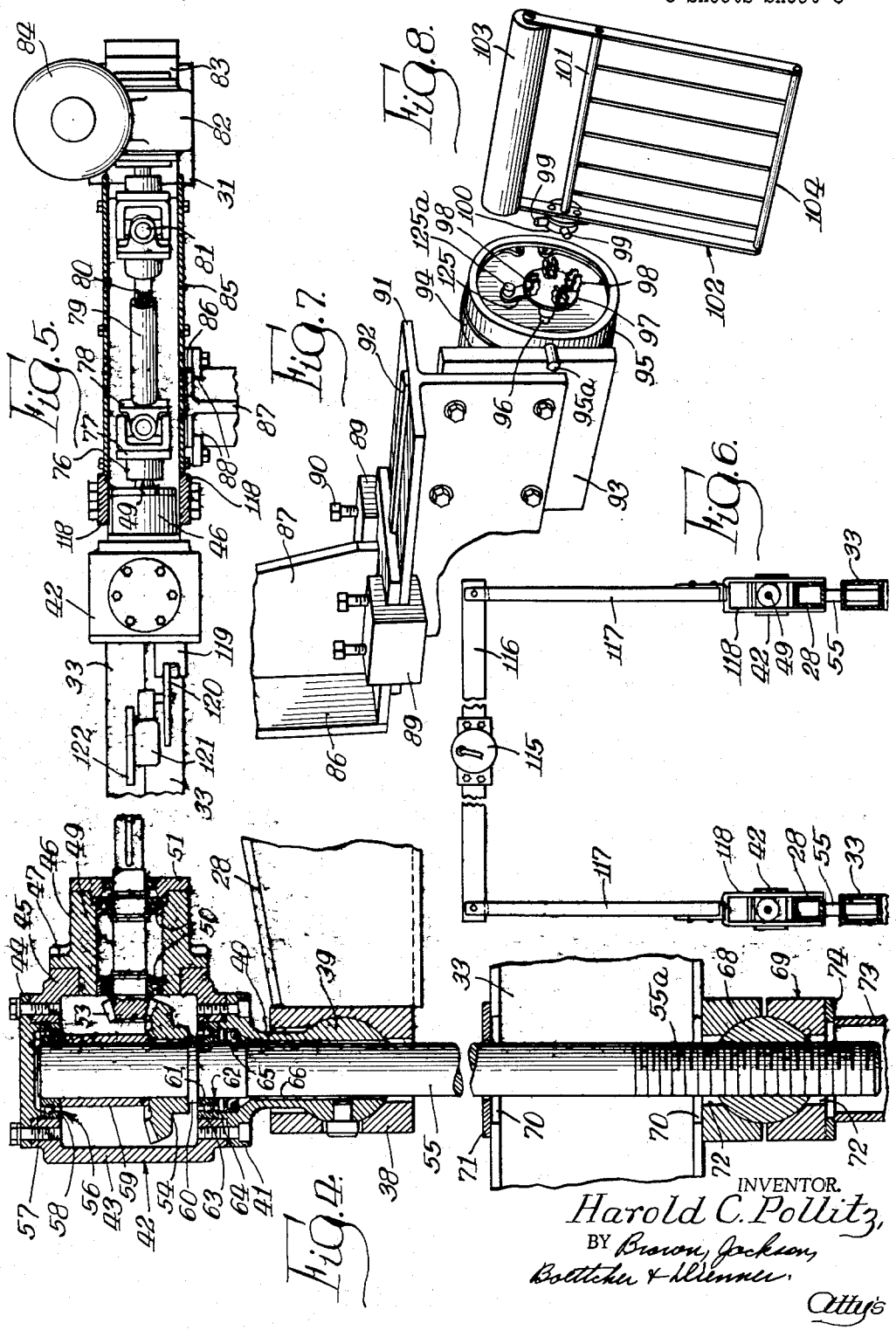
Fig. 3.

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PAVING MACHINE WITH AUTOMATICALLY CONTROLLED SCREED

Filed Dec. 8, 1961 6 Sheets-Sheet 3



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PAVING MACHINE WITH AUTOMATICALLY CONTROLLED SCREED

Filed Dec. 8, 1961 6 Sheets-Sheet 4

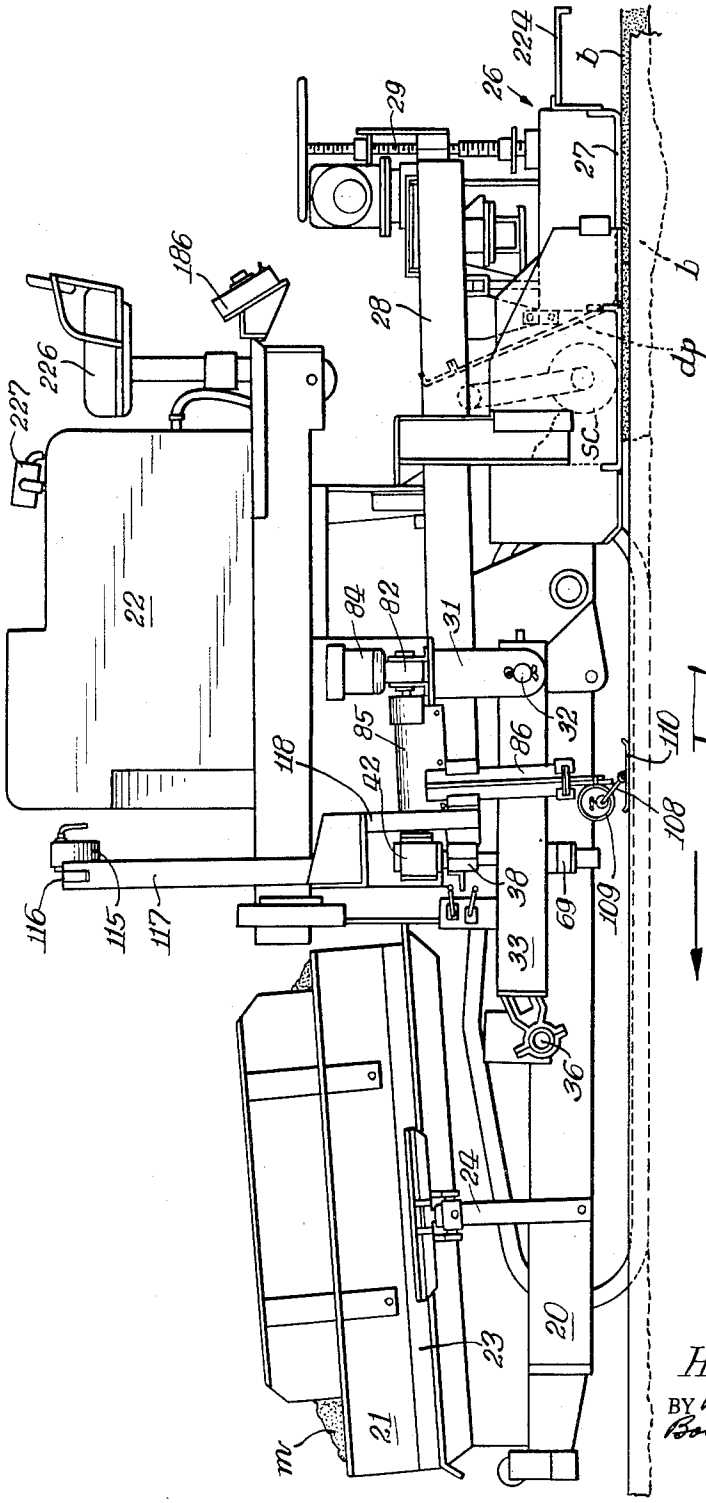


Fig. 9.

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PAVING MACHINE WITH AUTOMATICALLY CONTROLLED SCREED

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Fig. 10.

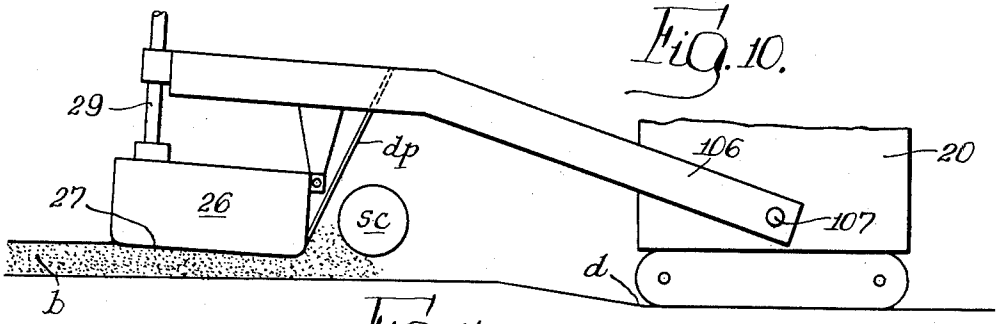


Fig. 11.

