ABSTRACT: Apparatus for continuous placement of paving material, and more particularly a paving apparatus which is readily connectable for carriage by an existing general-purpose mobile track assembly. The paving apparatus consists of a main frame supporting oppositely disposed slip-form side walls therealong and extending a series of paving material conditioning and extruding devices transversely between the slip-form sidewalks. The conditioning and extruding devices are arranged to provide most rapid and most thorough placement and finishing of the paving material; and these devices consist of an auger member for distributing paving material into feed meter apparatus which places paving material in an even volumetric disposition, this being further consolidated by internal vibrating members held within the paving material, and one or more oscillating extrusion screeds then smooths the paving material to a finished state.
SLIP FORM PAVING APPARATUS

CROSS-REFERENCE TO RELATED APPLICATIONS

The present invention is particularly related to the subject matter of the copending U.S. Pat. application, Ser. No. 446,239 filed on April 7, 1965 in the name of George W. Swisher et al., now U.S. Pat. No. 3,423,859, the application also being assigned to the present assignee.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates generally to roadway paving apparatus and, more particularly, but not by way of limitation, it relates to improved self-propelled slipform paving apparatus for use in forming dual lane pavement slab.

2. Description of the Prior Art

The prior art includes various types of paving apparatus which attempts in one form or another to place, continuously along a prepared road bed, a paving material with predetermined thickness and surface finish. The attainment of this desired end result has been somewhat elusive and the prior art attempts, while the basic slipform approach is generally employed, have dealt mainly with the types and combinations of floating finishing apparatus employed serially along the slipform apparatus. When certain of the prior art forms operated to give good paving material consistency and finish, it was generally necessary to sacrifice paving speed, and those machines attaining desirable paving speed suffered from inability to lay down a well-finished pavement of good consistency.

SUMMARY OF THE INVENTION

The present invention contemplates slipform paving apparatus of the type which is self-propelled and which employs a series of paving material conditioning and extrusion finishing devices operated in a continually moving material conditioning area as defined by the slipforms. In a more limited aspect, the invention consists of a main frame assembly which supports both the side slipforms and the series of paving laying and finishing devices; such finishing devices consist of a pavement distribution means across the leading edge of the slipform frame which serves to distribute the rough paving material evenly across the paving bed, and, thereafter, a series of vibrational consolidating and compacting means further displace the paving material into a more uniform cross-sectional bulk for still later conditioning by one or more oscillatory extrusion means which form a smoothly finished pavement. The present invention further contemplates a particular design which enables easy attachment and detachment to preexisting mobile equipment.

Therefore, it is an object of the present invention to provide a slipform paving apparatus capable of operating at relatively high speed to lay a continuously conditioned, uniform slab of pavement.

It is also an object of the invention to provide a slipform apparatus of rugged, heavy-duty structure which is readily connectable to and disconnectable from a mobile equipment.

It is a further object of the invention to provide slipform paving apparatus which employs laterally oscillating, extrusion screens which maintain positive control over paving slab thickness and crown.

It is still another object of the present invention to provide a slipform paving apparatus which is capable of more versatile usage, such as in paving off ramps and pavement entries, and enabling from the following detailed description when read in conjunction with the accompanying drawings which illustrate the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 illustrates a particular form of mobile unit which is the particular subject matter of the aforementioned copending related application;

FIG. 2 is a top view of the mobile apparatus of FIG. 1;

FIG. 3 is a side view of the FIG. 1 mobile apparatus with the slipform paving apparatus of the present invention connected thereto;

FIG. 4 is a vertical section through one side of the slipform apparatus;

FIG. 5 is a top view of the slipform apparatus;

FIG. 6 is a section taken along lines 6-6 of FIG. 5;

FIG. 7A is a section taken along lines 7-7 of FIG. 5;

FIG. 7B is a cross section of the assembly shown in FIG. 7A;

FIG. 8 is a section taken along lines 8-8 of FIG. 5;

FIG. 9 is a section taken along lines 9-9 of FIG. 5;

FIG. 10 is a section taken along lines 10-10 of FIG. 5;

FIG. 11 is a side elevation of the left side form of the paver apparatus of FIG. 5;

FIG. 12 is an enlarged rear view of the assembly of FIG. 11;

FIG. 13 is an enlarged view of a pivot assembly of the FIG. 11 apparatus;

FIG. 14 is an elevation of one form of paving depth gauge which may be employed with the invention; and

FIG. 15 is a functional block diagram of the control system which may be employed in the present invention;

FIG. 16 is a top view of a portion of the mobile apparatus of FIG. 2 including alternative structure;

FIG. 17 is a side view of a portion of the mobile apparatus showing still further alternative structure; and

FIG. 18 is a elevation of an edger device which may be employed with the invention;

FIG. 19 is a perspective view of the edger shown in operating position on a paving slab;

FIG. 20 is an end view of a slipform plate of the invention showing additional alternative structure; and

FIG. 21 is a hydraulic bar inserter which may be employed with the present invention.

DESCRIPTION OF THE INVENTION

FIGS. 1 and 2 are directed to the mobile apparatus 10 which is the particular subject matter of the aforementioned related copending patent application. The mobile apparatus 10 as is employed with specific grading and pavement bed preparation devices is specifically described and claimed in the previous application, and it is again briefly described herein as it constitutes the desirable mobile assembly for use with the slipform paving apparatus.

The mobile apparatus 10 consists of a central frame 12 having a front side 14 and a rear side 16. A pair of spaced track support members 18 and 20 extend forwardly from the front side 14 of the central frame 12. Similarly, a pair of rear track support members 22 and 24 extend rearwardly from the rear side 16 of central frame 12.

The forward track support members 18, 20, 22 and 24 are each pivotally connected to respective support posts 26 and 28 which carry respective endless track assemblies 30 and 32. In similar manner, the respective rear track support members 22 and 24 extend out into an aisle to support posts 34 and 36, each of which are pivotally secured to respective endless track assemblies 38 and 40. The support posts 26, 28, 34, and 36 located at each of the four corners of the mobile apparatus 10 actually comprise a hydraulic cylinder arrangement such that each is independently variable in length (vertical) to provide adjustment of the height and level of central frame 12 with respect to the road bed or such 42.

The track support members 18, 20, 22 and 24 are each pivotally connected to central frame 12 at a bottom point, for example, pivot points 44 and 46 (FIG. 1), and each point includes hydraulic expansion cylinders (not shown) which enable central frame 12 to be raised upward above the operating level as shown in FIG. 1. This, of course, is an important aspect of the structure of mobile assembly 10 and it is
completely disclosed in the aforementioned U.S. patent application. The facile capability to raise and lower central frame 12 with respect to the road bed 42 renders the mobile apparatus 10 easily portable as by a truck carrier or such. and it also enables rapid connection and assumption of operating attitudes with such as the slippage pavers apparatus in tow as will be further described below.

The central frame 12 consists of an operating platform 48 surrounded by safety rail 50. Also located in accessible relationship on platform 48 is a control console 52, a main power engine 54, suitable power conversion apparatus 56 and such as the hydraulic reservoir 58. A large hydraulic power system of conventional design with high capacity capability is required since the majority of individually powered components about the apparatus utilize hydraulic power. It should be understood however that various other forms of power, i.e., pneumatic, electrical, etc., may be utilized as certain specific advantages become apparent to the skilled artisan.

The steering of mobile apparatus 10 is carried out hydraulically and in synchronous relationship. A respective steering arm 60, 62, 64 and 66 is rigidly secured to each of the respective track assemblies 30, 32, 38 and 40. For example, FIG. 1 shows the right assemblies with steering arms 62 and 66 pivotally connected to respective bifurcated pivot members 68 and 70 which are again pivotally attached to the right front track 32 and the right rear track 40. Hydraulic control exerted at control console 52 then selectively displaces push rods 72, 74, 76, and 78 to guide their respective track assemblies 30, 32, 38 and 40. Actually, a double acting hydraulic cylinder (not shown) is centrally connected to effect reciprocal movement of forward push rods 72 and 74 while a rear cylinder (not shown) effects concerted movement of push rods 76 and 78. In a manner well known in the art, and as discussed in the aforementioned patent application, the respective string lines 80 and 82 provide a reference from which the hydraulic steering and level controls may be controlled to follow automatically. The sensing arms 84, 86, 88 and 90 located at the four corners of mobile apparatus 10 provide a variable control signal which continually monitors the location or level of the string lines 80 and 82 with respect to mobile apparatus 10.

