

Nov. 11, 1969

F. S. FUNK ET AL

3,477,351

BAR TYING MACHINE

Filed March 4, 1968

9 Sheets-Sheet 1

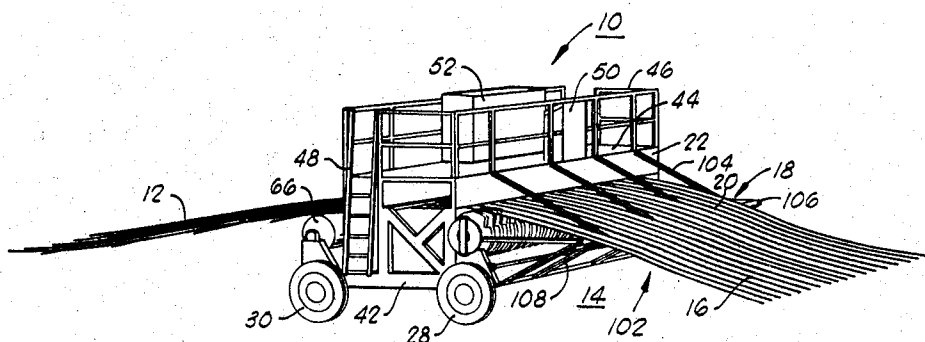


FIG. 1

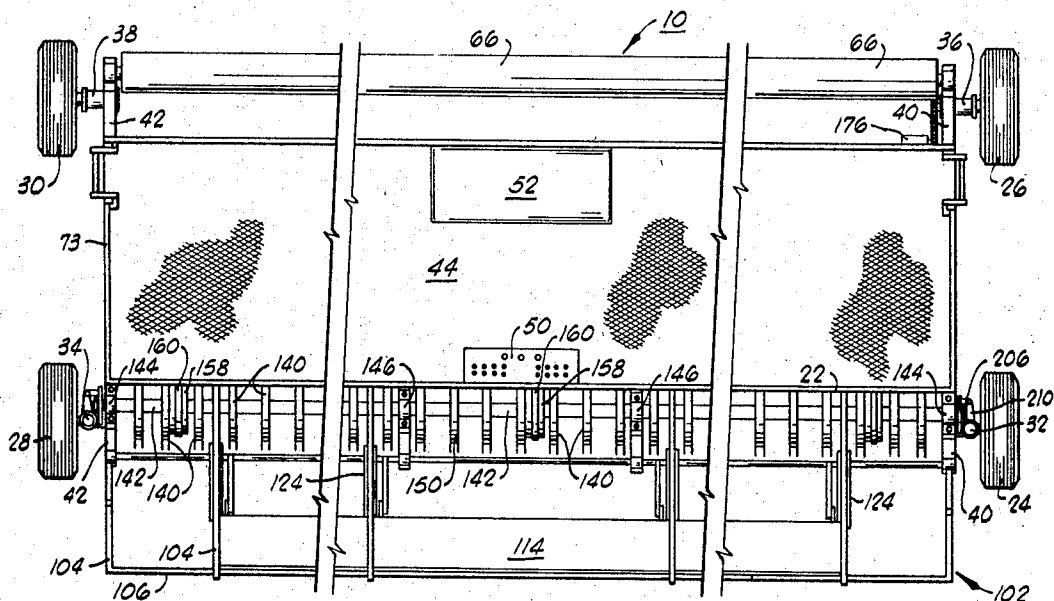


FIG. 2

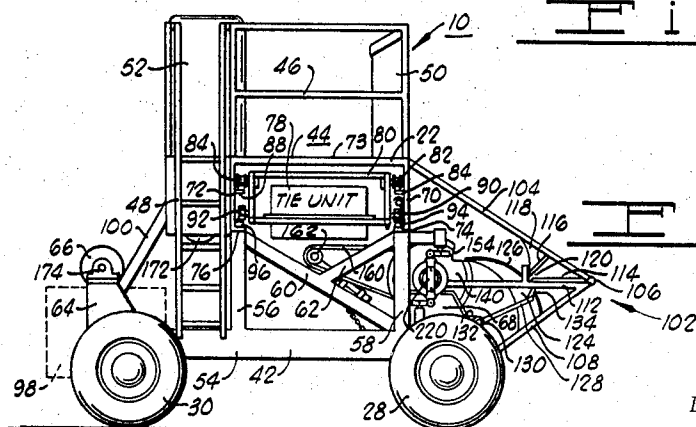


FIG. 3

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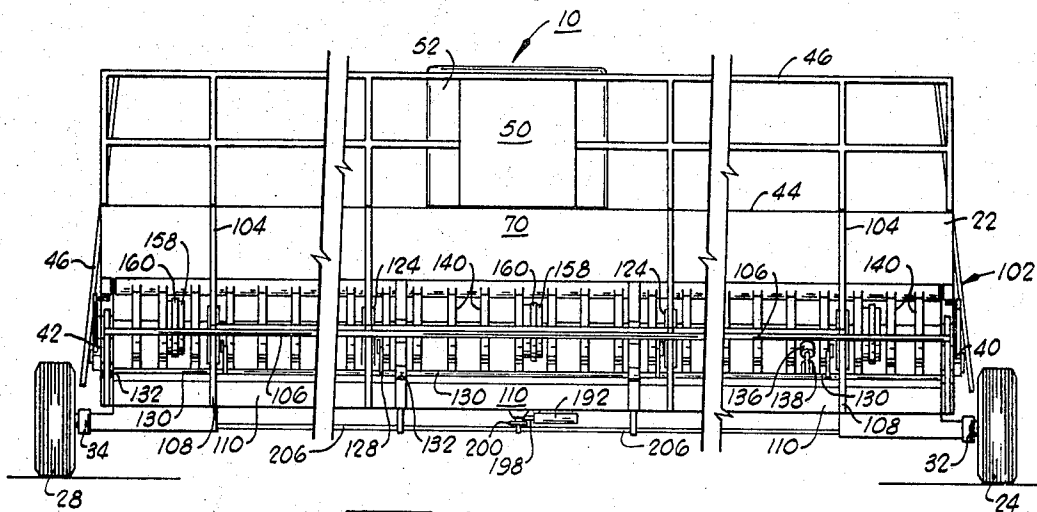