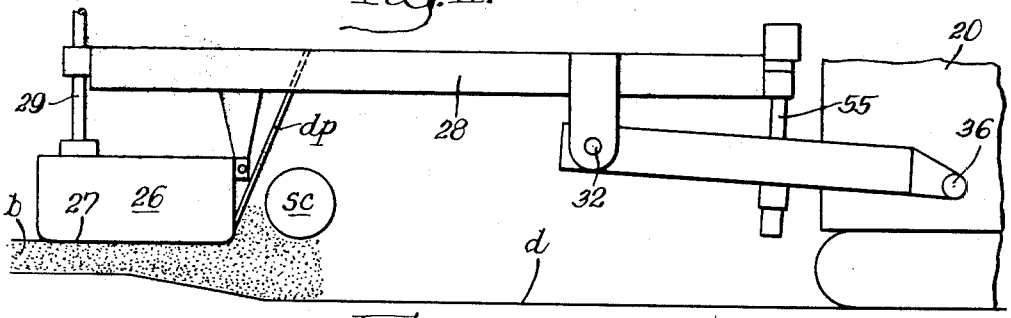


Fig. 12.

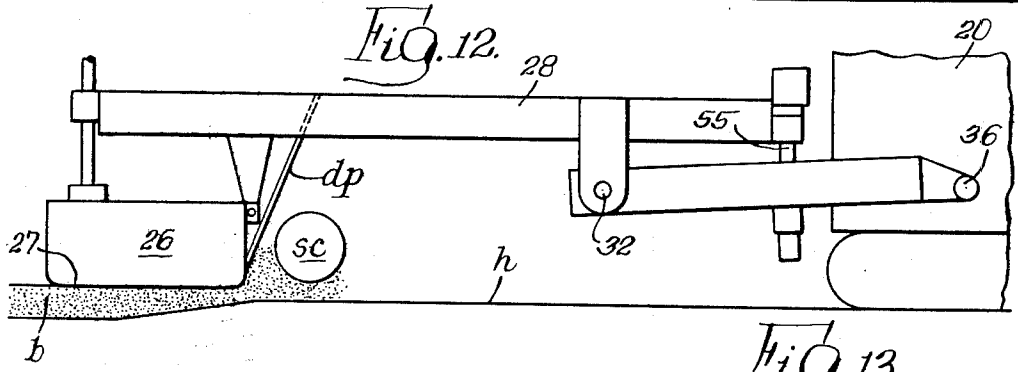
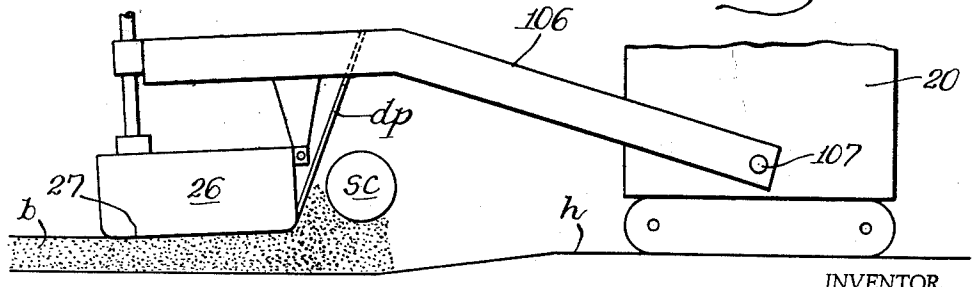


Fig. 13.



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Filed Dec. 8, 1961 6 Sheets-Sheet 6

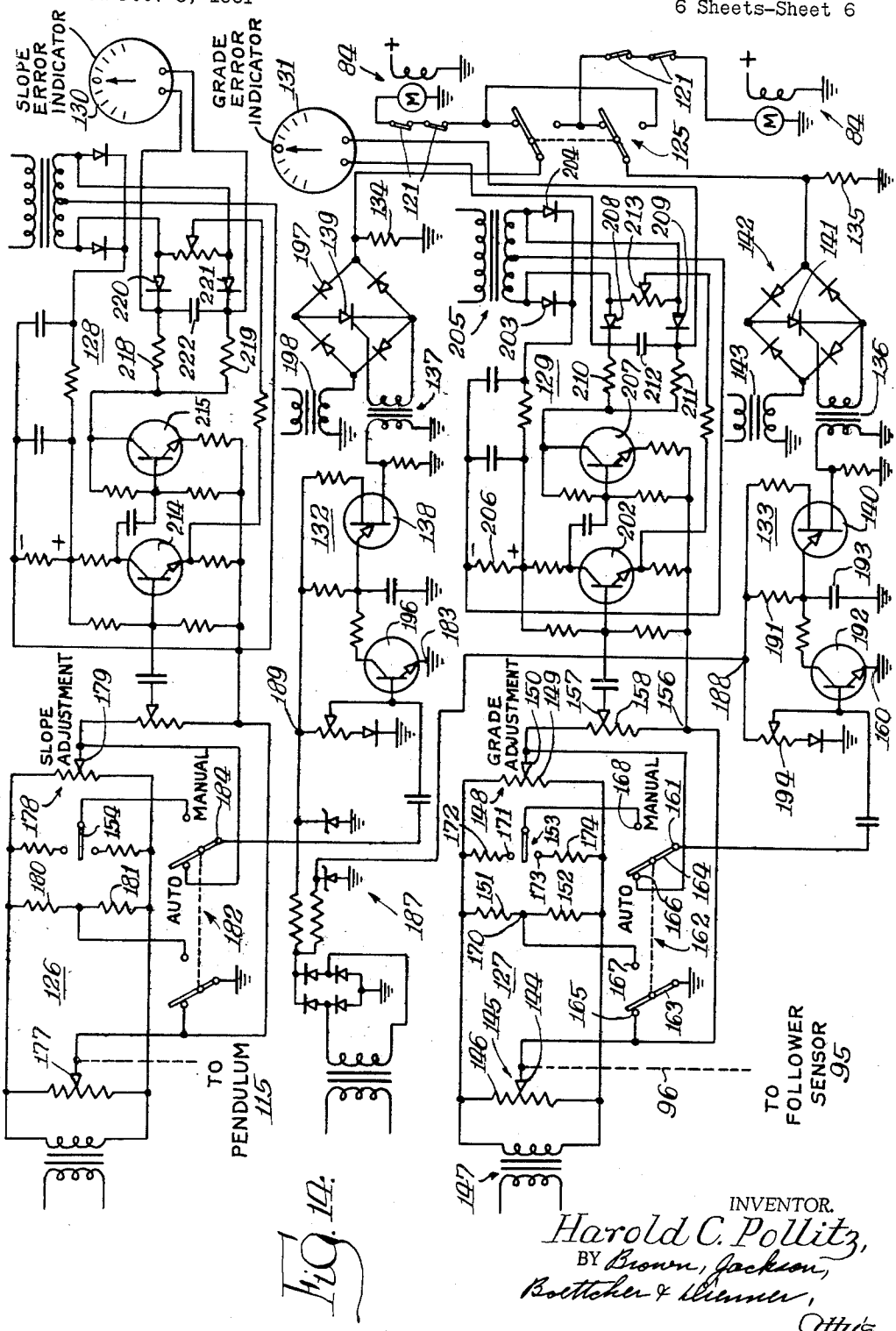


Fig. 14.

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United States Patent Office 3,111,070 Patented Nov. 19, 1963

3,111,070

PAVING MACHINE WITH AUTOMATICALLY CONTROLLED SCREED

Harold C. Pollitz, Cedar Rapids, Iowa, assignor to Iowa Manufacturing Company of Cedar Rapids Iowa, Cedar Rapids, Iowa, a corporation of Iowa

Filed Dec. 8, 1961, Ser. No. 157,959
3 Claims. (Cl. 94—46)

This invention relates to paving machines for surfacing roadways and has to do particularly with means for assuring that the material deposited upon the roadway will have a smooth surface free of objectionable hollows and humps and that the layer or mat of material laid will be of substantially desired uniform thickness.