The assignment of sensing functions, i.e. either level or steering, to particular corners of apparatus 10 will vary with particular applications.

Referring now to FIG. 3, the mobile apparatus 10 is shown in an operating attitude as it carries a slippage paving apparatus 100 along the road bed 42. The paving apparatus 100 consists of a central frame assembly 104. The main frame assembly 102 is secured to the underside of central frame 12 by means of four quadratically arranged securing pin connections, a pair of forward pin connections 106 and a pair of rear pin connections 108. The forward frame assembly 104 is then rigidly secured to the leading edge of main frame assembly 102 to extend forward in the same general plane. A main side form 110 and front side form 112 provide adjustable paving forms which function to form the edge on the paving slab. The front side form 112 includes a securing post 114 which may be utilized for supporting a deflector or such to maintain paving material out of the forward path of track element 32. Such precaution is conventional and similar deflecting blades or such would be employed on the opposite side to clear the forward path of track assembly 36.

FIG. 4 shows a form of the individual paving material handling and conditioning elements as they are serially arranged along paving apparatus 100. The main frame assembly 102 consists of a main frame 116 of generally rectangular shape while front frame assembly 104 is supported by the front frame 118 which is rigidly secured to the leading edge of the main frame 116. Each of the main frame 116 and the front frame 118 is a generally rectangular array of longitudinal and transverse frame members which will be further described below. The main frame 116 extends a hanger strap 120 upward for its connection to central frame 12 and connecting plate 122 by means of forward securing pin 106. Similarly, a hanger strap 124 and connecting plate 126 provide rigid rear connection of main frame 116 to central frame 12 by means of the rear securing pin 108. Forward frame 118 is maintained in position by virtue of the fact that it is rigidly secured to main frame 116 along the transverse panel 128 as will be further described below.

The forward frame 118 supports an auger assembly 130 along the leading edge, this serving to distribute rough paving material 132 evenly across the paving bed 42. Immediately after the auger assembly 130 is a primary feed meter 134 which is suspended from front frame 118 in vertically adjustable manner as will be described. A plurality of alternately positioned internal vibrator elements 136 and haffle plates 138 arranged in a transverse row contact the paving material 132 after it passes through feed meter 134. A secondary feed meter 140 is then disposed immediately to the rear of the internal vibrators 136 and this element is suspended from the forward side of main frame 116 in vertically adjustable manner.

Additional conditioning elements are arranged transversely and supported below main frame 116. Thus, a primary oscillating extrusion finisher 142 is maintained in oscillating contact with the surface of paving material 132 and a secondary oscillating extrusion finisher 144 is situated still further to the rear of main frame 116. Each of the primary and secondary extrusion finishers 142 and 144 is controllable as to the cyclical rate of the oscillatory finishing movement and they are readily controlled in positive manner as to both vertical height and crown profile. It should be understood that while two extrusion finishers 142 and 144 are shown in the exemplary form, design variations may dictate the use of one or more oscillatory extrusion finishing elements having contact areas of distinctly different dimensions.

Finally, a floating fine surface finisher 146 may be supported on the surface of paving material 132 at a rearward point. Actually, the inclusion of the fine surface finisher 146 is a matter of choice depending upon the degree of fine surface finish which it is desired to leave on the paving slab.

Referring now to FIG. 5, the main frame 116 consists of four equally spaced, longitudinal support beams 150, 152, 154 and 156 which are each securely affixed as by welding or such to each of the spaced, transverse support beams 158 and 160. An additional transverse beam, central support beam 162, is securely affixed between support beams 152 and 154 near the rear edge of main frame 116, and a pair of support blocks 164 and 166 are secured at the side of longitudinal support beams 150 and 156 in alignment with the central beam 162. Still another transverse support beam 168 extends across the rear of main frame 116 in secure affixure to each of the longitudinal beams 150—156.

The front frame 118 is similarly structured as a generally rectangular frame consisting of spaced longitudinal support beams 170, 172, 174 and 176 which are secured in alignment with each of the respective main frame support beams 150—156 along the support plate 128. In addition, a front support member 178, a right angle plate, is extended across the front of front frame 118 in secure engagement with each of the longitudinal support beams 170—176. A right angle plate 180 is welded to right angle plate 178 in the manner shown in FIG. 4 so that it extends at an acute angle to provide a supporting plate for the auger assembly 130. A pair of side support plates 182 and 184, left and right respectively, are secured along each side of front frame 118 and rigidly affixed on the ends of front support plates 178 and 180. A squeeze edging 185 formed of resilient material such as rubber may be secured along the lower edge of plate 178.

The auger assembly 130 consists of two individually controllable auger elements, a left auger 186 consisting of shaft 188 and a helical flight 190, and a right side auger element 192 which consists of a shaft 194 and an oppositely wound helical flight 196. The left auger shaft 188 is suspended for rotary movement between the left side plate 182 and a centrally-
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5 disposed bearing support 198 which may be suitably secured to the right angle plate 180 (See FIG. 4). Similarly the right angle plate 180 is supported on a bearing support 198 and the right side plate 184. Any of various conventional bearing and journal assemblies may be employed to suspend the auger elements 186 and 192 for proper rotation. Rotational drive power to the left auger element 186 is supplied from a hydraulic motor 200 operating through a selected speed reducing assembly 202 to impart rotation to the shaft 180. Similarly, the right side auger element 192 is rotated by means of a hydraulic motor (not shown), of the same type as motor 200, which operates into a speed reducing assembly 204. A commercially available motor which is suitable for use as motor 200 is a Dyna-Power Model Number 48 F 1231-50 available from the New York Air Brake Corporation and a suitable speed reducer may be a 26 to 1 ratio Funk gear reducer Model Number 27510, this element being specifically adapted for use with the Dyna-Power hydraulic motors. The speed of rotation of auger elements 186 and 192 are individually adjustable from 0 to 80 revolutions per minute from the operators console 52 (FIG. 3) as will be further described below.

20 The primary feed meter 134 is disposed closely behind and parallel to the auger assembly 130. Referring also to FIG. 4, the primary feed meter 134 consists of a transverse member extending across the front frame 118 and having a characteristic cross-sectional configuration. Thus, feed meter 134 is shaped as a generally rectangular channel structure having a sole portion 206 and an upright panel 208 which extends upward in sliding engagement with a vertical section of right angle plate 180. Adjacent plate 180 generally covers along the inner side of upright panel 210 to prevent collection of overflow flowing material. The primary feed meter 134 is supported below the front frame 118 by means of a plurality of remotely adjustable hydraulic cylinders 212, 214, 216 and 218. Each of hydraulic cylinders 212—218 is individually adjustable from the operator's console 52.

25 FIG. 6 shows the manner in which feed meter 134 is supported in vertically adjustable manner. A pair of securing blocks 232 and 234 are rigidly fastened to the outer side of support beam 170 and the hydraulic cylinder 212 is affixed thereto and held in vertical reciprocating position. Hydraulic cylinder 212 extends a piston rod 236 downward into secure threaded engagement with a securing block 238 forming a cover over the front plate 240. Adjacent plate 238 generally encloses cover along the inner side of upright panel 210 to prevent collection of overflow flowing material. The feed meter 134 is supported by a plurality of such vertically adjustable connections, e.g. four such suspensions, spaced across its transverse length. Immediately to the rear of the primary feed meter 134 is an internal vibrator compartment wherein the paving material is consolidated by a plurality of vibrators each immersed in the paving material. Each of a plurality of consolidating vibrators 136 is situated adjacent to a baffle plate 138, the alternating assembly extending transversely across the rearward part of front frame 118. A circular pipe or bar 262 extends transversely of front frame 118 in rotational affixure through the respective front support beams 170, 172, 174 and 176 and the bar 262 serves to control the immersion of the consolidating vibrators 136 and baffle plates 138 within the paving material below.

30 A plurality of right angle support braces 264 are secured to bar 262 in a relatively uniformly spaced manner therealong and each of these serves to support one of a plurality of internal vibrator units 266 (see also FIG. 4). A bracket 268 is secured to a transverse portion of support brace 264 and this bracket 268, in turn, extends a downward and forwardly curved support strap 270 (FIG. 4) which serves to secure and to guide a power cable 272 and its associated internal vibrator unit 266. Each of the internal vibrator units 266 is a commercially available electrical vibrator such as, for example, a commercially available types of consolidating vibrator. The baffle plates 138 may be similarly suspended from each of a plurality of securing bars 274 which are also rigidly fastened at uniformly spaced points across between center bearing support 198 and the right side plate 184. Any of various conventional bearing and journal assemblies may be employed to suspend the auger elements 186 and 192 for proper rotation.