Fig. 4

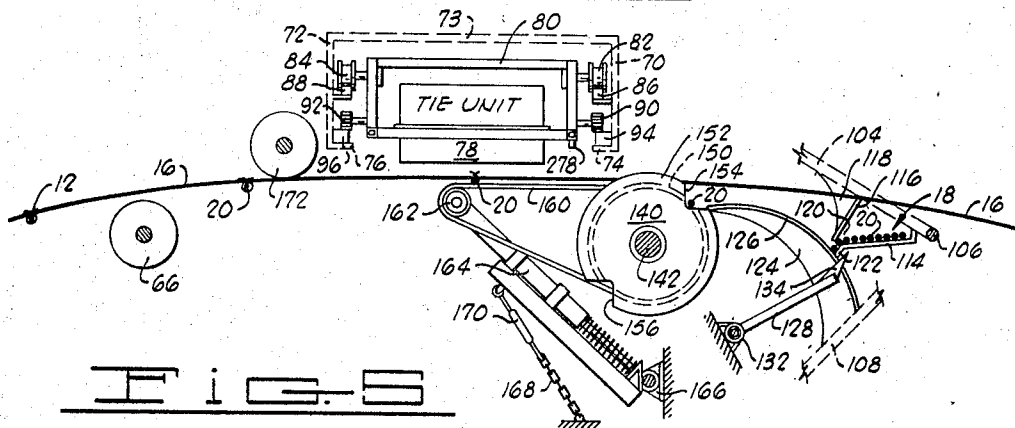


FIG. 5

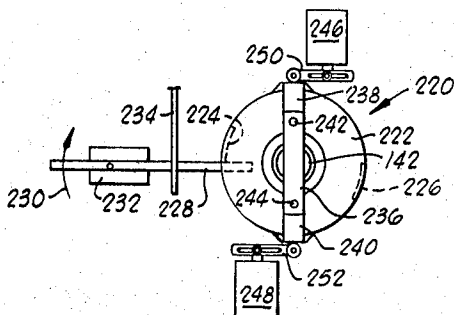


Fig. 8A

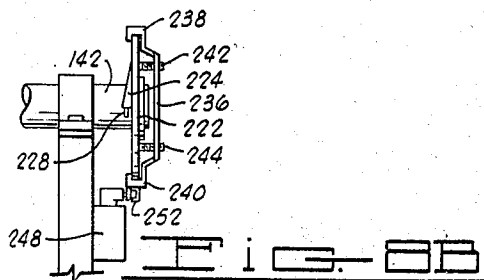


Fig. 8B

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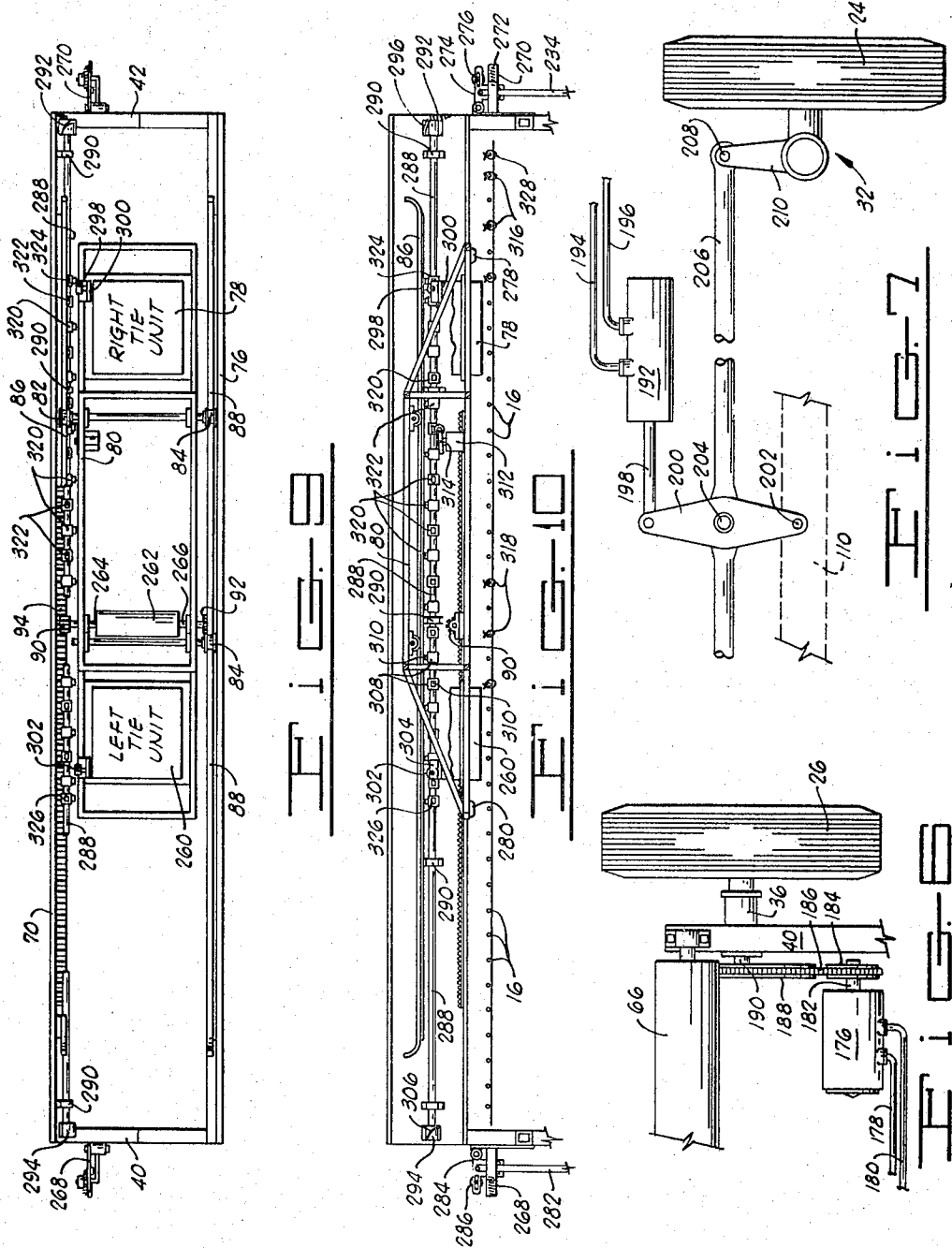
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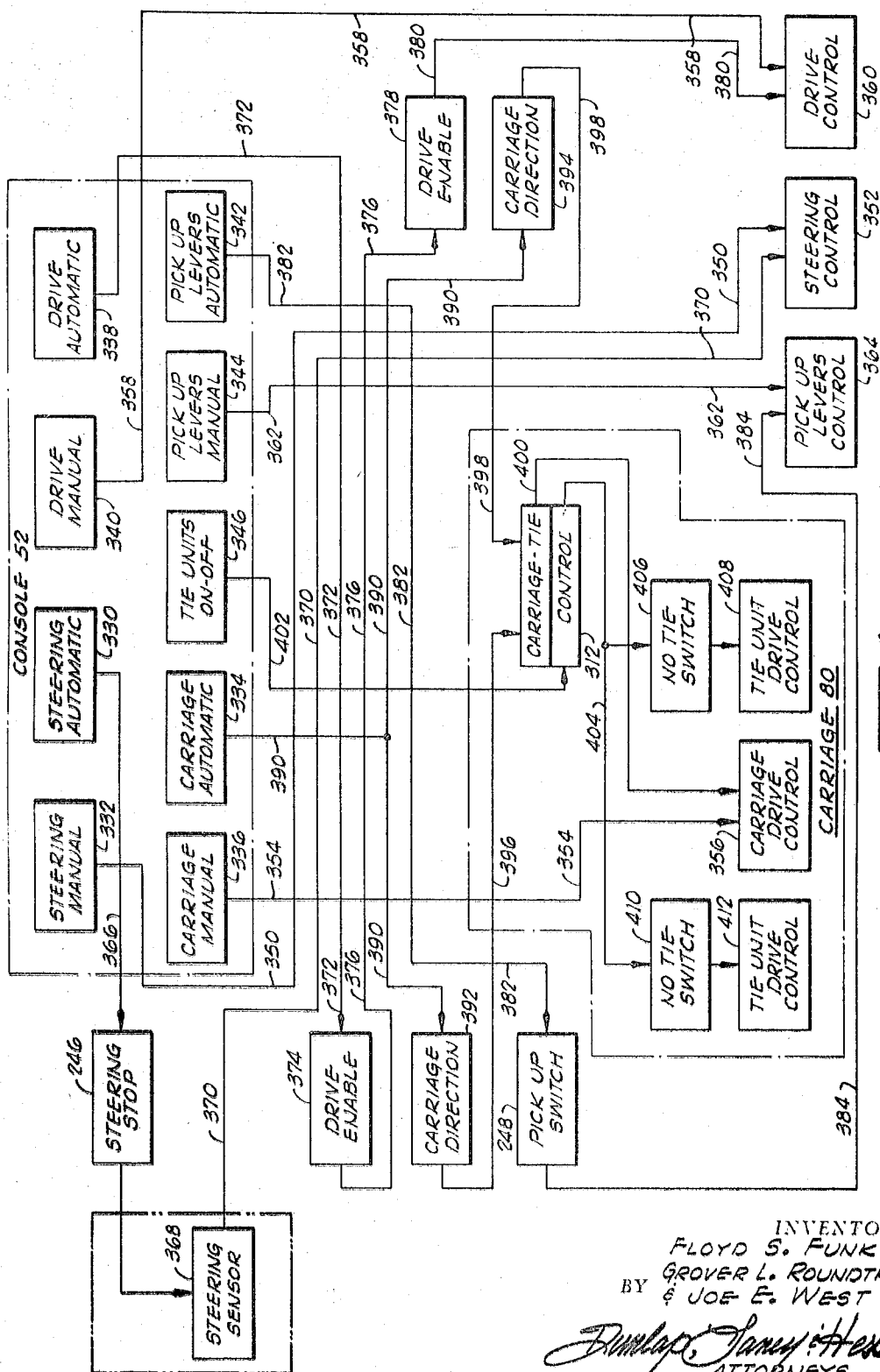
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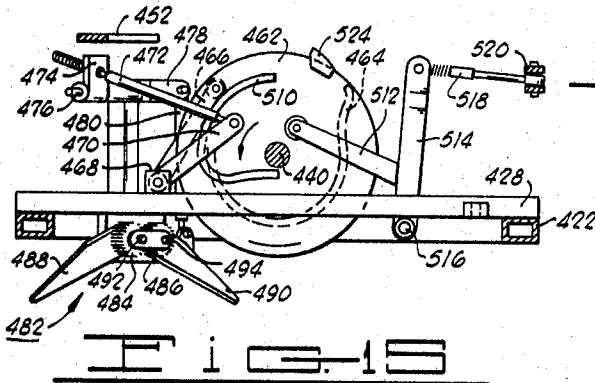
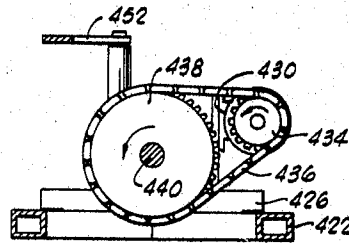
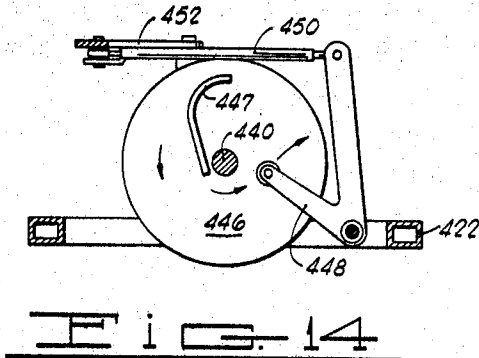
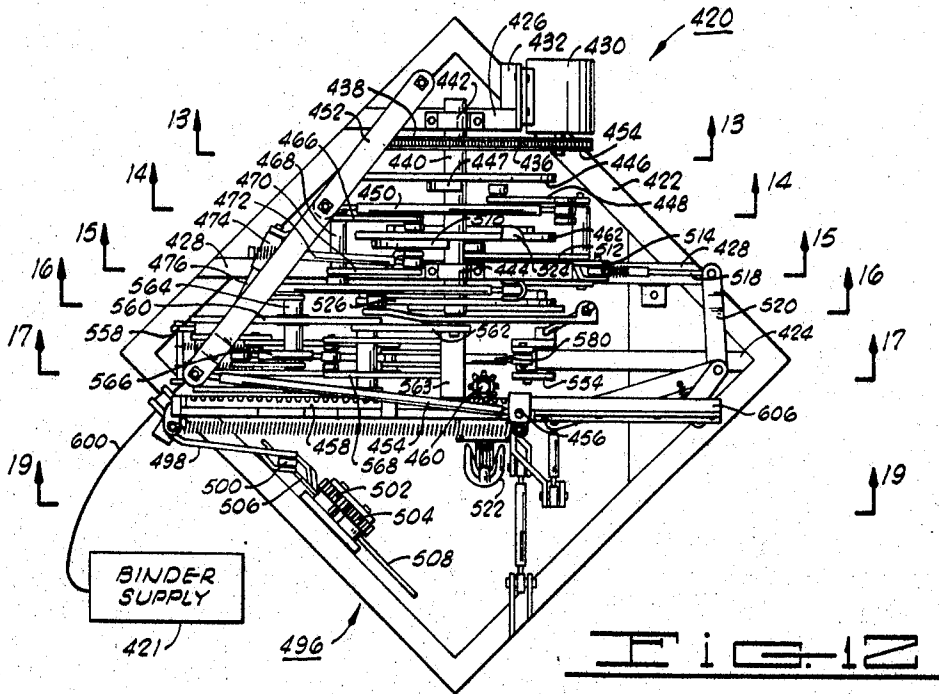