Road surfacing machines in which the surfacing or paving material, which may be a mix of bitumin and an aggregate, for example, is spread and compacted in suitable widths or mats upon the roadway or bed during advance therealong of the machine are well known and extensively used. In many of the presently used paving machines the mix or surfacing material is dumped from trucks into a hopper from which it is delivered by a conveyor, constituting the bottom of the hopper and comprising two independently driven sections, to a screw conveyor, also comprising two independently driven sections, which spreads the mix or blacktop across the roadway in front of a screed. The spread material is then subjected to leveling and compression by the screed drawn thereover during the forward travel of the machine, the screed being carried by pull arms pivoted at their forward ends to the tractor unit of the machine. The paving material or mix is applied in a strip or mat of desired thickness, frequently three or four inches, more or less, and several such mats may be formed one upon another to give the desired thickness of the final paving. The road or base upon which the paving is laid frequently is quite uneven and may contain numerous depressions or hollows and intervening high points or humps. In the presently used paving machines referred to, in which the screed carrying pull arms are directly pivoted at their forward ends to the tractor unit, if the latter drops downward in the depressions of the base or road that causes downward and forward tipping of the screed about its rearward edge portion, with corresponding tipping of the screed plate travelling upon the surface of the mat being laid. Such tipping of the screed plate causes thinning of the mat in the depressions and also results in the screed plate following the contour of the road at the depressed areas thereof. If the tractor unit encounters an abrupt rise or hump in the road it moves upward thereby tilting the screed upward about its rearward portion with resultant thickening of the mat at the area of the hump and causing the screed plate to follow the contour of the hump. Due to the screed carrying pull arms being directly pivoted at their forward ends to the tractor unit, the mat of surfacing or paving material conforms, in general, to the uneven contour of the base or road surface over which the tractor unit passes. Succeeding strips or mats of material will conform to the first laid mat with the result that the upper surface of the completed paving will contain humps and hollows producing a more or less corrugated effect which renders driving on such surface unpleasant and tiring to the motorist. If the depressions and humps in the roadway or base are inclined or tilted transversely of the roadway, the tractor unit will tilt transversely thereby causing tilting of the screed transversely of the mat with the result that it will have low spots and high spots at the sides thereof and extending transversely of the mat. Such transversely extending low and high spots may render steering difficult, particularly on curves and if travelling

at excessive speed. After the mat or strip has been laid it is subjected to rolling so as to be compacted and assure thorough bonding of the aggregate and the binder. Such rolling of the mat does not remove the humps an hollows due to depressions and humps in the base or roadway, so that such humps and hollows persist in the finished paving, as has been demonstrated by extensive tests. The presence of humps and hollows in the completed pavement is objectionable for the reasons stated and for the further reason that the resultant paving will be subjected to constant pounding by the vehicles travelling thereover with resultant rapid deterioration of the paving.

My invention is directed to a paving machine which eliminates the difficulties encountered in the use of the presently known machines, above referred to. To that end, I provide means whereby the screed is automatically controlled in a manner effective to maintain it in its desired set or adjusted relation to the roadway and prevent it from following the contour of depressions or humps in the base or roadway upon which the mat is being laid. More particularly, I provide means whereby the screed carrying arms are automatically adjusted responsive to the tractor unit dropping into a depression or passing over a hump, so as to compensate for such downward or upward movement of the tractor unit and thereby assure that the screed remains in its proper adjusted position relative to the roadway or base. Such automatic adjusting means is also effective for compensating for transverse tilting of the tractor unit and thereby assuring that the desired setting or adjustment of the screed is maintained. Further objects and advantages of my invention will appear from the detail description.

In the drawings:

FIGURE 1 is a side view of a paving machine embodying my invention, with certain parts omitted for clearness of illustration, being used for applying a mat of material to a road surface;

FIGURE 2 is a side view, on an enlarged scale, of the pull arm and the screed arm and associated parts, at one side of the machine, the screed arm being partly broken away and certain parts being omitted for clearness of illustration;

FIGURE 3 is a sectional view taken substantially on line 3—3 of FIGURE 2;

FIGURE 4 is a sectional view, on an enlarged scale, taken substantially on line 4—4 of FIGURE 3, certain parts being shown in elevation;

FIGURE 5 is a sectional view, on an enlarged scale, taken substantially on line 5—5 of FIGURE 1;

FIGURE 6 is an elevational view, on a reduced scale, of the pendulum switch yoke and associated parts, looking forward and taken in a vertical transverse plane indicated by section line 6—6 of FIGURE 2, the tractor unit being omitted for clearness of illustration;

FIGURE 7 is a perspective outer end view, on an enlarged scale, of the sensing switch unit and associated parts, certain parts being broken away;

FIGURE 8 is a perspective inner side view of the counter-weighted sensor, on the same scale as FIGURE 7;

FIGURE 9 is a view similar to FIGURE 1 but showing the machine as used for laying a second strip or mat of paving material contiguous to a previously laid and compacted mat, with a modified form of sensor travelling upon the latter mat;

FIGURE 10 is a diagrammatic view of a paving machine of a type presently used, with the screed assembly arms pivoted directly to the tractor unit, showing the tipping of the screed plate when the tractor unit enters a depression in the base or roadway;

FIGURE 11 is a diagrammatic view similar to FIGURE 10 but showing the machine of my invention with

the screed assembly automatically adjusted to compensate for the depression in the base or roadway;

FIGURE 12 is a diagrammatic view similar to FIGURE 11 but showing the machine of my invention with the screed assembly automatically adjusted to compensate for a rise or hump in the base or roadway;

FIGURE 13 is a diagrammatic view similar to FIGURE 10 of a paving machine of a presently used type, with the screed arms pivoted directly to the tractor unit, showing the tipping of the screed plate when the tractor unit travels over a rise in the base or roadway;

FIGURE 14 is a schematic diagram of the control system whereby the screed assembly may be controlled either automatically or manually, selectively; and

FIGURE 15 is a face view of the control box of the screed arm control system.

The machine of my present invention is in general, similar to that of my Patent No. 2,914,994 for Screed Compensating and Adjusting Means, with certain exceptions which will be noted. Referring to FIGURE 1 the machine includes a tractor unit 20 and a hopper 21 carried thereby, mounted on a track laying carriage and provided with a suitable power source, such as an internal combustion engine 22, the unit as a whole being self-propelled along the road being surfaced. The hopper 21 receives the road surfacing mix *m*, which may be bitumin and an aggregate, or any suitable mix. The mix is delivered by the rearwardly travelling conveyor, previously mentioned, to the screw conveyor means which spreads the mix upon the roadway in front of the screen, to be referred to more fully presently, to which the mix is directed. The screed assembly 26 includes a flat bottom screed plate 27 of elongated rectangular or oblong shape in plan and of substantial width. The screed plate 27 bears upon the mix distributed upon the roadway and, in the travel of the machine, levels out the material to provide a mat of the desired thickness having a smooth upper surface, it being understood that the screed assembly is attached to the tractor unit, as will be explained more fully presently, so as to be drawn thereby along the roadway being surfaced or paved. Preferably, though not necessarily, the hopper 21 is provided with side wings or extensions 23 pivoted for vertical movement by means of hydraulic cylinders or jacks 24 suitably connected thereto and to the frame of the tractor unit 20. The side extensions 23 of hopper 21 normally are in their lowered position shown and may be raised at appropriate times for dumping the mix in such extensions onto the sections of the conveyor constituting the bottom of the hopper.

The screed assembly 26 is similar to that of my above identified patent and need not be described in detail. It is provided with a bottom screed plate 27, above referred to, and is adjustably mounted at its rearward portion on forwardly extending screed carrying arms 28, by means of screw shafts 29 threaded through blocks secured to the rearward ends of arms 28 and having ball connections at their lower ends to the screed, as in my above identified patent. As will be understood, the screw shafts 29 provide means for adjusting the ends of the screeds vertically, as may be required. The forward portion of the screed assembly 26 is pivoted on the screed arms 28 as usual.

Each of the screed arms 28 is suitably secured, conveniently by welding, to the upper portion of an upright 31, in the form of a substantially rectangular steel plate of adequate strength, pivoted at its lower end, at 32, to the rearward end of a pull arm 33. The pull arm 33 is provided at its forward end with a bracket 34 secured thereto, conveniently by welding and the bracket 34 is provided at its forward end with a split bearing sleeve 35 mounted on a stub shaft 36 secured to the frame of the tractor unit 20, by means of which the pullarm 33 is pivoted at its forward end to the tractor unit 20.

The upright 31 is spaced a short distance from the forward end of the screed arm 28 which, as noted, is pivoted at 32 to the rearward end of pull arm 33. A split bearing

block 38 has one section thereof suitably secured, conveniently by welding, to the forward end of screed arm 28 which, like the pull arm 33, is preferably of box form in cross section. Referring to FIGURE 4, the block 38 receives a ball member 39 of approximately spherical form having a reduced tubular neck 40 extending above block 38 and provided at its upper end with an outwardly projecting circumferential flange 41. The flange 41 is bolted to the base of a gear housing 42 which is approximately square in plan. The gear housing 42 is provided with a removable front cover plate 43 and a removable top cover plate 44, both secured to the housing 42 in a suitable manner, conveniently by bolting. The rearward wall of housing 42 is provided with a thickened collar 45 which snugly receives the reduced forward end portion of a sleeve 46 having an outwardly extending circumferential flange 47 seating on and secured to collar 45 in a suitable manner, conveniently by bolting.