35 A hydraulic cylinder 278 is pivotally secured to a bracket 270 on transverse support beam 158 to extend a piston rod 280 into pivotal affixure to a lever 282 which is secured to extend vertically from the vibrator support bar 262. The hydraulic cylinder 278 is then controllable from the operating position (console 52) to retract piston rod 280 thereby raising internal vibrators 136 and baffle plates 138 up out of the paving material. This facet of the operation becomes extremely important in the paving of off-ramps, bridge floors, etc. as will be further described below.

The secondary feed meter 140, as shown in greater detail in FIG. 7A, consists of a channel member 284 which is formed to have a sole plate 286, a leading edge bevel portion 287 and an upright plate 288. A cover panel 289 is secured across the top of channel member 284 to close off the interior and prevent accumulation of foreign material. The feed meter 140 is adjustably supported by plural hydraulic cylinders 290, 292, 294 and 296, similar in mounting and function to hydraulic cylinders 212—218 supporting primary feed meter 134. As shown in FIG. 7A, the hydraulic cylinders such as cylinder 290 are supported from frame blocks 291 to extend a piston rod 292 downward into threaded connection with block 293 formed integral with collar bearing 294. The channel member 284 is then hung by means of a pin 294 secured through collar bearing 294, also containing a resilient collar packing 296, between a generally U-shaped hanger member 297 welded within the fold of channel member 284. As shown in FIG. 7B, the resilient packing insert 296 may be formed from rubber or similar material and it may be formed of a predetermined resilience quotient to effect a desired vibrational action. Thus, the secondary feed meter 140 is vibrated generally vertically by means of a plurality of vibrators 298 which are suitably secured as by a bracket member 300 to a rib plate 301 welded to the inside surface of sole plate 286. There may be a selected plurality of the rib plates placed across sole plate 286 to provide fastening points for an equal number of vibrators 298. The vibrators 298 may be selected from various commercially available types, e.g. a suitable, pneumatically powered vibratory shaker.

The primary and secondary extrusion finishers 142 and 144 provide oscillatory scribing and extrusion of the pavement surface by means of respective scrub members 302 and 304. Each of the scrub members 302 and 304 is a hollow, steel tube member having uniform cross section similar to that shown in FIG. 4. Thus scrub members 302 and 304 may be formed by conventional bending and welding techniques so that they will have all of the desirable characteristics, e.g. a flat sole and rounded leading edge. A pair of adjustable end plate assemblies 306 and 308 are pivotally secured on opposite ends of scrub member 302 while similar end plate assemblies 310 and 312 are affixed on each end of scrub member 304. The end plate assemblies 306—312 serve to allow a built up edge to be left on the paving slab so that natural slump is allowed for and settling leaves a near perfect right-angle edge.

The scrub members 302 and 304 are maintained below and unattached to the longitudinal support beams 150—156, their suspension being effected through vertically adjustable affixure to each of a plurality of longitudinally extending shafts 314, 316, 318 and 320. The outer shaft 314 (left side) is secured for rotation by end bushings 322 and 324 affixed to respective transverse frame beam 158 and block 164 and a central guide bushing 326 is secured to transverse beam 160. The opposite outer shaft (right side) 320 is secured in like manner between end bushings 328 and 330 and a central guide bushing 332. The central shafts 316 and 318 are similarly suspended from respective frame beams 158, 160 and 162 by means of forward guide bushings 334 and 336.
rear guide bushings 338 and 340 and a pair of center guide bushings 338 and 342. The supporting connection between screen members 302 and 304 and shaft 320 (right side) is made through respective eccentric assemblies 346 and 348. Eccentric assembly 346 includes a pair of parallel, transverse sleeves 350 and 352 including bushing inserts (not shown) which are slidably held on a pair of transverse eccentric shafts 354 and 356. The parallel eccentric shafts 354 and 356 are rigidly held between a pair of end plates 354 and 356 which are securely fastened to the upper surface of screen member 302. A pair of neoprene boots 362 and 364 are positioned to cover the outer ends of shafts 354 and 356 to prevent dust and other foreign material from interfacing with the slidable disposition of eccentric assembly 346. The eccentric assembly 348 is connected in identical manner to the screen member 304, i.e., by means of sleeves 366 and 368, eccentric shafts 370 and 372, and securing end plates 374 and 376 secured on the upper panel of screen member 304. The opposite or left side shaft 314 is similarly connected to support the screen members 302 and 304 through eccentric assemblies 378 and 380. The eccentrics 378 and 380 are movably connected to screen members 302 and 304 in the same manner as the right side eccentric assemblies 346 and 348. Thus, eccentric assembly 378 includes a pair of parallel transverse sleeves 382 and 384 which are slidable along eccentric shafts 386 and 388 secured on the upper panel of screen member 302. Again similarly, eccentric assembly 380 and sleeves 390 and 392 are reciprocally slidable on eccentric shafts 394 and 396. Once again, a plurality of neoprene boots 390 may be secured to cover the exposed portions of each of shafts 390 and 396.

Four more center eccentric assemblies 400, 402, 404 and 406, while differing in essential elements as will be further described below, are connected for reciprocal movement along the upper surfaces of screen members 302 and 304 in a manner similar to that previously described. The eccentric assembly 400 supports right center shaft 318 and includes sleeves 408 and 410 which are reciprocally slidable upon parallel eccentric shafts 412 and 414, and the eccentric assembly 402 is connected to its respective screen member 304 by means of sleeves 416 and 418 and eccentric shafts 420 and 422. Left center shaft 316 is supplied with the same linkage through eccentric assemblies 404 and 406, eccentric assembly 404 connects to eccentric assembly 402. Eccentric assembly 406 moves through sleeves 432 and 434 and eccentric shafts 436 and 438. Additional neoprene shaft protective boots are employed as needed.

Each of the individual eccentric assemblies is remotely adjustable through hydraulic control of an adjusting lever. Thus, with respect to right side eccentric assembly 346, a hydraulic cylinder 440 is connected from a pivot connection at a support plate 442 welded to frame 150 to extend a piston rod 444 into pivotal connection with a control lever 446. The sectional view of FIG. 8 shows the eccentric control mechanism to better advantage. The eccentric assembly 346 consists of an outer cylinder 448 which is welded or otherwise secured to the transverse sleeves 350 and 352 (See also FIG. 5). The control lever 446 is formed as a rigid extension of an inner member 450 which is rotatable within a cylindrical frame 448 and relative to or about the shaft 320. Thus, it can be seen that with shaft 320 held securely by the main frame 116, clockwise rotation of lever 446 will result in clockwise rotation of cylinder 448 to move sleeves 350 and 352 and, therefore, screen member 302 to a lower level with respect to shaft 320. Alternatively, counterclockwise movement of control lever 446 will tend to raise the level of reciprocal suspension sleeves 350 and 352 and thus screen member 302. The eccentric shafts 354 and 356 (FIG. 5) provide forward reverse pitch angle adjustment of screen member 302.

FIG. 8 also shows the end plate structure to better advantage. End plate 308 is comprised essentially of a lower or screeding surface 452 and an upright plate 454, the assembly being pivotally secured to the end of screen member 302 by a suitable securing pin 456. A bolt 458 or other such fastener may then be employed to fasten a stud 460 to a suitable post 462 or such which may be secured on the upper surface of screen member 302.

The rearward right side eccentric assembly 348 is controlled in an identical manner by means of a hydraulic cylinder 464, piston rod 466 and control lever 468. On the other side of the main frame 116, the left side eccentric assembly 378 and 380 are similarly controlled, all of the hydraulic controls being accessible and individually adjustable from the operator's position atop central frame 12. Thus, a hydraulic cylinder 470 is secured to a post 472 welded to frame beam 158 such that a piston rod 474 extends into contact with a control lever 476. Sideways movement of lever 476 introduces adjustment to the frontside eccentric assembly 378. As for the rearward eccentric assembly 380, the similar arrangement of hydraulic cylinder 478, piston rod 480 and control lever 482 provides the adjustment function. The eccentric shaft pair 386 and 388 and pair 394 and 396 provide pitch angle adjustment for left sides of respective screen members 302 and 304.