FIG. 13

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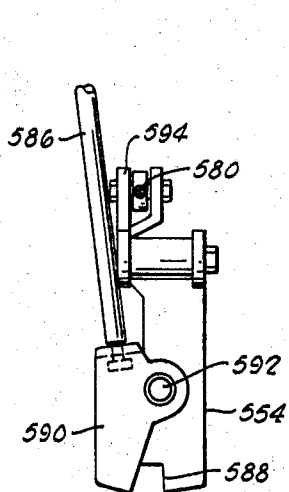


FIG. 18

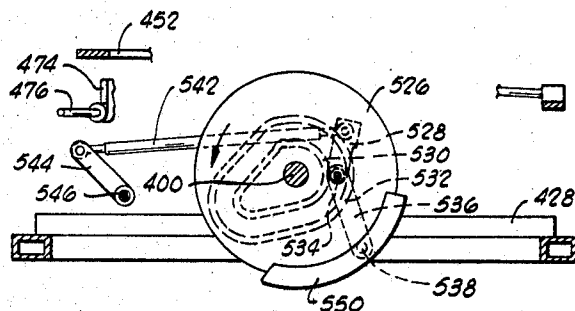


FIG. 19

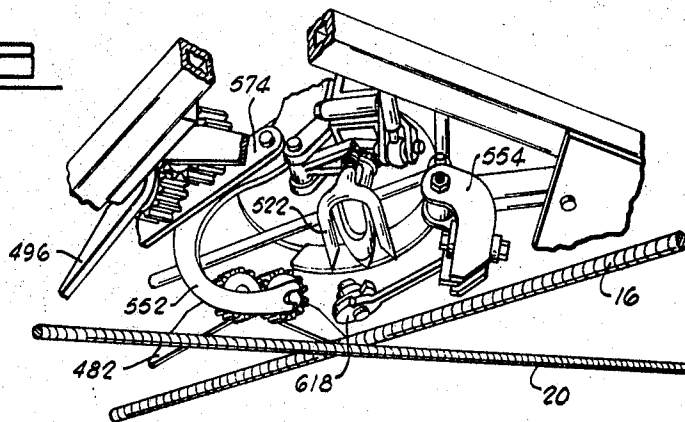


FIG. 20

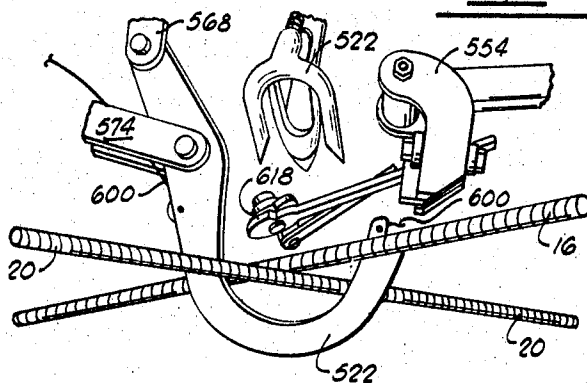


FIG. 21

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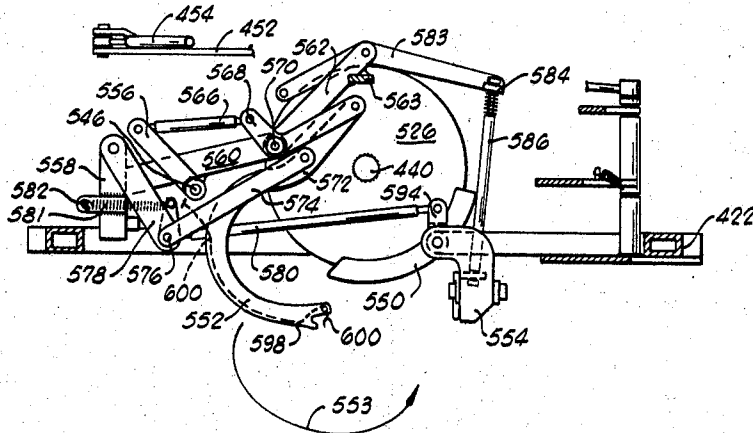