A stub shaft 49 is rotatably mounted in sleeve 46 and restrained against endwise movement, by means of bearing assemblies 50 and associated parts of known type. A flanged closure cap 51 is suitably secured, conveniently by bolting, to the rearward end of sleeve 46 and is recessed for reception of a seal of conventional type about stub shaft 49. A bevel pinion 53 is secured on the inner end of stub shaft 49, conveniently formed integral therewith. The pinion 53 meshes with a bevel gear 54 of materially greater diameter than the pinion 53, keyed on an adjusting shaft 55 extending upwardly through bearing block 38 and ball member 39 and neck 40 thereof into the gear housing 42. The upper end of shaft 55 is mounted in a bearing assembly 56 of conventional type mounted in the top of gear housing 42 and restrained against upward movement by an annular rib 57 of top cover plate 44 seating against the outer race 58 of bearing assembly 56. A spacing sleeve 59, mounted about shaft 55, is confined between the inner race of bearing assembly 58 and the upper face of the body portion of the bevel gear 54, the latter being confined between the lower end of sleeve 59 and a collar 60 fixed on shaft 55, conveniently formed integral therewith. Collar 60 seats on the upper end of the inner race 61 of a bearing assembly 62 of conventional type disposed about shaft 55, and the outer race 63 of assembly 62 seats on an annular rib 64 of flange 41, which rib 64 fits snugly into the base of gear housing 42. The flange 41 receives a seal 65 of conventional type, about shaft 55 the upper portion of which, extending from flange 41 upward, is of slightly increased diameter as shown. As will be clear from the above, the bevel gear 54, which is splined on shaft 55, and shaft 55, are restrained against vertical movement in either direction. The bearing block 38 is provided with clearance about the neck 40 of ball member 39 and about the shaft, as shown, and for a purpose to be explained more fully later. A bearing bushing 66 is mounted in the ball member 39 and neck 40 thereof about the shaft 55 and suitable known means is provided for lubricating the shaft and the ball member 39.

The shaft 55 extends downward through the pull arm 33 and is threaded at its lower portion, at 55*a*, which extends through a spherical ball member 68 in threaded engagement therewith. The ball member 68 is mounted for free tilting movement in a split bearing block 69 the upper section of which is suitably secured, conveniently by welding, to the underface of arm 33 and the lower section of which is suitably secured to the upper section, conveniently by bolting, with an intervening spacing shim. The top and bottom walls of arm 33 are provided with openings 70 of substantially greater length than the diameter of shaft 55, through which openings the shaft 55 passes, and a cover plate 71, through which shaft 55 passes loosely, is slidably mounted on the upper wall of arm 33 over opening 70 therein. The bearing block 69 is provided with upper and lower clearances 72 about shaft 55 to accommodate tilting thereof, as will appear

more fully later. The lower end of shaft 55 extends into a cupped housing 73 provided at its upper end with an outwardly extending circumferential flange 74 which is suitably secured, conveniently by bolts, to the underface of bearing block 69, such bolts also securing the lower section of block 69 to the upper section thereof. The housing 73 is of sufficient depth to accommodate maximum downward travel of shaft 55 through the ball member 68, as will be understood, and shields the lower threaded end portion of shaft 55 against dust and grit encountered in the operation of the paving machine.

Referring to FIGURE 5, a collar 76 is removably secured on the rearward end of stub shaft 49 in a suitable manner, as by means of a key and a set screw. The collar 76 is provided at its rearward end with an outwardly extending annular flange 77 to which is removably secured, as by means of cap screws and nuts, one member of a universal coupling 78 of conventional type. The other member of the coupling 78 is provided with an elongated sleeve 79 which is feathered or splined on the forward portion of a shaft 80 the other end of which is connected, by a universal coupling 81, also of conventional type, to the drive shaft of a speed reducing unit 82 of conventional type. The unit 82 is mounted on a bracket 83 suitably secured, conveniently by welding, on the top of the screed arm 28 above the plate or upright 31. The speed reducer 82 is part of a unit including a reversible electric motor 84 mounted on speed reducer 82 and having driving connection thereto. As will be understood from what has been said, the screw adjusting shaft 55 may be driven in either direction by the motor 84 and is effective for adjusting the distance between the forward end of the screed arm 28 and the pull arm 33. During such adjustments, the shaft 55 will be tilted to a certain extent, such tilting movement of the shaft being accommodated by the clearances above mentioned. Also, during such adjustments, the sliding connection provided between the sleeve 79 and shaft 80 will accommodate any slight variation in the distance between the gear housing 42 and the speed reducer 82 incident to the arcuate movement of the forward end of screed arm 28 in turning about the pivot 32. The shaft 80 and associated parts preferably are protected from dust and grit by an enclosing housing or shield 85 extending thereover and bolted to the screed arm 28.

A bracket 86, of substantially L-shape and provided with a reinforcing gusset plate 87, is adjustably mounted by clamps 88 on the screed arm 28 approximately midway between the upright 31 and the adjusting screw shaft 55. The clamps 88 are bolted to arm 28 and normally are forced into clamping engagement with the side flanges of the bracket 86. By loosening the bolts the bracket 86 may be adjusted vertically to desired extent, as will be clear. The lower horizontal arm of bracket 86 extends outwardly beyond the tractor unit 20 and receives about its side flanges U-shaped clamps 89 provided in their upper arms with cap screws 90 which bear upon the flanges of the lower arm of bracket 86. The lower arms of clamps 89 extend beneath the flanges of a supporting member 91 of T-shape in cross section. The member 91 is provided at the upper face of its head with a lengthwise rib 92 which fits snugly in a corresponding groove in the underface of the lower arm of bracket 86, to assure accurate alignment of the parts. As will be understood, the clamps 89 provide, in conjunction with the cap screws 90, means for adjustably securing the supporting member 91 on the lower arm of bracket 86, which projects a material distance outwardly beyond the side of the tractor unit 20. A mounting plate 93 is bolted to the downwardly extending flange or web of mounting member 91 and has secured thereto, by straps 94, a sensing switch unit 95 to be described more fully later. The unit 95 has secured thereto a positioning and anchoring stud 95*a* engaging in a notch in plate 93 and is provided with an oscillatory shaft 96 extending outwardly therefrom and having secured on its outer end a mounting disc 97. Four spring clips 98 are secured on the outer face of disc 96 and are uniformly spaced thereabout. The clips 98 receive four pins 99 extending radially from a hub 100 of a rod 101 extending transversely of a feeler or sensor 102 of rectangular shape releasably mounted, by means of the pins 99 and the clips 98, on the outer end of the oscillatory shaft 96 of the sensing switch unit 95. The sensor 102 is provided at its upper end with a counterweight 103 extending transversely thereof and is provided at its lower end with a transversely extending rod 104. The counterweight 103 is of such value, and the transverse rod 101 is so disposed, that the sensor 102 hangs downward with the lower cross rod 104 resting lightly upon a taut guide wire or cord *c* secured to the tops of stakes driven into the roadway along side the area to be paved and extending above the roadway to a height corresponding to the desired level of the paving to be laid.

It will be understood that means is provided at each side of the tractor for mounting thereon the sensing switch unit 95. Ordinarily that unit, with the feeler or sensor 102 is mounted at one side of the machine only and the motor at that side of the machine is controlled by the one sensing switch unit, as will be explained more fully later in describing the electrical controls and circuitry. In FIGURE 1 the machine is illustrated as being used for laying a first layer or mat of paving material, such as a mix of aggregate and bitumin, commonly termed blacktop, upon a road which has been graded to approximate level but has depressions and elevations or humps which, from the practical standpoint, are unavoidable. It may be assumed, for purposes of description, that the roadway is approximately straight and horizontal and that the mat of paving to be laid is to be of a predetermined thickness and is to have a flat horizontal upper surface. At the start of the operation the screed assembly 26 is supported by blocks with the screed plate 27 spaced above the road surface. The mix is then spread upon the roadway in advance of the screed assembly, at the forward edge portion of the screed plate and to a depth sufficient to assure a mat of the desired thickness. The tractor unit 20 is then put into operation and the screed assembly is pulled off of the blocks onto the layer of mix which is leveled off by the screed plate. After the machine has advanced a short distance, it is stopped and the screed assembly is adjusted so as to dispose the screed plate 27 horizontally both transversely and lengthwise and at the proper height to produce a mat of the desired thickness, as explained more fully later. The tractor unit 20 is then again put in operation and in the continued advance of the machine along the roadway it provides a mat of the desired thickness the upper surface of which is leveled off and smoothed by the screed plate 27, the material of the mat being compacted by the screed assembly the weight of which thereafter rests upon the mat being formed. At the start of the operation the feeler or sensor 102 is positioned with rod 104 thereof resting upon the level guide or gauge cord *c*, previously referred to, and sensor 102 disposed at a downward and rearward inclination, as shown. The sensing switch unit 95 is then in its neutral or zero condition, being properly adjusted to that end. If there is a depression in the roadway, such as the depression *d* the tractor unit entering such depression will move downward relative to the screed assembly.

Referring to the diagram of FIGURE 10, if the screed assembly 26 were carried by pull arms 106 pivoted at their forward ends, at 107, directly to the frame of the tractor unit 20, as in the presently used machines above mentioned, the downward movement of the tractor unit as it entered the depression *d* would cause tilting of the screed plate 27 about its rearward edge portion, as shown, so that it wouuld follow the contour of the depression during the continued travel of the machine. That would result in a corresponding depression in the mat *b* being

laid and would also cause thinning of the mat at that area, due to the tilting of the screed plate, both of which are objectionable for reasons above stated. In the machine of my invention if the tractor unit 20 enters a depression it will move downward relative to the screed assembly. Any such downward movement of the tractor unit will cause, in effect, turning of shaft 96 of the sensing switch unit 95 in a clockwise direction, as viewed in FIGURE 1. Such turning of the shaft 96 activates motor 84 which drives the adjusting screw shaft 55 in proper direction to raise the forward end of the screed arm 28 a proper distance to compensate for the downward movement of the tractor unit in the depression. As the tractor unit 20 passes out of the depression, it rises relative to the screed assembly 26. That causes turning of shaft 96 in counterclockwise direction, in effect, thereby moving the forward end of the screed arm 28 downward to its original position and then returning the sensing switch unit 95 to its neutral or zero condition and stopping the motor 84, with the screed plate 27 in its desired position. Such adjustment of the screed arm 28 is effective for maintaining the screed plate 27 in proper relation to the roadway so that the level of the upper face of the mat *b* is maintained and the depression is filled with mix, the mat being correspondingly thickened at the area of the depression. The operation just referred to will be clear from the diagram of FIGURE 11 in which the tractor unit has entered a depression in the roadway and the forward ends of the screed arms 28 have been moved upward as above described, it being noted that the screed plate 27 remains in horizontal position spaced a proper distance above the roadway. The sensing switch unit is highly sensitive and reacts practically instantaneously to downward or upward movement of the tractor unit relative to the screed assembly so that the latter remains uneffected by depressions or abrupt rises or humps in the roadway.