FIG. 9 shows the linkage for adjustment of the center eccentric assemblies 400-406. Thus, the front eccentric assembly 400 and 404 are connected for ganged adjustment by means of control levers 484 and 486 tied together by a cross linkage 488. The cross linkage 488 is then pivotally connected to a piston rod 490 and hydraulic cylinder 492 which is secured to the main longitudinal beam 152. Left center eccentric assembly 404 consists of an outer sleeve or cylinder 494 and a first cylindrical insert 496 which is rigidly secured to the control lever 496. Thus, movement of control lever 486 rotates first insert 496 with cylinder 494 following to provide vertical adjustment to the sleeves 424 and 426 and the suspended screen member 302. Eccentric assembly 400, consisting of cylinder 498 and first insert 500, carries out the same function in unison due to the cross linkage 488 and its control lever 484. Rotation of eccentric shafts 412 relative to 414 and 428 relative to 430, etc. provide pitch angle adjustment at the center of screen members 302 and 304.

The center eccentric assemblies 400 and 404 also provide a uniform vertical adjustment by rotation of shafts 316 and 318 relative to the remainder of the eccentric assemblies 404 and 400. The shafts 316 and 318 are actually formed as cam shafts extending respectively 502 and 504 into rotatable contact within the respective holes 506 and 508 in first inserts 496 and 500. Rotation of the shafts 316 and 318 will then effect a further degree of eccentric movement of both eccentric assemblies 400 and 404 in unison to alter the operating position or levels of screen members 302 and 304. As shown in FIG. 10, the adjustment or rotation of shafts 316 and 318 is effected by another independently controllable hydraulic cylinder 510, piston rod 512 and a cross linkage 514. The cross linkage 514 is then pivotally connected to each of control levers 516 and 518 which are suitably clamped about respective shafts 316 and 318.

The rearward center eccentric assemblies 402 and 406 may be individually controlled in the same manner as depicted in FIG. 9 by a hydraulic cylinder 520 and piston rod 522 operating through a cross linkage 524. The cross linkage 524 is then connected to manipulate respective control levers 526 and 528 at eccentric assemblies 402 and 406.

The oscillatory power is applied to screen members 302 and 304 through the respective connecting plates 530 and 532 which are welded or otherwise affixed along the rear edge of screen members 302 and 304. The connecting plates 530 and 532 are each pivotally connected to a respective connecting rod 534 and 536, each of which receives reciprocal drive from a cam shaft 538. The cam shaft 538 is connected to be driven from a speed reducer 540 and hydraulic motor 542. Motor 542 and reducer 540 may be similar to the motor 200 and speed reducers 202 and 204 which drive auger assembly 130, rotational output and control also being similar. A pair of sup-
port bushings 544 and 546 serve to support the cam shaft 538 outboard from the longitudinal beam 152 of main frame 116. It can be noted too that cam shaft 538 is formed such that its reciprocal drive applied to connecting rods 534 and 536 is in a 180° phase relationship. The main frame 116 includes side forms 550 and 552 which are laterally adjustable, this providing a great advantage in certain production operations as will be further described. The right side form 550 is supported by a plurality of hydraulically adjustable connections. Thus, supporting rods 554 and 556 secured at right angles to side form 550 extend through respective frame guide ways 558 and 560 into pivotal connection with piston rods 562 and 564 of hydraulic cylinders 566 and 568. The hydraulic cylinders 566 and 568 are each pivotally connected to transverse frame beams 158 and 160, respectively. The rear side of side form 550 may be similarly adjustably connected as by a support rod 570 and hydraulic cylinder 572 (shown in dash lines). In a similar manner, the left side form 552 is laterally adjustable by means of respective support rods 574 and 576 connected to hydraulic cylinder assembles 578 and 580, and the rearward support control may be effected through a support rod 582 and hydraulic cylinder 584.

FIG. 11 illustrates the left side form 552 as it is supported rearward of left side plate 182. Side form 552 consists of a front panel 586, a midpoint 588 and a rear panel 590 as joined by a side beam 592 welded across the top edges. This configuration establishes access openings 594 and 596 adjacent positions of respective screwed members 302 and 304 and their panel assemblies 506 and 510. A slippor 598 is then pivotally affixed along the lower edge of both of side plate 182 and side form 552 by spaced pivot connectors 600 and pivot assembles 602. Each of pivot connectors 600 and pivot assembles 602 are rotatably received with hinge pivots 604 spaced along slipporm 598 and the mating hinge pivots 606 placed on side plate 182 and side form 552.

The pivot assemblies 602 provide a connection by which the slipporm 598 can be completely raised up through retraction of the hydraulic cylinders 604, 606 and 608 and respective pistons 610, 612 and 614. Each of the hydraulic cylinders 604, 606 and 608 is pivotally supported by a respective bracket 616, 618 and 620 secured to extend upward from side plate 182 and utilized at properly spaced points. FIG. 12 shows the structure more clearly with respect to the upper edge of rear panel 590 to support rear hydraulic cylinder 608 and piston rod 614 therefrom. Piston rod 614 is pivotally secured at pivot tab 622 of pivot assembly 602. The pivot assembly 602 is pivotally secured in hinge pivots 624 secured as by welding to the upper part of slipporm 598, and the pivot assembly 602 extends a hydraulic cylinder 626 pivotally engaged with hinge pivot tabs 628 welded on the lower portion of the panels of side form 598 and side plate 182.

Referring also to FIG. 13, the pivot assembly 602 is formed in such manner as to provide plural adjustments as to the batter and lift angle of slipporm 598. The pivot assembly 602 consists primarily of a lever piece 630 which is formed with outer pivot tab 622 and lever arm 626 as well as a tab side 632. An adjusting screw 634 is inserted through tab 632 into threaded engagement with an adjusting lever 636 which is also pivotally secured within hinge pivots 624 as retained by a pivot pin 638. The adjusting lever 636 also extends downward to hold an adjustment screw 640 in contact with slipporm 598. Another locating screw 642 is threaded through lever 636 for secure abutment against a flange 642 formed along the top edge of slipporm 598. Slipporm 598 is shown with a channel 644 which is utilized for specialized operation as will be further described below. For normal or regular operation, the channel 644 can be filled by insertion of a half-round rod 646 and secure fastening as by a plurality of screws 648 or such other equivalent means. A rub rail 650 may be bolted along the bottom edge of slipporm 598.

Referring again to FIGS. 11 and 12, a pair of limit adjustments 652 and 654 are provided to set the minimum width between side forms. The limit adjustments 652 and 654 (and similar units on the right side) each consist of a square tube or channel member 656 having a threaded end cap 658 secured thereon. A manipulatable screw handle 660 then moves along screw 662 which provides a limit stop relative to the main frame assembly. Thus, the hydraulic cylinders 578, 580 and 584 (FIG. 5) are actuated to move side form 552 laterally subject to interior stops set by limit adjustments 652 and 654. The similar operation and adjustment would also apply to the right side of moving apparatus 100. Also, while not specifically detailed, the slipporm lifting hydraulics and pivot connection on the right side (FIG. 5) would be identical to the left side equipment shown in FIG. 11.

The fine surface finisher 146 (FIG. 4) may be attached to the rear end of frame 116. For example, fine surface finisher 146 may be dragged as supported by plural support arms 670 pivotally attached at a selected point to the main frame 116. The manner of connection needs only to insure that finisher 146 can be trailed in smooth manner along the paved slab.

As shown in FIG. 5, each of the transverse members is formed with a characteristic center joint structure due to their length. Such a slipporm paver capable of operating along a two-lane road bed has a width in the order of 14 feet and such a length becomes unwieldy with respect to part fabrication and handling as the assembly of the paver units. Thus, each transverse member such as, for example, screwed members 302 and 304, transverse beams 158, 160 and 168, and others of the long members are formed as two piece units having a flanged center joint. This is also an advantage in manufacturing and assembly since certain contemplated applications will require singlelane slipporm paver apparatus, and such machinery is easily assembled out of the similar components while requiring only those changes which are apparent to the skilled artisan.

The pavior apparatus 100 is readily adaptable for change to various widths. This is desirable since popular or standard pavement specifications may require any of several widths, e.g. 22 feet, 24 feet, 26 feet, 27 feet and 36 feet. The pavior apparatus 100 may be separated either along center line 672 or along each outer separation line 674 and 676 to insert spaced spacer elements into the various transverse members and thereby adjust the overall apparatus to a specified width. For example, the FIG. 5 showing includes width extensions 187 and 188 in each side and extends a forward guide way 189 and 194, and similar extension members 682 and 684 are inserted in respective sides of the transverse framing panel 128.