FIG. 17

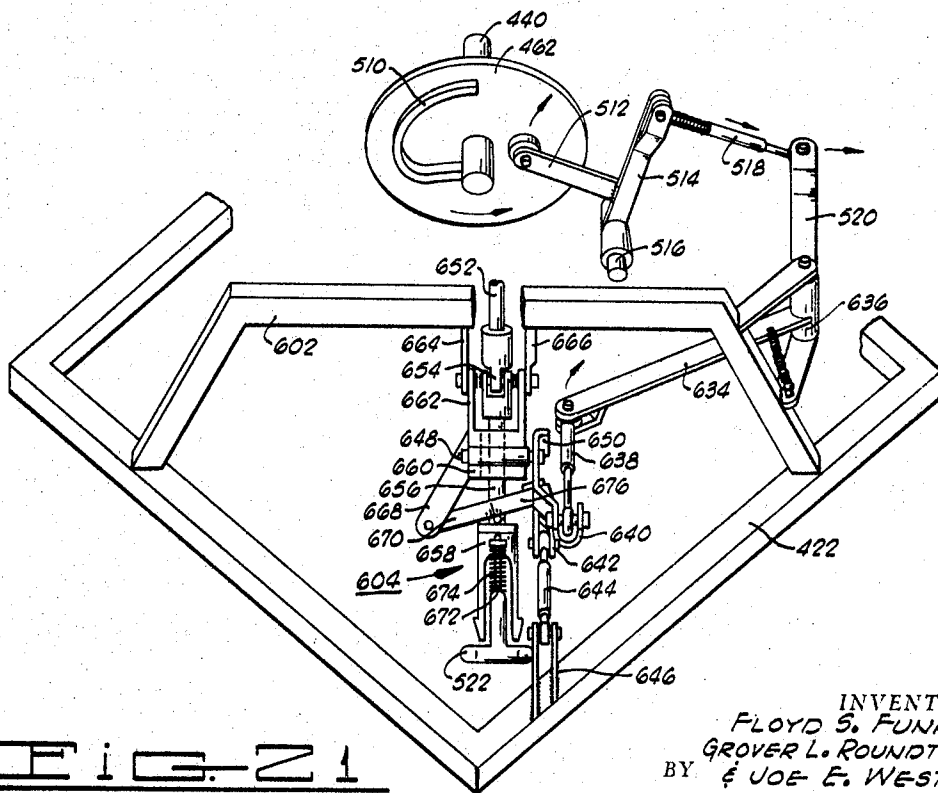


FIG. 21

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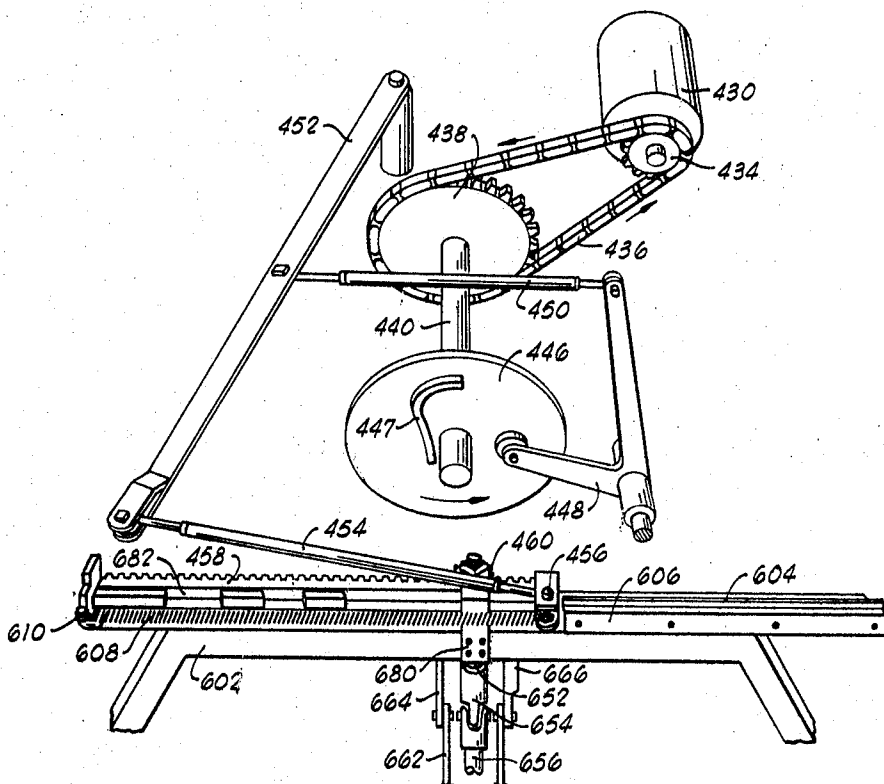


Fig. 22

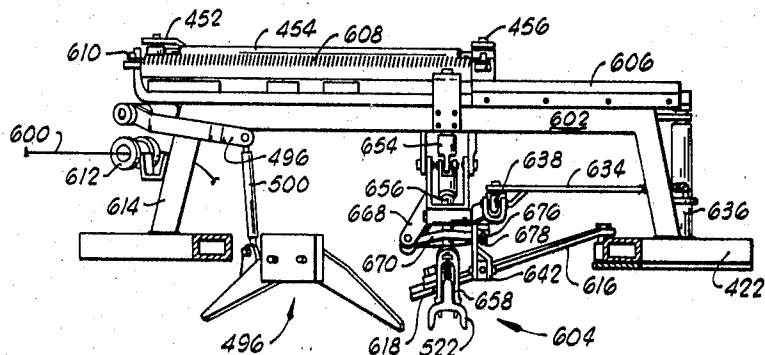


Fig. 19

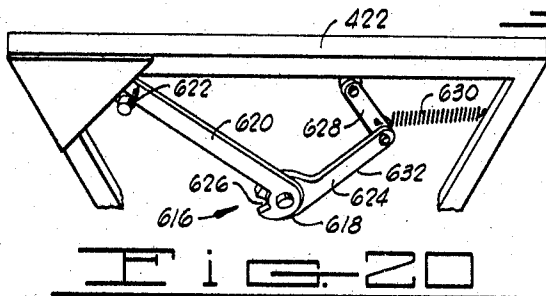


Fig. 20

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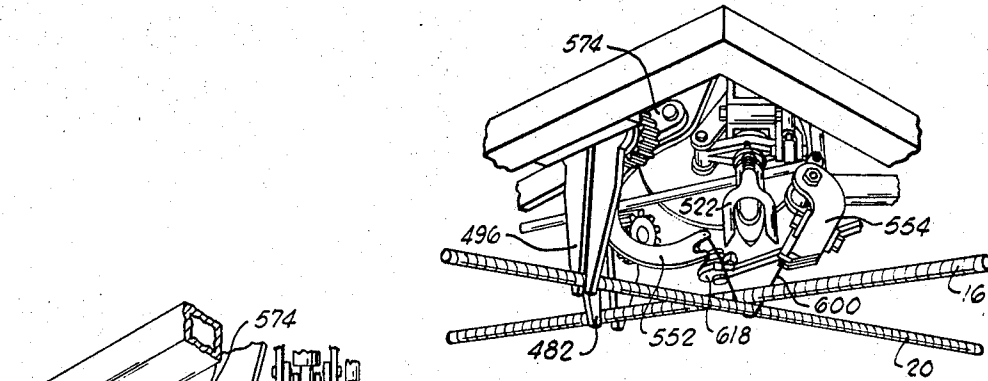