Assuming that the tractor unit 20 encounters a rise or hump *h* in the roadway, it will move upward relative to the screed assembly, in passing up the near side of the rise. When that happens the shaft 96 of the sensing switch unit 95 is, in effect, turned in counterclockwise direction, as viewed in FIGURE 1, thereby activating the motor 84 and driving the screw adjusting shaft 55 in proper direction and to proper extent to cause downward movement of the forward end of the screed arm 28 to appropriate extent to compensate for the upward movement of the tractor unit 20, thereby maintaining the screed plate in proper relation to the road to assure a level upper surface of the mat being laid. That operation will be clear from the diagram of FIGURE 12, in which it will be noted that the forward end of the screed arm 28 is a less distance from the pull arm 33 than in the diagram of FIGURE 11. When the tractor unit 20 passes over the rise or hump *h* and down the far side of the rise, the shaft 96 of the sensing switch unit 95 is, in effect, turned in clockwise direction, as viewed in FIGURE 1, effective for causing upward movement of screed arm 28 and thereby returning the screed assembly to its desired position and also returning the sensing switch unit 95 to its neutral or zero condition. In either case, that is, in the case of either a depression or a hump in the roadway, the screed assembly is maintained in proper relation to the roadway to produce a mat which, in general, is of uniform desired thickness and has a level top surface, the mat being thickened at the areas of depressions in the roadway, due to the filling of such depressions and thinned at the areas of abrupt upward extensions or humps in the roadway. The diagram of FIGURE 13 illustrates the operation of a presently used paving machine, previously mentioned, in which the screed assembly is carried by pull arms 106 directly pivoted at 107 to the tractor unit 20, when the latter encounters an abrupt rise or hump in the roadway. The tractor unit 20 rises thereby raising the forward ends of the pull arms 106. That tilts the screed assembly 26 and with it the screed plate 27 upward and forward about its rearward portion, as shown. Such tilting of the screed plate 27 results in thickening of the mat and reproduces at the upper surface thereof the hump in the roadway in accentuated form.

When the screed assembly 26 has been pulled off of the supporting blocks, previously mentioned, and the machine has travelled a short distance, a final adjustment of the screed assembly 26 is made, by means of the screw shafts 29, to position the screed plate 27 in the desired proper relation to the roadway. That is necessary because the paving mix or blacktop may vary somewhat in consistency and the extent of compacting thereof under the weight of the screed assembly 26 may vary. Referring further to the diagrams of FIGURES 11 and 12, and to FIGURE 1, it will be clear that adjustment of the screed arm 28 toward and away from pull arm 33 causes turning of arm 28 about pivot 32 with a scissors-like action. The arrangement of the arms 28 and 32 to produce that operation is conductive to compactness as well as to accuracy and rapidity in effecting the compensating automatic adjustments of the screed assembly 26 and plate 27. In that connection, the adjusting screw shaft 55 is disposed midway between pivot 32 of the screed arm 28 and the pivot 36 of the pull arm 33. The forward portion of screed arm 28, extending from pivot 32 to adjusting screw 55 is of slight length compared to the portion thereof extending rearward to the screed assembly 26, the bracket 86 which supports the sensing switch unit 95 is disposed approximately midway between pivot 32 and the forward end of screed arm 28, and the lower bearing block 69 is disposed at the underside of pull arm 33. The space between arms 28 and 33 is unobstructed, ample to accommodate movement of the forward end of screed arm 28 toward pull arm 33 to the extent required under any condition of operation ordinarily encountered.

In the above description of the operation of my machine it has been assumed that the screed plate is disposed horizontally lengthwise as well as transversely, for laying a mat of blacktop the upper surface of which is horizontal. If the tractor unit of my machine encounters areas of the base or roadway which are inclined transversely, the tractor unit will tilt transversely toward the lower side of such an area. If the guide cord *c* is at the lower side, the forward end of the screed arm 28 will be raised an appropriate amount to compensate for the tilt of the tractor unit 20. The operation is the same as when the tractor unit enters a depression in the roadway. The mat will be thicker at the lower side of the slant than at the upper side, such thickening being similar to that occurring in the case of a depression at one side of the roadway but extending a greater distance transversely thereof and tapering out toward the higher side. If the guide cord *c* is at the higher side of the slant or incline the forward end of the screed arm 28 will be lowered an appropriate amount to compensate for the tilt. In such case the mat will be of the desired thickness at the lower side of the tilt in the roadway and of somewhat less thickness at the high side. In either case, the upper surface of the mat will be smooth and level and will not partake of the tilt of the base or roadway. When the tractor unit passes off of the tilted area of the base or roadway, the sensing switch unit 95 is returned to its neutral or zero condition and the screed assembly 26 and plate 27 are returned to their desired positions.

In the diagram of FIGURES 10 to 13, inclusive, the mat of blacktop is designated *b*. The screw conveyor *sc*, which receives the blacktop from the hopper conveyor, is disposed a short distance in front of a moldboard or deflector plate *dp* which extends upward and forward from the screed plate 27. The blacktop is distributed toward the sides of the machine, i.e., toward the ends of the screed plate and provides a pile of substantial depth, as is known, over which the screed plate passes in the travel of the machine. The operation is well known in the use of presently used paving machines for laying

blacktop and need not be described here in greater detail. In the above description of the operation of my machine it has been assumed that the screed plate 27 is disposed or adjusted in horizontal position both lengthwise and transversely. It may be originally adjusted in any desired position without affecting the operation as above described.

As previously explained, the blacktop paving may be of substantial thickness and is formed by disposing a plurality of layers or mats one upon the other. It is of primary importance that first laid mat have a smooth upper surface and be free of humps and hollows which, as previously noted, would, in the use of the presently known machines referred to above, be reproduced in successively laid mats and are difficult to remove even though the paving is rolled in the finishing operations. In the machine of my invention that difficulty is avoided by adjusting the screed arms to compensate for depressions, rises or humps, and transverse inclines or slants in the roadway, thereby assuring that the first laid mat has a smooth upper surface free of humps and hollows. Accordingly, the succeeding mats will be of uniform thickness and will each have a level and smooth upper surface with the result that the top surface of the completed paving will be level and smooth and free of humps and hollows, which facilitates the final rolling and finishing operations and assures a smooth driving surface.

In the preceding description of the operation of my machine it has been assumed that the screed plate is disposed horizontally lengthwise as well as transversely, as noted above. It is desirable, in certain cases, that the finished paving be inclined transversely, to a comparatively slight extent for drainage and to a greater extent for banking on turns. In such cases the screed plate is disposed or adjusted at the desired lengthwise inclination and thereafter is automatically controlled so as to maintain its desired predetermined relation to the roadway. In such operation the sensing switch unit 95 and the sensor 102 are disposed at one side of the tractor unit, usually the lower side, with the sensor resting lightly upon the level indicating or guide cord *c* as before. If a depression or dip in the roadway is encountered the forward end of the screed arm 28 is raised to compensate for the dip effective for maintaining the screed plate in proper relation to the roadway. Similarly, if a rise or hump in the roadway is encountered the forward end of the screed arm 28 is moved downward to adjust the screed assembly 26 and plate 27 to compensate for the hump, the screed arm being returned to its initial position when the tractor unit has passed beoynd the depression or the hump, as the case may be, and the sensing switch unit 95 being returned to its neutral condition, as before. If the roadway has been graded at the desired inclination or slant, the screed assembly 26 is adjusted correspondingly so that the screed plate 27 is disposed in substantially parallel spaced relation to the roadway, and the mat formed will be of uniform thickness except as to the depressions and humps occurring in the roadway. If the roadway has not been graded to the desired slant or inclination transversely, the mat will be somewhat thicker at the higher side than at the lower side, as will be understood. Likewise, on turns the mat will be of substantially uniform thickness if the roadway has been banked at the proper inclination for the turn and, if it has not been banked, the mat will be thicker at the higher side of the turn than at the lower side thereof.