As taught in the aforementioned U.S. patent application Ser. No. 446,239, the mobile assembly 10 (FIG. 2) may be automatically controlled as to fill and extend a hydraulic cylinder having its forward and rear edges rolled or bent to form a forward guide way 694 and a rear edge way 696. A forward bar 700 of the mobile assembly 10 is extended to form a guide way 694 and a rear edge way 696. A forward bar
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698 and rear bar 700 are slidably retained within guide ways 694 and 696 and each of bars 698 and 700 is pivotally affixed to opposite ends of a balanced linkage 702. The balanced linkage 702 is a generally triangular member having a lower or upper point pivotally connected to a carriage member 704 which supports rotatably a front sensing wheel 706 and a rear sensing wheel 708.

An upper, bisecting point 710 of triangular linkage 702 provides pivotal connection to a pivot eye 712 and connecting rod 714 which is adjustably connected for reciprocal movement with a suitable control assembly 716. The control assembly 716 serves to generate an electrical signal in response to reciprocal movement of connecting rod 714, the electrical signal being conducted via a cable 718 to the appropriate control equipment. The particular configuration of the widespread sensing wheels 706 and 708, and pivotal interconnection through triangular linkage 702 to connecting rod 714, allows a continual average depth indication to be delivered to the sensing assembly 716. One form of sensing assembly 716 which may be employed is an electrical switching assembly which is particular subject matter of U.S. patent application Ser. No. 683,256 entitled “Line Tracer Control Device” filed on Nov. 15, 1967 in the name of Steele et al and assigned to the present assignee. This same type of sensing apparatus is also suitable for use in sensing the string lines 80 and 82 (as shown in FIG. 2) to derive either steering or vertical level indications.

FIG. 12 depicts the various control elements of the slipform paving apparatus 100 as it is carried by mobile assembly 10. Primary power is supplied by the engine 54 mounted on main frame 12 of mobile assembly 10. Primary power output is then available as shown via lines 720 to energize a pneumatic power supply 722, a hydraulic power supply 724, and an electrical power supply 726. Control of each of engine 54, pneumatic power supply 722, hydraulic power supply 724 and electrical power supply 726 is effected via lines 728 and 730 actuated at control panel 732 (located on control console 52 of FIG. 2).

The pneumatic power supply 722 may be employed to energize metering vibrators 734, the plurality of vibrators 220, 222, 224, 226 and 298 (plurals) along the primary feed meter 134 and the secondary feed meter 138. This is actually a matter for selection since the feed meter vibrators 734 may be energized by means other than a pneumatic source. The plurality of internal vibrators 136, plural vibrator elements 266 (FIG. 4) may be controlled variably from an electrical control panel 732 via line 736 designating an array of parallel electrical cables.

The remainder of the slipform functions are controlled by the hydraulic power supply 724 and each of the functions is individually controllable from the control panel 732. Thus, a first output via line 738 is applied to control the direction and speed of rotation between 0 and about 8 r.p.m. of each of the left auger 186 and right auger 192, this function being denoted as a block 740. A control outlet 742 is supplied to adjust the metering levels function 744, the individual adjustment of each of the hydraulic cylinders 212-218 and 290-296 (FIG. 5) which set the levels of the primary feed meter 134 and the secondary feed meter 140. The hydraulic control line 746 controls the slipform lateral adjustment 748 and this consists of adjusting the left side hydraulic cylinders 578 and 580 and the right side hydraulic cylinders 566 and 568 so that the respective left side form 552 and right side form 550 are adjusted in their proper lateral position. This adjustment becomes especially attractive since it allows straight takeoff from a lighter portion when restarting paving operations after a work discontinuity.

The control of line 750 to internal vibrators 752 provides the function of operating hydraulic cylinder 276 to move lever 282 such that support bar 262 is rotated to move internal vibrators 136 and baffle plates 138 into and out of the mass of paving material therebelow. Control line 754 may provide adjustable control of screed oscillation function 756, i.e. control through speed reducer 542 and hydraulic motor 540 to impart lateral oscillatory movement to screed members 302 and 304. The level and crowning control of screeding is effected via control line 758 which adjusts screeding level left 760, screeding level center 762 and right 764. The control of the screed positioning control 766 which sets the general or rough level of both of screed members 302 and 304 relative to the main frame.

In terms of specific structure, screeding level 760 refers to the adjustment of hydraulic cylinders 470 and 478 to set individually the respective left eccentric assemblies 378 and 380 while screeding level right 764 performs the same function with hydraulic cylinders 440 and 464 controlling right eccentric assemblies 346 and 348. The screeding level center 762 is a function attributed to adjustment of individual hydraulic cylinders 492 and 520 to adjust respective ganged eccentric assemblies, right 400 and 402, and left 404 and 406. The screed positioning control 766 is effected by adjustment of hydraulic cylinder 510 which adjusts the rotation of the duplex cam shafts 316 and 318, the linkage shown more clearly in FIG. 10. The transverse resilience of feed meters 134 and 140 is designed such that individual control of the respective metering level adjustments 744, hydraulic cylinders 212-218 and 290-296, will allow a properly crowned under surface in contact with the paving material. Similarly, the type of structure employed in forming screed members 302 and 304 will allow shaping of the respective sole surfaces to allow the desired crown profile. Adjustment of center shafts 316 and 318 will generally provide primary control over the crown profile shaping.

OPERATION

A suitable roadway may be prepared and leveled with proper base material by means of a well-known form of automatic grade preparing device which, in one form, is described in the aforementioned U.S. patent application Ser. No. 446,239, and it may also utilize the same mobile assembly 10 of FIGS. 1 and 2. Thus, after preparation of the road bed, the mobile assembly 10 is capable of dropping off the various units of grading equipment, e.g., cutters, moldboards and auger elements, whereupon it may then move over the slipform apparatus 100 whereon it is connected to means for connecting pins, front pins 106 and rear pins 108 (See FIG. 4), and the unit is ready for the paving operation. The mobile assembly 10 with slip form paving apparatus 100 connected thereto may still be operated with automatic steering as obtained, for example, by following one or both string lines 80 and 82 (FIG. 2). These string lines 80 and 82 may also be employed to provide level sensing for adjustment of the hydraulically adjustable support posts 26, 28, 34 and 36. Thus, each corner supporting the central frame 12 is continually adjusted to maintain the central frame 12 in a proper attitude.

Referring now primarily to FIG. 5 and other FIGS. as noted, each of the finishing components such as primary feed meter 134, internal vibrators 136 and baffle plates 138, feed meter 140, primary extrusion finisher 142 and extrusion finisher 144 may each be set at a predetermined level which is consonant with the desired depth of the paving slab, the respective left and right side forms 552 and 550 as well as front side forms 182 and 184 being maintained in close proximity to the road bed to provide the sliding side forms. As shown in FIG. 4, the rough paving material 132 is dumped in the road bed ahead of the slipform paving apparatus 100 in generally evenly distributed piles or rows and the helicoid spreader, consisting of auger assemblies 186 and 192, then contacts the rough paving material 132 and spreads it in even disposition across the road bed. The auger assembly 130 is in full view of the operator at console 52 and it is continually adjustable in direction and speed of rotation from 0 to 80 revolutions per minute to spread the paving material 132 in whatever the desired manner. The auger assembly 130 serves to blend, mix and pro-
portion the paving material as it enters the front of the paving apparatus 100 and it is capable of moving or spreading paving material across the paving apparatus 100 in either direction or in both directions at the same time.

Immediately behind the auger assembly 130 is the primary feed meter 134, a strikoff member which serves to proportion the volume of paving material entering the area of internal vibrators 136 and baffle plates 138 to assure the proper flow of paving material to maintain the desired slab depth and working speed. The primary feed meter 134 is adjustable as to vertical level and profile by individual control of any or all of hydraulic cylinders 212-218 from the console 52.

As paving apparatus 100 progresses the paving material then comes into the area of internal vibrators 136 and baffle plates 138 whereupon still further blending, mixing and consolidating of paving material takes place. Thus, each of a plurality of internal vibrator elements 266 (FIG. 4) is immersed down into the paving material 132 and vibrated at a very high rate of vibration tending to consolidate further the paving material. It is contemplated that up to 15 such internal vibrators 136 (Vibrator elements 266) may be used in equispaced relationship across support bar 262, this depending on the requirement of each individual job.