FIG. 25

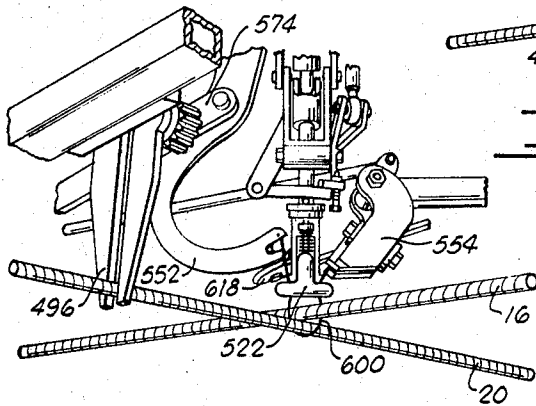


FIG. 26

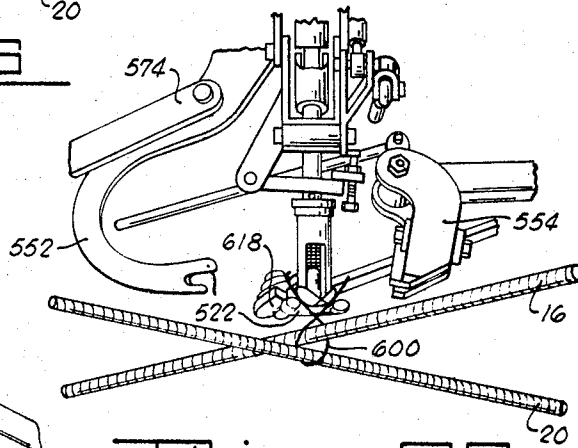


FIG. 27

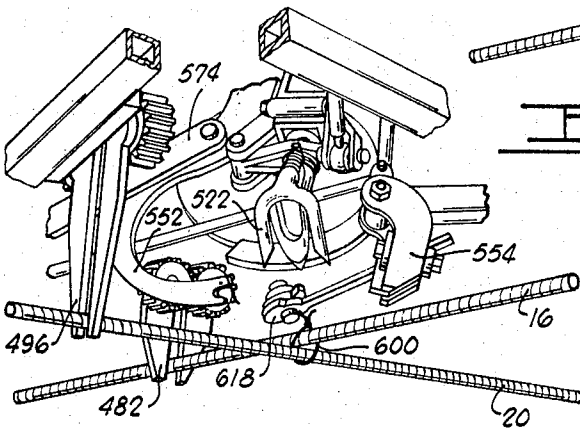


FIG. 28

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BAR TYING MACHINE

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Filed Mar. 4, 1968, Ser. No. 710,244

Int. Cl. E01c 19/00, 23/02

U.S. Cl. 94—39

27 Claims

ABSTRACT OF THE DISCLOSURE

Apparatus for binding rectangularly arrayed longitudinal and transverse paving material reinforcing bars in situ, the apparatus consisting of a self-propelled frame assembly which includes means for raising up each individual one of the longitudinally arrayed reinforcing bars and for periodically tying a transverse bar thereacross with a plurality of binder ties placed at selected intersections of longitudinal and transverse bars. The frame includes transversely arrayed means for supporting the plurality of longitudinal reinforcing bars and inserting a transverse bar therebeneath in position to receive binding ties; thereafter, a carriage assembly bearing a pair of spaced tying assemblies and supported movably on the frame is driven intermittently across the frame to effect a tie at every other longitudinal bar. The next following transverse bar is similarly tied with the carriage moving back across the frame in the opposite direction.

BACKGROUND OF THE INVENTION

Field of the invention.—The invention relates generally to automatic tying machines and, more particularly, but not by way of limitation, it relates to an automatic wire tying machine which binds longitudinal reinforcing bars to transverse reinforcing bars in situ in a pavement bed or such.

Description of the prior art.—The prior art includes several types of machines for placing and positioning reinforcing steel in various concrete forming operations; however, the concept of additionally wire-tying transversely arrayed reinforcing steel appears to be completely novel. While there are various forms of mechanized apparatus for handling reinforcing steel and rapidly laying it in a prepared roadbed, it is done with the intention that a tying crew will then follow up to effect wire ties in accordance with specifications either manually or by means of manually operated wire twisters. For obvious reasons then, such laying of pavement reinforcing steel must suffer from various defects of nonuniformity, time-consuming placement, and various other problems which can be generally attributed to the human element.

SUMMARY OF THE INVENTION

The present invention contemplates a self-propelled device for automatically binding concrete reinforcing steel at a sufficient plurality of bar intersections as specification requires. In a more limited aspect, the invention consists of a main frame assembly carrying a motor or primary power source as well as supporting wheel assemblies and means for controlling the direction of movement of the frame assembly. The frame assembly includes a plurality of transversely disposed guide means for raising and feeding longitudinally arrayed steel bars through the frame assembly and a transverse steel bar may be periodically moved from a standby or storage position into a position proximate the longitudinal steel bar whereupon automatic wire binding is effected. A carriage assembly transversely movable across the frame assembly provides a movable mount for a pair of automatic tying machines,

and additional power means and program control means are provided to index the carriage, and therefore the tying machines, back and forth across the frame assembly to tie selected intersections of longitudinal and transverse reinforcement bars in accordance with a predetermined program.

Therefore, it is an object of the present invention to provide a mobile automatic tying machine which is capable of binding reinforcing steel in accordance with predetermined specification.

It is also an object of the invention to provide an automatic tying machine which is capable of wire-tying longitudinal and transverse reinforcement bars in situ in a prepared pavement bed.

It is a further object of the present invention to provide a tying machine which is capable of placing relatively heavy gauge wire around a steel bar intersection and of forming a binding twist which provides rigid affixture of one bar to the other.

Finally, it is an object of the present invention to provide an automatic tying machine which is capable of moving intermittently along a longitudinal array of reinforcing steel to place successive transverse bars in wire-tied, secure placement in accordance with predetermined specifications.