A roadway to be paved may be of considerable width requiring the laying of several strips or mats of blacktop contiguous to one another to completely cover the width of the roadway. In such cases the paving machine of my invention will travel upon the roadway parallel to and adjacent a previously laid mat, as shown in FIGURE 9. The feeler or sensor 102 is then replaced by a sensor 103 comprising an L-shaped support having an upper horizontal arm attached at its inner end to the disc 97 on shaft 96 of the sensing switch unit 95, by means of the spring clips and associated pins carried by the support 109, as before. A shoe 110 is pivoted to the lower end of the downwardly extending arm of support 109 for movement about a horizontal axis extending transversely of the shoe, with the latter travelling upon a previously laid strip or mat of blacktop. The screed assembly is adjusted or set at such a height that the newly laid strip or mat will extend a predetermined distance above the previously laid mat after the latter has been rolled and compacted, to allow for compacting of the second laid strip or mat. Referring further to FIGURE 9, the previously laid mat is shown in the foreground and the second mat being laid is shown in the background and extends a short distance above the previously laid and compacted mat as and for the reasons above stated. If depressions or humps are encountered on the roadway the proper position of the screed assembly and the screed plate relative to the roadway is automatically maintained, as previously described, so that the second laid mat is of substantially uniform thickness, except as to the areas thereof overlying depressions and humps in the roadway, and extends the desired predetermined distance above the first laid mat, the adjustment of the screed assembly assuring that the upper surface of the second laid mat will be level and free of objectionable humps and hollows, as before.

The control system comprises the sensing switch unit 95, sensor 102, motors 84, a pendulum switch 115, and certain other instrumentalities and associated circuitry, to be described more fully presently in connection with FIGURE 14. Referring to FIGURE 6, the pendulum switch 115 is mounted at the midlength of a cross bar 116 pivoted at its ends in the upper ends of uprights 117. The uprights 117 are fixed at their lower ends to brackets 118 suitably secured, conveniently by bolting, to the screed arms 28 adjacent the gear housings 42. The cross bar 116 and the uprights 117 constitute a yoke which straddles the tractor unit 20, as will be understood. If the tractor unit 20 tilts transversely, or one of the screed arms 28 is higher than the other, as may be desirable under certain conditions, the cross bar 116 will be inclined accordingly and will actuate the pendulum switch 115 correspondingly, as will be explained more fully later. The bearing block 38 of each of the screed arms 28 has welded thereto a trip finger 119. The finger 119 extends between the operating arms 120 of two switches 121, of suitable known type, mounted on a plate 122 welded to, and extending upward from, the pull arm 33. The switches 121 control the corresponding motor 84 and are normally closed. When the forward end of screed arm 28 approaches the limit of its movement in either direction, the finger 119 opens the corresponding switch 121 thereby stopping the motor 84 effective for preventing overloading thereof.

Referring now to FIGURE 14, in this figure I disclose a schematic diagram of an electronic circuit by which the paving machine and thus the finished road surface may be manually or automatically controlled at the option of the operator of the paving machine. In this figure I disclose two channels, one of which is operative with the pendulum switch or sensor 115 and the other of which is operative with the follower sensor or sensing switch unit 95. The outputs of each of these channels may be selectively connected to control the D.C. reversible motors 84 under the control of manually operable switch means 125.

The basic components of the control system constitute A.C. bridge circuits 126 and 127, meter drive circuits 128 and 129 connected to indicating meters 130 and 131 respectively, and motor drive circuits 132 and 133 which provide a reversible polarity D.C. voltage across output resistors 134 and 135 respectively. As will be apparent, the output resistors 134 and 135 may be selectively connected to either of the motors 84, depending upon the position of the manual switch 125.

To avoid the switching of high magnitude motor currents, resistors 134 and 135 may be directly connected to motors 84 respectively and switch 125 may be connected to switch the control signals at the primary windings of transformers 136 and 137. For example, in one position of switch 125, when so connected, unijunction transistor 138 is connected to silicon controlled rectifier 139 and unijunction transistor 140 is connected to silicon controlled rectifier 141. The rectifier 141 constitutes a portion of a bridge rectifier 142 whose supply voltage is derived from a transformer 143 connected to the source of alternating voltage. The other position of switch 125 reverses this interconnection of the unijunction transistors and silicon controlled rectifiers. As disclosed in FIGURE 14, the output of the channel connected to the wire or cord follower, that is resistor 135, is connected to one of the control motors 84 and thus controls the height of the forward end of the corresponding screed arm 28. The output of the motor drive circuit connected to be controlled by the pendulum sensor, that is resistor 134, is connected to control the other motor 84 and thus to control the height of the forward end of the corresponding and other screed arm 28.

It is intended to not only provide switch 125 to reverse the control of motors 84 but by this means provide means whereby the wire or guide cord follower sensor or sensing switch unit 95 may be mounted on the other side of the paving machine from that shown in FIGURE 1, as shown in FIGURE 9. The follower sensor controls the motor 84 on the side the sensor is mounted by proper selection of the position of switch 125. That is effected by means of a lever 125*a* mounted on the outer end or head of unit 95 and appropriately connected to switch 125. As will be seen from FIGURES 7 and 9, the lever 125*a* is manually adjustable to either of two positions selectively, for the purpose stated.

Considering the schematic diagram of FIGURE 14 in greater detail, the lower portion of the figure will first be considered, that being the portion controlled by the follower sensor. The sensor follower or feeler 102 of FIGURE 1 is mechanically connected by shaft 96 to control the position of wiper 144 of potentiometer 145 having a resistance element 146. Potentiometer 145 constitutes a portion of the A.C. bridge circuit 127 whose input voltage is supplied by means of a transformer 147 having a primary connected to a source of alternating voltage, conveniently a generator (not shown) driven by the engine 22, as is known. This A.C. bridge circuit 127 includes a further potentiometer 148 designated a grade adjustment potentiometer having a resistance element 149 and a manually adjustable wiper 150. A.C. bridge circuit 127 also includes a pair of resistors 151 and 152 which are connected in series, the series connected resistors being connected in parallel with the resistance elements 146 and 149 of potentiometers 145 and 148 to the supply voltage for the bridge. Reference numeral 153 identifies a manual switch having a normal open position and having a pair of closed positions to which the switch may be moved and held, the switch returning to its center position upon being released.

The input of meter drive circuit 129 is connected to bridge circuit 127 at a terminal 156 and at a manually adjustable potentiometer wiper 157. The resistance element 158 cooperating with potentiometer wiper 157 has one terminal connected to the wiper 150 of the grade adjustment potentiometer 148 and the other terminal connected to the wiper 144 which is controlled by shaft 96 of the wire or cord follower sensor or sensing switch unit 95.

The input of the motor drive circuit 133 consists of a grounded terminal 160 and a further terminal 161 which is connected to the movable blade of manual switch means identified generally by means of reference numeral 162. This manual switch means 162 constitutes the automatic and manual switch of my apparatus whereby the operator of the paving machine may select automatic or manual control of the screed arms 28. Switch means 162 includes a pair of movable switch blades 163 and 164 which cooperate with stationary contacts 165 and 166 in the automatic position of the switch means and which cooperate with stationary contacts 167 and 168 in the manual position of the switch means. With switch means 162 positioned in the automatic position, as shown in FIGURE 15, input terminal 160 of the motor drive circuit 133 is connected through switch blade 163 and contact 165 to potentiometer wiper 144, the position of which is controlled by the wire follower or guide cord sensor 102 or shoe 110. The other input terminal 161 of the motor drive circuit 133 is connected by switch blade 164 and contact 166 to the wiper 150 of the grade adjustment potentiometer 148.

Should the switch means 162 be disposed in the manual position, then the input terminal 160 of motor drive circuit 133 is connected by switch blade 163 and contact 167 to a terminal 170 connected between resistors 151 and 152. Thus, the input terminal 160 of the motor drive circuit 133 is effectively connected to a fixed A.C. potential level. The input terminal 161 of motor drive circuit 133 is connected by means of switch blade 164 and contact 168 to the manual switch means 153. Thus, when the manual switch 153 is moved in an upward direction, in FIGURE 14, or to the left in FIGURE 15, a contact 171 and a resistor 172 connect terminal 161 to an A.C. potential of a first level, whereas when switch 153 is moved in a downward direction, in FIGURE 14, or to the right in FIGURE 15, to engage contact 173, input terminal 161 is connected through a resistor 174 to a second A.C. potential level. Thus, with switch 162 in the manual position switch 153 may be "pulsed" to engage either contact 171 or 173 to achieve the desired direction control of the motor 84 connected to the output 135 of motor drive circuit 133.

Thus far, the explanation of the diagram has concerned itself primarily with the description of the operation of A.C. bridge circuit 127. This description of operation can be readily applied to bridge circuit 126 wherein a potentiometer wiper 177 has its position controlled by the pendulum switch or sensor 115. A slope adjustment potentiometer 178 having a manually adjustable wiper 179 is connected to form a portion of A.C. bridge circuit 126 in much the same manner as the grade adjustment potentiometer 148 of bridge circuit 127, above described. Resistors 180 and 181 are provided, corresponding to resistors 151 and 152 of bridge circuit 127. Reference numeral 182 identifies a manual switch having an automatic and a manual position to control the input to motor drive circuit 132 at terminals 183 and 184, in much the same manner as described in connection with motor drive circuit 133. Reference number 154 identifies a manual switch having associated resistors, similar to the switch 153 and resistors 172 and 174 of circuit 127.