The steel plate 32 mass then passes into the area of the secondary feed meter 140, a unit similar in construction and control to the primary feed meter 134. The secondary feed meter 140 further compacts and tends to assure proper volume control and this, in turn, contributes to accurate yields of paving materials. The secondary feed meter 140 is similarly controlled from the operating console 52 as to its level, profile and working speed. The plurality of vibrators 298 provide a high frequency stroke, generally vertical vibration tending to consolidate the paving material.

The primary oscillating extrusion finisher 142, forward screed member 302, lends still further consolidation to the paving material while, at the same time, the initial grade and finish is applied to the surface of the paving slab. Thus, screed member 302 is oscillated in a side-to-side approximately 4 inch stroke by means of a hydraulic motor 542 and speed reducer 540 applying rotational drive to cam shaft 538. This drive is similar to that for auger assembly 130 and it is adjustable between 0 and 80 revolutions per minute to account for variations in paving speed differences in the aggregate of the paving material.

The steel plate 32 mass is conveyed to a horizontal conveyor assembly 307 and 308 and thence to a set of rollers 302 and 304 thereupon. These rollers are individually rotatable to adjust the pitch angle of forward and rear screeds 302 and 304 for forward or reverse slope, depending on aggregate texture and wetness. A floating fine surface finisher 146 (FIG. 4) may also be trailed behind the paving apparatus 100 upon the rear of the paving slab. This is particularly desirable for paving up to bridge floor entries as well as for resuming the paving slab on the opposite side of the bridge floor while leaving a neat and complete pavement juncture across the bridge. This adjustment also enables the sillform paving of angularly joining "on" and "off" ramps since the sillform paver can follow along and over stationary forms, all paving finishing elements being located at or slightly above the form and pavement level when employed for this particular operation.

Various forms of auxiliary structure may be employed with the mobile assembly 10 and slip paving apparatus 100 to enable specific functions on the paving job. For example, as shown in FIG. 16, it may be desirable to employ wedges 770 in interconnection between selected support arms and the main frame 12, e.g. as shown between support arm 20 and the main frame 12. The wedges 770 may be employed at any one or all of the support arms, this depending upon the particular operation. Wedges 770 may be interconnected and secured by means of complementary pin connections providing a structurally rigid linkage between the respective support arm and main frame 12. This mlay be resorted to in various situations where it is desired to offset or elevate any portion of the mobile track units 30, 32, 38 and/or 40 to allow for such clearance of permanent forms, protruding steel tie-bars, and various other appurtenant structure.

FIG. 17 shows still another auxiliary device in the form of an outrigger 774. The outrigger 774 consists of a hydraulic cylinder 776 which is securely supported from a pivot point 44 to extend a piston rod 778 and foot pad 780 into contact with the earth. The outrigger 774 is employed to support a corner of the mobile assembly 10 while that particular support arm and motive track is elevated for entry onto a higher plane, this adjustment being made without disturbing the automatic control setting as derived from stringline or other such reference.

Thus, in operation, it is possible to pave a surface from a bridge floor by utilizing the outrigger 774. The mobile assembly 10 and paving apparatus 100 are operated up to the point where the forward track assembly, e.g. forward track 32, approaches the bridge floor. Thereafter, the outrigger 774 is secured at pivot point 44 and extended with foot pad 780 bearing against the earth to support main frame 12 while the track assembly 32 is raised upward to the level of the bridge floor. A suitable blocking means (not shown) is then placed under track assembly 32, and the mobile assembly 10 can be driven right up to and across the bridge floor, paving apparatus 10 making a complete juncture of smooth paving material up to the bridge entry abutment. In the case of a bridge entry operation as described, it would also be necessary to employ a similar outrigger on the opposite side of mobile assembly 10 as both of the forward track assemblies 30 and 32 would need to be raised up to the new reference or bridge floor level.

FIG. 18 shows another auxiliary equipment, and edge unit 782 which is employed to provide optimum corner shaping of the paving slab. The edge unit 782 represents a left hand edge unit and it is suitably secured to the rear edge of the left side form 552. A similar right side assembly would also be employed. Thus, an upper rectangular frame 784 is suitably bolted to a rear edge stiffener 786 of side form 552. Four quadrilaterally arranged hangers 788 suspend the edge unit 782 from frame 784 so that the edge unit 782 floats along the edge of the paving material. A suitable brace 790 is then secured to frame 784 to extend vertically downward along the outer edge to support a pair of horizontal compression spring
units 792 and 794 which tend to urge the edger unit 782 inward. As shown in FIG. 19, the edger unit 782 is merely a right angle panel having flared front edges to provide minimum interference in moving over the wet paving material. Thus, a top panel 796 is formed with an upwardly flaring front portion 798, and this is rigidly joined to a vertically extending side panel 800 having a flared leading edge portion 802. The top panel 796 bears in the direction of arrow 804 and floats on the top of the paving slab 42 while side panel 800 is continuously urged inward in the direction of arrow 806 by the previously mentioned spring assemblies. The upper panel 796 is preferably formed with an upwardly flaring side portion 808 which provides the edger rise to allow for natural slump of the paving material. The dash lines 810 shows a desirable cross section of finished paving material 42 with such slump allowance at edge portion 811. Various means may be provided for adjusting both the slope of taper portion 808 as well as the relative angle and batter of the side panel 800. Such adjustment structure is deemed to be well within the normal design skills.

FIG. 20 shows still further alternative structure which provides the capability of placing scoring or other configuration on the edge of the paving material. This can be especially desirable, and it is indeed finding increasing use in many areas today, when paving slabs are laid in direct contact with other previously laid slabs. As shown in FIG. 13 the slifform 598 includes the longitudinal key 644 and half round filler rod 646 which, in effect, leaves the plain straight side paving slab edge. FIG. 20 shows a similar slifform 598 with different appendant structure. Thus, a filler rod such as 812 may be formed to have a cross section such that a half round portion 814 can be secured within the longitudinal groove 644 by such as a plurality of screws 815 to extend a key portion 816 therefrom. This type of slifform would provide a longitudinal key or groove shaped as bar portion 816 along the length of the edge of the paving slab. A paving slab plate adjacent to this would then find an interlocking edge surface and the entire paving structure would tend to be strengthened as against forces of upheaval.

A dash line 818 of FIG. 20 shows an alternative form of key extension of the longitudinal fller rod 812. The actual cross section of the key is a matter of choice, various forms being suitable depending upon the consistency and aggregate size of the paving material. It is also contemplated that the fller rod 812 be omitted altogether such that slifform 598 and channel 644 will tend to raise a continuous bead along the edge of the paving slab. Moreover, the prime size and shape of channel 644 is for the accommodation of appendant structure which may be employed to insert reinforcing steel in the edge of the paving slab.

Certain paving specifications require that short bars of reinforcing steel be inserted through the edge of a paving slab to provide secure connection with a later laid adjacent slab. FIG. 21 shows one form of hydraulic bar inserter 820 which may be employed to insert tie-bars into the edge of a paving slab. The inserter 820 is shown as being affixed to a left side form 552 by means of suitable brackets 822 and 824 welded or otherwise affixed thereto. The inserter 820 may be installed, for example, near the rear edge of the forward side form 820 so that insertion of the steel tie-bars takes place just before the paving material 132 enters the area of the secondary feed meter or vibrating screw 140.

The inserter 820 consists of a first right-angle panel 826 and a second right-angle panel 828 secured in parallel-spaced relationship so as to form a right-angle magazine 830 for containing a plurality of steel tie-bars 832 which are bent in the characteristic right-angle configuration. The right-angle panels 826 and 828 may be suitably secured in spaced apart relation by means of the bracket portions 822 and 824 or other such related structure. A frame panel 834 is rigidly secured as by welding to a base plate 836 which extends below the entire inserter assembly 820 as well as to the lower edge of right-angle panel 826. A suitable ramrod 838 having a broad contact face 840 is arranged in pushing relationship to successive ones of tie-bars 832 as they rest on base plate 836. A lever 842 pivotally connected at a fulcrum stud 844 is actuated by a hydraulic push rod 846 which is periodically extendable under control of a conventional form of hydraulic cylinder 848. The hydraulic cylinder 848 may be suitably secured to the frame 834 as by bolts, welding or whatever, and it may be energized from the primary power source situated on mobile apparatus 10. Most specifications would require accurate placement of such steel tie-bars, and it would therefore be desirable to control actuation of hydraulic cylinder 848 automatically by a suitable metering or timing device so that tie-bar insertion takes place periodically along the paving slab in accurate manner.