Other objects and advantages of the invention will be evident in the following detailed description when read in conjunction with the accompanying drawings which illustrated the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of the bar tying machine in an operational attitude;

FIG. 2 is a top view of the bar tying machine of FIG. 1;

FIG. 3 is a side view of the bar tying machine of FIG. 1;

FIG. 4 is a front view of the bar tying machine of FIG. 1;

FIG. 5 is a functional side view of primary components of the bar tying machine;

FIG. 6 is a partial view of the FIG. 1 machine showing a suitable form of rear wheel drive application;

FIG. 7 is a partial view of the FIG. 1 machine showing a suitable form of steering linkage;

FIG. 8A is an end view of a programming assembly of the bar tying machine;

FIG. 8B is a side view of the FIG. 8A assembly;

FIG. 9 is a top view of the carriage assembly of the bar tying machine;

FIG. 10 is a view of the carriage assembly looking forward toward the front of the bar tying machine;

FIG. 11 is a block diagram showing the control system of the bar tying machine;

FIG. 12 is a top view of a tie unit as supported on the carriage assembly;

FIG. 13 is a sectional view taken along lines 13—13 of FIG. 12;

FIG. 14 is a sectional view taken along lines 14—14 of FIG. 12;

FIG. 15 is a sectional view taken along lines 15—15 of FIG. 12;

FIG. 16 is a sectional view taken along lines 16—16 of FIG. 12;

FIG. 17 is a sectional view taken along lines 17—17 of FIG. 12;

FIG. 18 is a partial front view of a wire gripping assembly shown in FIG. 17;

FIG. 19 is a sectional view taken along lines 19—19 of FIG. 12;

FIG. 20 is a perspective view of a wire cutting mechanism shown in FIG. 19;

FIG. 21 is a perspective view of a portion of the wire tie unit;

FIG. 22 is a perspective view of selected wire twisting components of the wire tie unit; and

FIGS. 23, 24, 25, 26, 27 and 28 are perspective views of the wire tie unit depicted at successive operational intervals.

DESCRIPTION OF THE PREFERRED EMBODIMENT

A bar tying machine 10 is shown in FIG. 1 as it might be disposed in an operating attitude securing or tying reinforcing steel 12 along a prepared paving bed 14 or such. An array of longitudinal steel bars 16 are first laid out in their approximate disposition along paving bed 14, and paving machine 10 carrying a supply 18 of transverse bars 20 progresses intermittently along paving bed 14 while placing and wiring a transverse bar 20 at specific intervals.

In a usual roadway paving operation the reinforcement steel may be specified such that the longitudinal steel bars are five-eighths inch bars and, in the case of a dual lane operation, thirty-nine such bars would be equally spaced across the pavement bed. The transverse reinforcing bars are generally specified as one-half inch steel rod or bars and these may be spaced at, e.g. one and one-half foot intervals. The tying together of longitudinal and transverse steel bars may vary once again with standard specifications; however, a popular requirement is to have each alternating intersection of bars securely wire-tied, i.e. alternating in both the width and length dimensions. The longitudinal steel bars 16 are usually supplied in sixty foot lengths such that they must be periodically spliced together by additional wire ties to keep a continuous length of reinforcement.

Referring also to FIGS. 2, 3 and 4, the bar tying machine 10 consists of a main frame 22 which extends transversely across road bed 14 as supported by left side wheels 24 and 26 and right side wheels 28 and 30. Front wheels 24 and 28 may be rotatably attached to frame 22 by any of various conventional pivotal connecting means 32 and 34 (not specifically shown) while rear wheels 26 and 30 may be rotatably secured through such as sleeve members 36 and 38. The sleeve members 36 and 38 may be secured as by welding in transverse disposition through opposing side frame members 40 and 42 of main frame 22. The top of main frame 22 is formed as an operating platform 44 surrounded by a guard rail 46; access ladders 48 and another on the left side (not shown) may also be provided. An operating console 50 is mounted on the upper surface of platform 44, a station providing full view of the operation and the various powering equipment. Housing 52 includes a main power source, for example, a conventional gasoline engine energizing a hydraulic power supply. While the particular power supply is a matter of choice, good advantage is obtained by using a well-known industrial type of Wisconsin Air-Cooled engine operating into a conventional form of hydraulic pump and supply system as is commonly used with heavy machinery.

The frame 22 may be constructed in accordance with conventional standards to provide whatever support and structural requirements are necessary and in good form. For example, and referring to FIG. 3, the right side frame 42 may be formed with a bottom beam 54 providing primary longitudinal strength with other superstructure beams extending upward therefrom. Thus, a pair of beams 56 and 58 may be welded to lower beam 54 to extend upward, and suitable diagonal bracing beams 60 and 62 may be included therebetween. The lower beam may be formed to include an upward extension 64 at its rear end, this serving to support a roller member 66 to be further described. Similarly, the forward end of lower beam 42 may be formed with a suitable upward extension 68 which supports various bar guiding equipment as will also be further described. The left side frame member 40 (not

specifically shown) would be similarly constructed as a mirror-image of the right side frame member 42.

The superstructure or upper deck 44 may be supported atop a forward transverse plate 70 and a rearward transverse plate 72. The transverse plates 70 and 72 are formed as channels with respective flanged bottom walls 74 and 76 formed thereon, the bottom walls 74 and 76 providing a surface for affixture to the upright frame members 58 and 56, respectively, and those similar parts disposed on the left hand side of frame 22. The space defined by deck 44 and front and rear transverse plates 70 and 72 provide a transverse race wherein a tie unit 78 as carried by a movable carriage 80 is contained. The carriage 80 is transversely movable by means of forward carriage wheels 82 and rear carriage wheels 84 which rest on suitable transverse horizontal race ways 86 and 88, respectively. The raceways 86 and 88 may be welded to the inner side of front and rear transverse plates 70 and 72. The carriage 80 is further supported and driven by means of front drive gear 90 and rear drive gear 92 disposed in engagement with a front rack gear 94 and a rear rack gear 96 which are suitably welded on the upper surface of reflective flanges 74 and 76.

While the primary power source and various hydraulic fixtures have previously been designated as being positioned within compartment 52, and alternative structure operates to good advantage with the engine and hydraulic power equipment located at the bottom rear in a space designated generally by dashed lines 98. Actually, a wide range of choices may be exercised in the selection of power equipment mounting and routing of transmission facilities. One or more additional upright support frames 100 may be utilized to provide support between the upper extremities of the superstructure and the lower part of frame 22. This too is a matter of choice and well within standard engineering applications.

A front portion or bar guide assembly 102 of bar tie machine 10 provides the function of accepting the plurality of longitudinal reinforcing bars 16 and of periodically placing one of the transverse reinforcing bars 20 into a tie position. A forward projecting frame is formed by a plurality of upper diagonal supports 104 which are equip-spaced transversely across machine 10 and connected between the upper edge of front frame plate 70 and a forward bar 106. Similar, in-line frame structure is formed by lower diagonal bars 108 which are secured between forward bar 106 and the forward edge of a lower transverse brace 110 secured between forward lower edges of side frames 40 and 42. A similar plurality of horizontal frames 112 are extended from front bar 106 directly to the rear for suitable affixture relative to transverse brace 110 by any of various suitable heavy construction techniques.

The forward ends of horizontal frames 112 are secured to a horizontal plate or tray 114 which serves as the transverse bar storage 18 to hold the bars and allow them one at a time to be placed in a stand-by position. Thus, each of upper diagonal frame members 104 has a generally perpendicular arm 116 welded on the under side and a strengthening web 118 is included to insure that arm 116 remains at the proper angle relative to tray 114. A plurality of transverse reinforcing bars 20 may then be placed in the tray 114 and only one transverse bar at a time is able to pass diagonally downward through an opening 120 whereupon additional bar selection apparatus will carry it into tying position as will be further described. The various moving parts of the bar guide assembly 102 are shown to better advantage in FIG. 5. It can also be seen that the tray 114 is formed with a downwardly bent rear edge 122 which serves to hold a single transverse bar 20 in proper position for pickup.

Each of the lower diagonal members 108 has a bar guide member 124 welded thereto. The bar guide 124 is formed with a flanged, circular upper surface 126 which provides a guideway for transverse bars 20 as they are

carried through operational traverse. Such traverse is effected by means of a plurality of guide levers 128. Guide levers 128 are secured perpendicularly (as by welding) to a lever shaft 130 which is rotationally secured in suitable brackets or pillow blocks 132. Each of guide levers 128 is fitted with a pawl member 134 at its outer end, pawl member 134 being free to move upward, as on the downstroke of guide lever 128, but which is held secure on the upstroke to deliver successive ones of the transverse reinforcing bars 20 up along the surface 126 of guide member 124. Periodic actuation of guide levers 128 is effected by rotation of lever shaft 130 through rotation by means of hydraulic cylinder 136 (FIG. 4). Thus, a suitable control lever 138 is affixed to lever shaft 130 and connected through a piston rod 138 to the hydraulic cylinder 136. The control of hydraulic cylinder 136 is carried out in accordance with a predetermined program as will be further described below.