In normal operation of the paving machine of FIGURE 1 the operator first activates the automatic control system with the switch means 162 and 182 in the manual position. By means of manual switch 153 the screw shaft 55 at the side of the machine at which the sensor switch unit or sensor 95 is located is operated to dispose the forward end of the corresponding arm 28 at about its midpoint position. The slope adjustment potentiometer 178 is adjusted, by means of the wiper 179, to the desired slope setting, or to dispose the screed plate 27 horizontally lengthwise, as desired, and switch 182 is then set to the "Auto" position. This will result in the screw shaft 55 at the other side of the machine being driven and adjusting the forward end of the corresponding screed arm 28 to a vertical position that will maintain the cross bar 116 at the desired slope angle, or in horizontal position, as the case may be. The tractor unit 20 is then activated to start the paving operation, and the screed assembly 26 is adjusted manually to produce the desired mat thickness of bituminous material or blacktop. This final manual

adjustment of the screed assembly **26** is necessary because the bituminous material compacts under the weight of assembly **26** and this compaction varies with the mix being received from the hopper **21**. When this desired bituminous mat thickness has been achieved, the tractor unit **20** is stopped and the height of the sensing switch unit **95** is adjusted on the arm **28** such that the grade error meter **131** is at its null or zero position as shown in FIGURES 14 and 15. The grade error indicating meter **131** is then brought to the absolute null position by manual movement of the grade adjustment potentiometer wiper **150**. Switches **182** and **162** are now set to their automatic position and the tractor unit **20** moves in a forward direction to produce the mat of blacktop *b* with a finished surface at the height selected by the height datum or guide cord *c*, such surface being at the slope controlled by the slope adjustment potentiometer wiper **179**, or horizontal transversely, as desired.

In unusual situations of large slope requirements or large deviations of the existing surface (to be repaved) from the desired slope, the procedure outlined above may not be satisfactory due to limitations in the mechanical travel of the adjusting screw shafts **55**. Such a case may require initial differential setting of screed adjusting screw shafts **29** so as to keep the forward ends of the screed arms **28** reasonably close to the center of travel of the screed arm adjusting screw shafts **55** when the desired mat thickness and mat slope are achieved during initial manual operation. When this is done, the slope potentiometer **178** calibration will not correspond to mat slope. There will exist a constant offset angle that can be readily measured and the slope error indicating meter **130** offset by the required amount. Switches **162** and **182** can now be set to their automatic position and the paving operation started. Once the calibration has been obtained, the screed adjusting screws **29** should not be changed. Small variations in mat thickness can be obtained by changing the setting of the grade adjustment potentiometer **148** and slope variations obtained by changing the setting of the slope adjustment potentiometer **178**.

As the paving progresses, the operator may change the slope of the resulting roadbed, for example as the paving machine rounds a curve to be formed in the road. Furthermore, the degree of automatic control being achieved by my invention may at all times be observed by reference to the slope error indicating meter **130** and the grade error indicating meter **131**, these meters being contained within the control box **186** shown in FIGURE 15 and mounted on the tractor unit **20** as shown in FIGURE 1.

Referring now specifically to the motor drive circuit **133**, the trigger amplifier of the motor drive circuit receives its energizing voltage from a full wave rectifier, unfiltered, and clipped source **187**. As a result of this circuit, the supply voltage present at terminal **188** (and terminal **189** for motor drive circuit **132**) consists of a series of trapezoid shaped pulses, having a steep leading edge, a flat top portion, and a steep trailing edge joining the leading edge of the next pulse. Capacitor **193** charges through resistor **191** when terminal **188** is positive. Conduction of transistor **192** modifies the charging rate by means of forming a shunt path around capacitor **193**. In the absence of an input signal potentiometer **194** is adjusted to provide conduction of transistor **192** such that the voltage across capacitor **193** is not sufficient to cause firing of unijunction transistor **140** during the flat top portion of the voltage wave form at terminal **188**. As the voltage falls on the trailing edge of the wave form at **188**, the unijunction transistor **140** will fire. Thus the capacitor **193** is discharged at the end of each half cycle and therefore is "synchronized" to line frequency.

As an A.C. control signal is derived from bridge **127**, transistor **192** is rendered less conductive for a particular half cycle, depending upon the phase of this control signal. With transistor **192** less conductive, capacitor **193** now charges more rapidly (its shunt path has been at least partially removed) to the firing voltage of unijunction transistor **140**. The rate of charging of capacitor **193** depends upon the state of conduction of transistor **192**, this in turn being controlled by the magnitude of the control signal, the greater the magnitude of the control signal, the less the conduction of transistor **192**. As a result, the unijunction transistor **140** is rendered conductive during the flat portion of its supply voltage pulse. When unijunction transistor **140** fires, capacitor **193** is discharged through the primary of transformer **136**, generating a secondary pulse from transformer **136** which fires silicon controlled rectifier **141**, resulting in a D.C. voltage developed across resistor **135**. Larger magnitude control signals produce earlier firing of the silicon controlled rectifier **141** during the particular half cycle, resulting in a greater average D.C. across resistor **135**. Reversal of the phase of bridge **127** control signal causes firing of the silicon controlled rectifier **141** during the opposite half cycle resulting in a reversal of the D.C. voltage across resistor **135**. Thus, depending upon the phase and magnitude of the input voltage applied from the A.C. bridge circuit **127** to transistor **192**, unijunction transistor **140** is effective to control the conduction of silicon controlled rectifier **141** and produce a D.C. voltage of a polarity which is reversible with the phase of the A.C. signal voltage applied from bridge circuit **127** and of a magnitude corresponding to the magnitude of bridge voltage. Thus, reversible control of motor **84** is achieved.

By way of a specific example, if it is assumed that the tractor unit **20** drops into a hole which exists in the roadbed, then the forward ends of screed arms **28** tend to drop in a downward direction and the sensor switch unit **95** will be lowered. As unit **95** lowers, the feeler or sensor **102** causes turning of shaft **96** of unit **95** and the position of potentiometer wiper **144** is altered and an input signal is applied to not only the input of meter drive circuit **129** but also to the input of motor drive circuit **133**. The phase of the A.C. voltage applied to the input of motor drive circuit **133** is such as to control the conduction of silicon controlled rectifier **141** to produce a D.C. voltage across resistor **135** of a polarity which causes rotation of motor **84** to drive the screw shaft **55** in proper direction to cause upward movement of the forward end of the corresponding screed arm **28** to proper extent to compensate for the drop or downward movement of the tractor unit **20**. Further, since pendulum switch **115** is responsive to the relative positions of the screed arms **28**, the raising of the forward end of the one screed arm **28** causes tilting of the cross bar **116**. This change in attitude of cross bar **116** is sensed by pendulum switch **115** to effect a corresponding control of the other motor **84**, by means of motor drive circuit **132**, effective for raising the forward end of the corresponding screed arm **28** to proper extent to compensate for the downward movement, the operation as to both of the screed arms being substantially simultaneous. In that manner the screed assembly **26** is automatically adjusted responsive to a dip or hole which is present in the roadbed to compensate therefor and thus maintain the finished road surface at the desired level and, if desired, at the slope which has been selected by means of the slope adjustment potentiometer wiper **179**. As will be understood from the above, the sensing switch unit **95** at one side of the tractor controls the motor **84** for adjusting the screed arm **28** at that side and the pendulum switch **115** controls the motor **84** for adjusting the screed arm **28** at the other side of the tractor.

The above description has concerned itself with the motor drive circuit **133**. Motor drive circuit **132**, cooperating with A.C. bridge circuit **126**, corresponds to motor drive circuit **133** and is provided with a transistor **196** controlling a unijunction transistor **138**, the output of unijunction transistor **138** being provided at the trans-

former 137 whose secondary is connected to control the conduction of the silicon controlled rectifier 139 constituting a portion of a bridge rectifier 197 whose supply voltage is derived from a transformer 198 connected to the source of alternating voltage. Thus, as above described in connection with the sensing switch unit 95, should the tractor unit 20 tilt in a transverse direction, due to irregularities in the roadbed, this tilting of the tractor unit 20 is sensed by pendulum switch 115 to adjust the position of wiper 177 thereof. An A.C. input signal of a given phase is then applied to the input of motor drive circuit 132 to control transistor 196 and in turn to control unijunction transistor 133. Unijunction transistor 138 is effective to control the conduction of silicon controlled rectifier 139 to provide a D.C. voltage at resistor 134 having a polarity to effect operation of the proper motor 84 to restore pendulum switch 115 to its original set condition, and thus maintain the screed assembly 26 in its desired relation to the roadway or base. For example, if it is assumed that the tractor unit 20 of the paving machine tilts so as to lower the side thereof away from the guide cord *c*, pendulum switch 115 is effective to sense this resulting change in position of cross bar 116 and potentiometer wiper 177 associated with the pendulum switch 115 is moved to provide an A.C. input signal to motor drive circuit 132 to produce control of silicon controlled rectifier 139 resulting in a D.C. voltage present across resistor 134 which is of a polarity to drive the corresponding motor 84 to effect an upward movement of the forward end of the corresponding screed arm 28 and thereby restore the desired position of cross bar 116 and thus return the screed assembly to desired position.