The slifform 598 would include a channel or groove 644; however, it would also include a slot 850 at least as long as the longitudinal length of each of tie-bars 832 and in alignment with the exit opening 852 and ramrod 838. After insertion of each of tie-bars 832, the slifform 598 can continue to move along the edge of the paving slab as the exterior portion of each of the tie-bars 832 will ride within groove 644. In some cases it may be desirable to employ an edger device such as shown in FIG. 19 also, and it would then be necessary to provide a groove similar to groove 644 along the side panel 800 of edger device 782. This provision can be made with normal exercise of engineering skills. After the paving material has been allowed to set, the protruding portions of each of tie-bars 832 can be bent outward so that they will extend into the volume of an adjacent paving slab to provide positive joinder.

It should be understood that the advantageous conditioning of paving mix as accomplished by oscillating extrusion spreading assemblies may be enabled by a wide variation of structures. Thus, while the invention is described in conjunction with shown efficiency and methods, and one including certain paving mixture conditioning elements, viz. auger, strikeoff, internal vibrators, metering means, first and second extrusion screed, etc., it is well within contemplation to vary the structure by a great margin to gain various advantages as to operation and machine construction. Therefore, it is planned that such as the variably controlled oscillation extrusion scr eed may take various shapes and dimensions each of which might be used singularly or as one of a series in the paving mixture conditioning operation. The extrusion screeds may also be employed in a paver unit consisting of serial conditioning elements or it may constitute the sole operative element.

The foregoing discloses a novel slifform paving apparatus which is capable of automated operation controlled to provide a continuous conditioning of paving mixture into an accurately profiled paving slab having an extremely smooth surface. Such a slifform paving apparatus enables extremely rapid laying of pavement with maximum accuracy of yield of material to effect great savings in time and cost of paving material. The apparatus applies continuous conditioning to paving mix from the time it enters the machine until the paving slab is laid and finished and, despite variations in slump and consistency of different paving mixes, the apparatus is able to handle large loads of paving material to lay a slab with a squareable vertical edge at speeds up to many feet per minute.

Changes may be made in the combination and arrangement of elements as heretofore set forth in this specification and shown in the drawings; it being understood that changes may be made in the embodiments disclosed without parting from the spirit and scope of the invention as defined in the following claims.

We claim:

1. A machine for continuously conditioning and laying deformable paving material in a pavement bed, comprising:

frame means having first and second sides and plural transverse support members;
motive means affixed to said frame means for moving said frame means along a pavement bed;
spreadert means supported across said pavement bed by said frame means for receiving said paving material and distributing said material across the pavement bed as a generally uniform layer;

extrusion means supported below said frame means and across said pavement bed at a position rearward of said spreader means;
support means supporting said extrusion means from said frame means in a fixed horizontal plane relative to said frame means such that the weight of the frame means is transmitted through the extrusion means to bear upon said deformable paving material;
drive means secured to said frame means and connected to impart oscillatory movement to said extrusion means: wherein said support means comprises:
pluralshaft means disposed in parallel and supported by said frame means parallel to said sides, said shaft means being spaced transversely across said frame means;
a plurality of eccentric means disposed for rotation on respective ones of said shaft means and being horizontally slidably connected to said extrusion means; and control means for separately actuating each of said eccentric means through selected rotation to adjust the vertical level and transverse profile of said oscillating extrusion means; and wherein each of said eccentric means comprises:
a eccentricassembly which varies in elevation in response to rotation about the respective one of said shaft means;
sleeve means receiving said eccentric assembly therethrough in freely rotatable engagement;
a pair of transversesleeves disposed in parallel and being affixed to said sleeve means;
a pair of transverse shafts disposed horizontal and in parallel and received through each of said transverse sleeves in freely slidable and rotatable engagement; and means for securing the ends of each of said transverse shafts to said extrusion means so that said extrusion means is supported in laterally slidable relationship at a height determined by rotation of said eccentric assembly.

2. A machine as set forth in claim 1 which is further characterized in that: each of said transverse shafts is an eccentric shaft having offset end extensions which are releasably secured within the respective means for securing such that said transverse shafts can be individually rotated to adjust the pitch angle of said extrusion means.

3. A machine for continuously conditioning and laying deformable paving material in a pavement bed, comprising:
frame means having first and second sides and plural transversesupport members;
motive means affixed to said frame means for moving said frame means along a pavement bed;
spreadert means supported across said pavement bed by said frame means for receiving said paving material and distributing said material across the pavement bed as a generally uniform layer;
extrusion means supported below said frame means and across said pavement bed at a position rearward of said spreader means;
support means supporting said extrusion means from said frame means in a fixed horizontal plane relative to said frame means such that the weight of the frame means is transmitted through the extrusion means to bear upon said deformable paving material;
drive means secured to said frame means and connected to impart oscillatory movement to said extrusion means; wherein said extrusion means consists of plural separate and parallel aligned oscillating extrusion means each supported by individual adjustable support means from said frame means; and further characterized to include:
pluralshaft means disposed in parallel and supported by said frame means parallel to said sides, said shaft means being spaced transversely across said frame means;
plural groups of eccentric means disposed for rotation on respective ones of said shaft means and the eccentric means of each group being horizontally slidingly connected to one of said oscillating extrusion means; and control means for separately actuating each of said individual groups of eccentric means to adjust the vertical level and transverse profile of selected ones of the plural oscillating extrusion means.

4. A machine as set forth in claim 3 wherein each of said eccentric means comprises:
an eccentric assembly which varies in elevation in response to rotation about the respective one of said shaft means;
sleeve means receiving said eccentric assembly therethrough in freely rotatable engagement;
a pair of transverse sleeves disposed in parallel and being affixed to said sleeve means;
a pair of transverse shafts disposed horizontal and in parallel and received through each of said transverse sleeves in freely slidable and rotatable engagement; and means for securing the ends of each of said transverse shafts to the respective extrusion means so that said extrusion means is supported in laterally slidable relationship at a height determined by rotation of said eccentric assembly.

5. A machine as set forth in claim 4 which is further characterized in that: each of said transverse shafts is an eccentric shaft having offset end extensions which are releasably held by means for securing such that said transverse shafts can be individually rotated to adjust the pitch angle of said extrusion means.

6. A machine as set forth in claim 3 wherein selected centrally disposed ones of each group of said eccentric means comprise:
first eccentric means being slidingly connected to said respective oscillating extrusion means;
second eccentric means received within and rotatably supporting said first eccentric means, said second eccentric means receiving centrally disposed ones of said plural shafts therethrough;
first means for rotating selected ones of said first eccentric means to adjust individually the level of respective oscillating extrusion means relative to said pavement bed; and second means for rotating said second eccentric means to adjust in unison the level of all of the oscillating extrusion means relative to said pavement bed.

7. A machine as set forth in claim 6, wherein each of said first eccentric means sliding connections include means for varying the longitudinal pitch angle of respective ones of said transverse oscillating extrusion means.

8. In a machine for placing deformable paving material in a pavement bed which includes detachable, self-propelled motor means carrying a power source, slipform paving apparatus comprising:
frame means having first and second sides and plural transverse support members; extrusion means supported by said frame at a fixed horizontal level in extruding contact with said paving material; support means for continually holding said extrusion means rigidly at a predetermined level relative to said frame means; variable drive means connected to impart lateral oscillatory movement to said extrusion means at a selected cyclical rate; and fasterener means of readily detachable type for rigidly securing said frame means beneath said self-propelled motive means such that the weight of the motive means is transmitted directly through said extrusion means to bear upon said deformable paving material.

9. An apparatus as set forth in claim 8 which is further characterized to include:
slipform means disposed along each side of said frame means and extending below said frame means by a predetermined, uniform distance.

10. An apparatus as set forth in claim 8 which is further characterized to include:
19 auger means supported by said frame means first and second sides and extending across said pavement bed in advance of said extrusion means; and drive means for variably controlling the rotational speed and controlling the rotational direction of said auger means.

11. An apparatus as set forth in claim 8 which is further characterized to include: shaft means extending transverse of said pavement bed and supported by said frame means in advance of said extrusion means; plural vibrator elements rigidly suspended from said shaft means; power means for energizing said vibrator elements; and means for rotating said shaft means to raise and lower said vibrator elements out of and into said deformable paving material.

12. An apparatus as set forth in claim 10, which is further characterized to include: metering means extending across the forward part of said frame means rearward of said auger means; and means for adjusting said metering means to a preselected height relative to said pavement bed.