Each of the longitudinal bars 16 is led over a respective guide disc 140. A plurality of such guide discs 140 are secured in equi-spaced relationship along a shaft 142 which is supported for rotational movement in a plurality of brackets such as journal blocks 144 secured on side frames 40 and 42 and bushing blocks 146 secured on plural internal frame members (see FIG. 2).

Each of guide discs 140 is constructed in the form of a thin drum having a narrow cylindrical race 150 secured between a pair of circular side guides 152 which serve to keep a longitudinal reinforcement bar in position on race 150. Each of guide discs 140 is further shaped to include oppositely disposed bar holding notches 154 and 156 which serve as holding spaces for movement of transverse reinforcement bars 20. One guide disc 140 along the rotational shaft 142 is employed for each longitudinal steel bar which is to be included in the array. It should be obvious of course that a lesser number of steel bars may be handled simply by omitting certain numbers and/or positions of the bars themselves.

A plurality of pulleys 158 are also included periodically along the rotational shaft 142. The pulleys 158, e.g. on the order of six or eight equally spaced pulleys, serve to impart movement to respective belts 160 which function to move transverse bars 20 toward the rear and into a tying position. Thus, as shown most clearly in FIG. 5, each of belts 160 is tensioned rearwardly from rotational shaft 142 by means of a tension pulley 162 which is adjustably positioned so that the top level of belt 160 is at a proper, generally horizontal attitude with respect to tie units 78. Such tension is provided through a spring-loaded tensioning assembly 164 which is pivotally attached at a bracket 166 to the frame 22 in suitable manner, and which is further adjusted as to tension and level by means of a suitably anchored chain 168 and turnbuckle 170.

After the completion of plural ties across a transverse bar 20, the reinforced steel mat 12 is passed under a first or upper roller 172 and, in turn, it is supported by rear roller 66 to be allowed to reassume its position at rest in the pavement bed. Suitable chair elements or other such supports may be applied to keep mat 12 up off of the bed floor. The rear roller 66 may be suitably secured for rotation by means of oppositely disposed brackets 174 (FIG. 3) suitably mounted on the side frame members 40 and 42, and similar rotational securing points may be located for the upper roller 172.

Forward motion may be applied to the machine 10 by hydraulic means such as hydraulic motor 176 of FIG. 2. As shown in greater detail in FIG. 6, hydraulic motor 176, suitably mounted to the frame 22, receives energizing power via hydraulic lines 178 and 180. Rotational output on a shaft 182 and drive gear 184 is then transmitted via a chain 186 to a gear 188. The driven gear 188 then transmits motion via axle shaft 190 through sleeve member 36 to the rear wheel 26. It should be understood that this is only one of many possible forms of drive sys-

tem which may be employed with the programmed control of the present invention.

Similarly, an exemplary form of hydraulic steering system is depicted in FIG. 7. A reciprocating hydraulic cylinder 192 (also shown in FIG. 4) is suitably secured to the under side of frame 22, and it is energized by means of hydraulic power as supplied through hoses 194 and 196. The hydraulic cylinder 192 then extends a reciprocating piston rod 198 into pivotal connection with one end of a pivot plate 200. Pivot plate 200 is pivotally secured at a pivot point 202 to the under side of transverse frame 110, and a central pivot point 204 may be secured to a transverse tie rod 206. The transverse tie rod 206 may then be secured in conventional manner to the opposite front wheel pivot assemblies 32 and 34 to effect coordinated turning action. Thus, the left side of the tie rod 206 may be pivotally connected by a pin 208 to a pivot lever 210 associated with the wheel pivot assembly 32, and similar connection would be made between the opposite end of tie rod 206 and the right hand wheel pivot assembly 34 (FIG. 2).

A program assembly 220 is secured on the end of the rotational shaft 142, that which turns in response to movement of plural guide discs 140 in contact with the longitudinal steel bars 16. The program assembly 220 is shown in greater detail in FIGS. 8A and 8B. Program assembly 220 consists of a disc 222 which is rigidly secured on the outer end of the rotating shaft 142. The rear face of disc 222 is formed with a pair of cam tabs 224 and 226 disposed 180° apart and on the outer edge of disc 222. The cam tabs 224 and 226 provide alternate means for actuating a switch arm 228 in the direction shown by arrow 230 to control switch 232. Switch 232 in its normal position disables traverse of carriage 80 and enables forward drive of tying machine 10. An additional actuator arm 234 moved by the carriage at the end of a tying traverse, serves to urge switch 228 inward to free it with respect to the cam tabs 224 and 226; this allowing the next program sequence.

The disc 222 carries an additional adjustable cam lobe strap 236. Thus, lobe strap 236 extends a pair of cam lobes 238 and 240 on each end, 180° displaced, and these may be adjustably positioned by tightening a pair of set screws 242 and 244 against the program disc 222. The cam lobes 238 and 240 serve to actuate alternately a pair of switches 246 and 248. The upper switch 246 is periodically actuated by means of a roller arm 250 for the purpose of disabling steering power while forward motion of tying machine 10 is stopped, and lower switch 248 is actuated by a roller arm 252 to actuate transverse bar pickup operation, i.e. energization of hydraulic cylinder 136 to raise pickup levers 128. The interrelationship of all switch functions in the operating program will be further described below.

Referring now to FIGS. 9 and 10 the reciprocating carriage 80 carrying right tie unit 78 and a left tie unit 260, is shown in greater detail. The carriage 80 is movable as supported by forward guide wheels 82 and rear guide wheels 84 on respective guide bars 86 and 88 (which are suitably affixed across the inner side of forward and rear transverse plates 70 and 72, respectively). A hydraulic motor 262 may be controlled to provide rotational output on a forward shaft 264 and a rearward shaft 266 and these impart drive power to the drive gears 90 and 92, respectively. Thus, drive gear 90 is driven along the forward rack gear 94 in one or the other direction, depending upon control as will be described, and the rear drive gear 92 is similarly disposed in mesh with rack gear 96 (FIG. 5).

Carriage traverse control is effected utilizing switch actuators 268 and 270 disposed on opposite side frames 40 and 42. Thus, actuator 270 consists of an actuating arm 234 which is pivotally connected to a spring loaded support 272 to extend a T-connected pivot bar 274 and a roller 276 thereabove. Traverse of carriage 80 to the

right side will reach its limit when a lower tab 278 welded on the underside of carriage 80 contacts roller 276 to urge actuating arm 234 inward to effect a control actuation as will be described. Similarly, the left side structure includes a tab 280 welded on the underside of carriage 80 and, in operating alignment therewith, the actuating assembly 268 consisting of actuating arm 282, T-connected pivot bar 284 and roller 286.

Tie control or the operational switching of right tie unit 78 and left tie unit 260 is effected by means of a program bar 288. Program bar 288 is rotationally secured in horizontal disposition along the inner side of the front frame panel 70 by means of a plurality of bearing blocks 290. Each end of program bar 288 includes an oppositely oriented helical bearing member 292 and 294. The helical bearing member 292 provides helical bearing surface 296 which coacts with a roller 298 during rightward movement of carriage 80 to move program bar 288 through a 90° arc. Roller 298 is suitably secured by a bracket 300 welded to carriage 80 and disposed in proper alignment to contact helical bearing surface 296. Similarly, a roller 302 secured to carriage 80 by means of a bracket 304 provides similar function for leftward movement of carriage 80. Thus, bearing member 294 includes a helical bearing surface 306 which is oppositely pitched from bearing surface 296 and which, when contacted by roller 302 during leftward movement of carriage 80, causes rotation of program bar 288 through an oppositely directed 90° arc, i.e. a return rotation.