Referring now specifically to the meter drive circuit 129 associated with the A.C. bridge circuit 127, this meter drive circuit transistor 202 derives its energizing voltage from a pair of diodes 203 and 204 connected to the secondary winding of a transformer 205 whose primary is connected to the source of alternating voltage. The D.C. voltage resulting from diodes 203 and 204 is supplied across a resistor 206, which voltage is effective to supply operating voltage to the transistor 202. This first transistor is connected in controlling relation to a second transistor 207, the second transistor receiving its supply voltage from the secondary of transformer 205 by way of a further pair of diodes 208 and 209, these diodes being connected to the collector electrode of transistor 207 through resistors 210 and 211. The output of meter drive circuit 129 consists of a capacitor 212 which is connected to the grade error meter 131, this meter being a D.C. meter of the center position null type. The A.C. signal present at input terminals 156 and 157 of meter drive circuit 129 is amplified by transistor 202 and is applied to the input electrode of transistor 207 to cause this transistor to conduct such that one half cycle of conduction is greater than the other half cycle of conduction, depending upon the polarity of the A.C. voltage present at input terminals 156 and 157. The voltages developed across resistors 210 and 211 (during the alternate half cycle above mentioned) will be of unequal magnitude, one voltage being larger than the other, corresponding to that half cycle during which transistor 207 conducts to a greater degree than it does on the other half cycle. Thus, capacitor 212 is charged as a result of the voltage differential across resistors 210 and 211 and a voltage of one polarity or another is applied to the grade error indicating meter 131, depending upon the phase of the A.C. input voltage applied at terminals 156 and 157. It of course follows that with the relative position of the sensor or feeler 102 and guide cord *c* as desired, the output of bridge circuit 127 is at a null position and likewise meter 131 is nulled to indicate that the mat of blacktop is being produced at the desired height. Potentiometer 213 provides an A.C. to signal to the electrode of transistor 202 to null the meter under the conditions of zero signal at terminals 156 and 157.

The meter drive circuit 128 associated with A.C. bridge circuit 126 corresponds to meter drive circuit 129 above described. Here again, a transistor 214 is connected to control a transistor 215. Transistor 215 in conjunction with resistors 218 and 219 and diodes 220 and 221, is effective to control the charge on a capacitor 222 which is connected to the slope error indicating meter 130, this meter being of the null reading D.C. type. In this case, so long as the mat of blacktop is being formed at the slope which has been selected by adjustment of the slope adjustment potentiometer wiper 179, the A.C. output of bridge 126 is at a null and the slope error indicating meter 130 is likewise at a null position.

The meter drive circuits 128 and 129 are at all times connected to the output of the respective briges 126 and 127 and, thus the slope error indicating meter 130 and the grade error indicating meter 131 are effective to indicate to the operator of the paving machine the degree of correlation between the resutling mat surface and that which has been selected by the slope adjustment potentiometer wiper 179 and the height datum line or cord *c*. This is true even though the switch means 162 or 182 are switched to the manual position wherein control of the height of the forward end of either or both of the screed arms 28 may be manually controlled by the manual switches 153 and 154. Thus, the paver may be manually controlled by means of switches 153 and 154 and the meters 130 and 131 may be observed by the operator to determine the degree of control which he is effecting by manual means.

In the above description the manual switch 125 is so adjusted that one of the motors 84 is connected to be controlled by motor drive circuit 133 and thus by means of the switch sensing unit 95 at that side of the tractor unit 20 while the other motor 84 is controlled by pendulum switch 115. If the switch sensing unit 95 is positioned at the other side of tractor unit 20, switch 125 is adjusted to its other position effective to reverse the control of the motors such that the other motor 84 is now controlled by unit 95 while the first motor 84 is controlled by pendulum switch 115.

The control box 186, FIGURE 15, contains the slope and grade indicating meters 130 and 131, as previously noted, and also contains the potentiometer wipers 150 and 179, and the switches 153, 154, 162 and 182. The control box 186 is suitably disposed, conveniently mounted on the tractor unit 20 so as to be readily accessible to an operator standing upon a platform 224 extending rearwardly from the screed assembly 26, as shown in FIGURE 1. Other components of the control system may be enclosed in a suitable box or housing 225 also mounted on the tractor unit 20. If desired, the control box 186 may be otherwise suitably disposed, as will be understood. The tractor unit 20 is provided with a tractor operator's seat 226 and an adjacent tractor control box or panel 227.

It will be understood that changes in detail may be resorted to without departing from the field and scope of my invention, and I intend to include all such variations, as fall within the scope of the appended claims, in this application in which the preferred form only of my invention has been disclosed.

I claim:

1. In a road surfacing machine, a tractor unit, pull arms at the sides of said unit pivoted thereto at their forward ends on an axis extending transversely of said unit, screed arms respectively pivoted to the rearward ends of said pull arms on an axis extending transversely of said unit, said screed arms extending from the pivots thereof forwardly in vertically spaced relation to said pull arms and rearwardly beyond said tractor unit, a screed assembly carried by said screed arms rearward of said tractor unit and having a screed plate adapted to rest upon and smooth and level a surfacing mix deposited upon a roadway in advance of said plate during travel there-

along of said machine, adjusting means connecting the forward ends of said screed arms to said pull arms effective for adjusting said screed arms about their pivots and thereby varying the vertical distance between the forward ends of said screed arms and said pull arms, independent reversible motors having driving connection to said adjusting means respectively, first sensing means mounted on one of said screed arms between the ends thereof, and second supplemental sensing means mounted on said screed arms, said first sensing means being responsive to rise and fall of said tractor unit incident to entry thereof upon rises and depressions in the roadway and effective for actuating the corresponding motor in proper direction and to proper extent to compensate for said rise and fall, said second sensing means being responsive to transverse tilting of said tractor unit and effective for actuating the other motor in proper direction and to proper extent to compensate for said transverse tilting, said second sensing means being effective in cooperation with said first sensing means for maintaining said screed at a desired predetermined level both transversely and longitudinally.

2. In a road surfacing machine, a tractor unit, pull arms at the sides of said unit pivoted thereto at their forward ends on an axis extending transversely of said unit, screed arms respectively pivoted to said pull arms on an axis extending transversely of said unit, said screed arms extending forwardly from the pivots thereof in vertically spaced relation to said pull arms and rearwardly beyond said tractor unit, a screed assembly carried by said screed arms rearward of said tractor unit and having a screed plate adapted to rest upon and smooth and level a surfacing mix deposited upon a roadway in advance of said plate during travel therealong of said machine, adjusting means connecting the forward end portions of said screed arms to said pull arms effective for adjusting said screed arms about their pivots and thereby varying the vertical distance between the forward end portions of said screed arms and said pull arms, independent reversible motors having driving connection to said adjusting means respectively, first sensing means mounted on one of said screed arms between the ends thereof, and second supplemental sensing means mounted on said screed arms, said first sensing means being responsive to rise and fall of said tractor unit incident to entry thereof upon rises and depressions in the roadway and effective for actuating the corresponding motor in proper direction and to proper extent to compensate for said rise and fall, said second sensing means being responsive to transverse tilting of said tractor unit and effective for actuating the other motor in proper direction and to proper extent to compensate for said transverse tilting, said second sensing means being effective in cooperation with said first sensing means for maintaining said screed at a desired predetermined level both transversely and longitudinally.

3. In a road surfacing machine, a tractor unit, pull arms at the sides of said unit pivoted thereto at their forward ends on an axis extending transversely of said unit, screed arms respectively pivoted to said pull arms on an axis extending transversely of said unit, said screed arms extending forwardly from the pivots thereof in vertically spaced relation to said pull arms and rearwardly beyond said tractor unit, a screed assembly carried by said screed arms rearward of said tractor unit and having a screed plate adapted to rest upon and smooth and level a surfacing mix deposited upon a roadway in advance of said plate during travel therealong of said machine, adjusting means connecting the forward end portions of said screed arms to said pull arms effective for adjusting said screed arms about their pivots and thereby varying the vertical distance between the forward end portions of said screed arms and said pull arms, reversible motors having driving connection to said adjusting means respectively, first sensing means mounted on one of said screed arms between the pivot thereof and the forward end of the corresponding pull arm, a yoke mounted on said screed arms between the pivots thereof and the forward ends of said pull arms and straddling said tractor unit, and second supplemental sensing means mounted on said yoke, said first sensing means being responsive to rise and fall of said tractor unit incident to entry thereof upon rises and depressions in the roadway and effective for actuating the corresponding motor in proper direction and to proper extent to compensate for said rise and fall, said second sensing means being responsive to transverse tilting of said tractor unit and effective for actuating the other motor in proper direction and to proper extent to compensate for said transverse tilting, said second sensing means being effective in cooperation with said first sensing means for maintaining said screed at a desired predetermined level both transversely and longitudinally.

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