13. An apparatus as set forth in claim 9 wherein said slip form means comprises: side form means disposed on each side of said frame means; and plural adjustable length means on each side of said frame means and each having one end secured to one of said side forms with the other end secured to said frame means such that the side forms are moved outboard from each side of the frame means when said adjustable length means are extended.

14. An apparatus as set forth in claim 13 wherein said side form means each comprise: upper plate means lower plate means hingedly connected to and extending along the lower edge of said upper plate means; means for adjusting the angle of batter of said lower plate means by limiting the obtuse angle at which said lower plate means is disposed relative to said upper plate means as it rotates downward about the axis of said hinged connection; and elongatable control means connected between said lower plate means and said frame means to raise and lower said lower plate means about said hinge axis.

15. A machine for continuously conditioning and laying deformable paving material in a pavement bed, comprising: frame means having first and second sides and plural transverse support members; motive means affixed to said frame means for moving said frame means along said pavement bed; spreader means supported across said pavement bed by said frame means for receiving said paving material and distributing said material across the pavement bed; means supported by said frame means for compacting said distributed paving material into a consolidated and generally uniform layer; extrusion screed means; adjustable support means carried by said frame to support said extrusion screed means rigidly at a fixed level with respect to said frame means such that the weight of the frame means bears directly upon said extrusion screed means in contact with said deformable paving material; and variable drive means connected to said screed means to impart oscillation to said screed means at a controllable cyclical rate.

16. A machine as set forth in claim 15 which is further characterized to include: slipform means disposed along each side of said frame means and extending below said frame means by a predetermined, uniform distance.

17. A machine as set forth in claim 16 wherein said spreader means comprises:

20 auger means supported by said frame means first and second sides and extending across said pavement bed; and drive means for variably controlling the rotational speed and controlling the rotational direction of said auger means.

18. A machine as set forth in claim 15 wherein said screed means and said support means constitute plural individual screed means and support means disposed consecutively on said frame means.

19. A machine as set forth in claim 17 wherein said auger means comprises: first and second auger means aligned in end-to-end relationship and having opposite helical flights, said first and second auger means being separately controllable as to their rotational speed and direction.

20. A machine as set forth in claim 15 wherein said support means comprises: plural cam follower means affixed in horizontally slidable relationship to said screed means; plural cam means having an offset axis rotationally secured to said frame means and being disposed to actuate respective ones of said plural cam follower means; and control means for individually rotating said cam means to vary the level of said screed means relative to said frame means.

21. A machine as set forth in claim 20 wherein said plural cam means and plural cam follower means are disposed near opposite ends of said screed means as well as at a central point of the screed means.

22. A machine as set forth in claim 21 wherein each of said plural cam follower means comprises: sleeve means received over a respective cam means in slidable engagement; a pair of transverse sleeve means disposed in parallel alignment and being affixed to the underside of said sleeve means; a pair of transverse shafts received through respective transverse sleeve means in slidable engagement; and means securing opposite ends of each transverse shaft to said screed means.

23. A machine as set forth in claim 22 which is further characterized in that: said transverse shafts are each eccentrically formed with an offset central portion which is slidable within a respective transverse sleeve, said transverse shaft ends being releasably secured and rotatable with said means securing such that the pitch angle of said screed means may be adjusted.

24. A machine as set forth in claim 15 wherein said motive means comprises: self-propelled mobile means including a power source; auxiliary power means energized by said power source for providing operating power to said spreader means, said means for compacting, and said first and second screed means; and connecting pin means for readily attaching and detaching said motive means from said frame means.

25. A machine as set forth in claim 15 wherein said screed means and support means comprise: plural screed means disposed consecutively along said frame means; and plural support means carried by said frame means to support each one of said plural screed means at a predetermined level with respect to said pavement bed.

26. A machine as set forth in claim 15 wherein each of said support means comprises: plural cam follower means affixed in horizontally slidable relationship to respective ones of said plural screed means; plural cam means having an axis rotationally secured to said frame means and being disposed to actuate respective ones of said plural cam follower means; and
21 control means for individually rotating said cam means to vary the level of said first screed means relative to said frame means.

27. A machine as set forth in claim 16 which is further characterized to include:

plural lift means pivotally supported between said frame means first and second sides and respective slipform means on each side;
control means for actuating said lift means to raise said slipform means out of contact with said paving material in the pavement bed.

28. A machine as set forth in claim 16 which is further characterized to include:
laterally adjustable connection means extending between said frame means transverse support members and said first and second sides;
a first plurality of elongateable means connected between said transverse support members and said first side;
a second plurality of elongateable means connected between said transverse support members and said second side; and
control means for energizing each of said elongateable means to extend each of said first and second sides outward from said frame means and said paving material.

29. A machine as set forth in claim 16 which is further characterized in that each of said slipform means includes keying means rigidly secured along the inside thereof to score the vertical edge of said paving material.

30. A machine as set forth in claim 16 which is further characterized in that each of said slipform means includes an outwardly extending groove along the inside thereof to form a projecting bead along the vertical edge of said paving material.

31. A machine as set forth in claim 15 which is further characterized to include:

a pair of edger means supported on each rear side of said frame means to continually screed and shape each vertical side of the paving material and an adjacent strip of the top surface.

32. A machine as set forth in claim 31 wherein each of said edger means comprises:

horizontal plate means suspended from said frame means to float on the top of said paving material;
vertical plate means supported from said frame means and being adjustable affixed to form a predetermined angle with said horizontal plate means while in contact with said paving material vertical edge; and
means for urging said vertical plate means against said paving material edge.

33. A road construction machine of varied utility in preparing and paving a road bed, the machine consisting of a generally rectangular main frame which is supported at each corner by a mobile assembly, each of the mobile assemblies being driven by a primary power source mounted on said main frame, and including a readily attachable and detachable grade preparation assembly suspended from said main frame, the machine further comprising:

slipform paving means including spreader, compacting and screeding assemblies extending transverse to said road bed;
plural hanger means affixed to the underside of said main frame at spaced points;
plural securing pin means for readily connecting said slipform paving means to each of said plural hanger means when said grade preparation assembly is detached from said main frame;
plural drive means mounted on said slipform paving means to provide drive power for said spreader, compacting and screeding assemblies; and

34. A road construction machine as set forth in claim 33 wherein said plural drive means are hydraulic motors, said power transmission means are a plurality of hydraulic pressure hoses, and said primary power source includes a hydraulic power supply.

35. A road construction machine as set forth in claim 33 wherein said slipform paving means comprises:

a rectangular frame providing secure connection for each of said plural pin securing means;
slipform side panels supported on each side of said frame in laterally adjustable mounting;
an auger assembly rotatably supported across the forward side of said frame for spreading paving material in even distribution across the road bed;
metering and vibrating assemblies supported by said frame behind said auger assembly for compacting said distributed paving material; and
a screeding assembly supported by said frame at an adjustable level for oscillation at a controllable cyclical rate.

36. A road construction machine as set forth in claim 35 wherein said screeding assembly comprises:
a pair of first adjustable support means connected between each end of the screeding assembly and the frame;
a second adjustable support means connected between the central part of the screeding assembly and said frame; and
means for controlling said first and second adjustable support means to provide a pavement slab with a predetermined thickness and crown profile.

37. A road construction machine as set forth in claim 35 wherein two such screeding assemblies each having independently controllable first and second support means are supported consecutively from said frame.

38. A machine as set forth in claim 8 wherein said adjustable support means comprise:

first adjustable support means for reciprocally supporting one side of said extrusion means;
second adjustable support means for reciprocally supporting the other side of said extrusion means;
third adjustable support means for reciprocally supporting the central part of said extrusion means; and
control means for individually controlling the first, second and third adjustable support means.

39. A machine for continuously conditioning and laying deformable paving material in a pavement bed comprising:

frame means having first and second sides and plural transverse support members;
plural endless track assemblies affixed to said frame means first and second sides to support said frame means for movement along said pavement bed;
means supported by said frame means at a forward disposition for compacting said distributed paving material into a consolidated and generally uniform layer;
extrusion screed means;
adjustable support means carried by said frame to support said extrusion screed means rigidly at a fixed level with respect to said frame means such that the weight of the frame means bears directly upon said extrusion screed means in contact with said deformable paving material; and
variable drive means connected to said screed means to impart oscillation to said screed means at a controllable cyclical rate.

40. Apparatus as set forth in claim 8 wherein said self-propelled motor means is further characterized to include:

plural endless track assembly supporting said machine and said slip form paving apparatus over said pavement bed for movement therealong.