The program bar 288 has a plurality of programming blocks 308 disposed therealong. Each of programming blocks 308 includes an actuating tab 310 and each of the blocks 308 is positionable by means of set screws or such so that the spacing and orientation of tabs 310 can be set to impart a predetermined program sequence to program bar 288. The program actuation is effected by means of a carriage-tie control switch 312. The carriage-tie control switch 312 includes an actuating arm 314 and it is secured on the carriage 80 in such a manner that actuating arm 314 is disposed to traverse along program bar 288 as carriage 80 moves sideways.

Alternate ones of program blocks 308 are disposed with their actuating tabs 310 in a 90° phase relationship for the purpose of programming left and right traverse of carriage 80 and left and right tie units 260 and 78 so that they tie every other intersection of longitudinal bars 16 and transverse bar 20. Thus, as shown in FIGS. 9 and 10, carriage 80 is making a leftward traverse, having made right ties 316 and left ties 318, and the carriage-tie control switch 312 is actuated by each one of the programming blocks 320 having an actuating tab 310 disposed horizontally (as depicted). At the end of the leftward traverse of carriage 80, roller 302 will contact the helical bearing surface 306 to rotate program bar 288 such that the alternate ones or program blocks 322 will then be disposed with horizontal tabs 310 to effect programming of rightward movement of carriage 80. That is, program blocks 322 will be in position to contact actuating arm 314 of control switch 312 during rightward traverse of carriage 80. It may be noted that the respective right and left end programming blocks 324 and 326 are formed to have two 90° displaced actuating tabs such that they actuate carriage-tie control switch 312 in either disposition of program bar 288. This is desirable, at least in the application employing 39 longitudinal reinforcement bars, as it provides an extra tie on the odd bar (bar 328 of FIG. 10) as carriage 80 begins its traverse in either direction.

FIG. 11 is a block diagram of the electrical interconnection which controls the various hydraulic operations through the programmed tying function. Various switch controls available to the operator at console 52 include steering automatic 330, steering manual 332, carriage automatic 334, carriage manual 336, drive automatic 338, drive manual 340, pickup levers automatic

342, and pickup levers manual 344. These are well-known switching devices which provide the interconnection of automatic control apparatus or, in the alternative, a manual override control for the various machine functions. A tie unit on-off switch 346 provides control energization to each of tie units 78 and 260.

Actuation of steering manual 332 would provide energization via line 348 to energize steering control 350, a selected form of solenoid valve connected to energize the steering hydraulics, hydraulic motor 192 (FIG. 7). Control of carriage manual 336 provides energization via line 354 directly to carriage drive control 356. Thus, carriage 80 can be moved either left or right depending on the switch connection at carriage manual 336. Drive manual control 340 energizes line 358 which controls drive control 360. Drive control 360 may also be a conventional form of solenoid valve operated to energize the drive hydraulics, hydraulic motor 176 (FIG. 6). The pickup levers manual control 344 operates via control 364, a solenoid valve controlling hydraulic cylinder 136 (FIG. 4).

Steering automatic 330 is effected via line 366 and a steering stop switch 246 to energize a steering sensor 368 which, in turn, provides proper steering actuation via line 370 to steering control 352. Steering stop switch 246 is the cam actuated switch as shown in FIG. 8A while steering sensor 368 may be a suitable form of sensor switch adapted for following a string line in accordance with conventional practice. There are various forms of switch which would be suitable for use as steering sensor 368; however, one form which is particularly adaptable is a control switch which is the subject matter of a co-pending U.S. patent application Ser. No. 683,256 entitled "Line Tracer Control Device," and filed on Nov. 15, 1967, in the name of Steele et al.

The automatic drive 338 is effected via line 372 which leads first through a drive enable switch 374 and return lead 376 to drive control 360 and, in the alternative, through the oppositely disposed drive enable switch 378 for return via line 380 to energize drive control 360. The drive enable switch 374 forms a portion of the switch 232 of FIG. 8A, that portion which is actuated by rotary movement of actuating arm 228. The drive enable switch 378 may be a similar switch (not specifically shown) disposed on the opposite or left side of the guide disc assembly 220. Automatic control of pickup levers is effected by the pickup levers automatic switch 342 acting via line 382 through pickup switch 248 for control energization via lead 384 to pickup levers control 364. The pickup switch 248 is the lower switch as energized by the lower cam lobe 240 in FIG. 8A.

Automatic control of the carriage is effected so that carriage 80 will make alternate, intermittent traverses across the frame of tying machine 10 in opposite directions. Control switching provides that carriage 80 will be driven a distance of the spacing of two longitudinal bars 16 in accordance with the program bar 288 (FIG. 10) whereupon carriage drive is removed and energization is applied to the bar tie mechanisms. Thus, the carriage automatic switch 334 provides an energization on lead 390 which is applied to carriage direction switch 392, the right side carriage control, as well as to the left side carriage direction switch 394. The outputs from oppositely disposed carriage direction switch 392 and 394 is then applied via respective leads 396 and 398 to the carriage-tie control switch 312 (FIG. 10). The carriage-tie control switch 312 then applies appropriate energization via a line 400 to carriage drive control 356 to effect either rightward or leftward movement of the carriage in intermittent manner. Control energization for the tie units is provided from the tie units on-off switch 346 via line 402 whereupon the carriage-tie control switch 312 effects energization on line 404 to a no-tie switch 406 and right tie unit drive control 408 as well as in parallel to a no-tie switch 410 and the opposite tie

unit drive control 412. The carriage-tie control switch 312 may be a conventional form of switch which exercises alternate application of carriage drive control and tie units drive control, this insuring proper carriage traverse, stop, tie, resume traverse, etc. The no-tie switches 406 and 410 may be ganged with control switch 312 and energized by the same roller actuator 314 (FIG. 10) when in its normal or relaxed position.

Referring now to FIG. 12, there is a top view of a tying mechanism 420 such as makes up the major portion of tie units 78 and 260. Tie apparatus 420 consists of a main frame 422, a generally rectangular array which includes additional and strategically located internal frame members such as diagonal frame 424, cross frame 426, a diagonal frame 428, and others as will be noted. Tie unit drive is applied by means of a hydraulic motor 430 suitably mounted as by a welded bracket 432 to the outer frame 422. The motor 430 then applies rotational output to a drive gear 434 driving a chain 436 onto an increased diameter gear 438 which is secured to impart positive rotation to a main drive shaft 440. Main drive shaft 440 is suitably retained by bushing brackets 442 and 444 which are mounted to the respective cross frame 426 and diagonal frame 428.

The main drive shaft 440 applies rotational force to a first cam wheel 446 which functions to effect binder twisting in forming the final knot or wire-twist. Thus, rotation of cam wheel 446 effects movement of roller arm 448 which, in turn, moves connecting rod 450 to rotate pivot arm 452 counterclockwise and this, in turn, moves connecting rod 454. The connecting rod 454 is pivotally connected at a pivot point 456 to a movable rack gear 458 which is longitudinally reciprocal and in mesh with a drive gear 460 which controls twisting mechanism extending therebelow (as will be further described).

A second cam wheel 462 is also connected to be rotated by main drive shaft 440 and cam wheel 462 provides additional functions through its rotation. Thus, and referring also to FIG. 14, cam wheel 462 is formed with a first cam lobe 464, the clamping lobe, which is positioned to catch and rotate a roller linkage 466 inward toward main shaft 440. Roller linkage 466 is secured to a cylinder portion 468 which is pivotally secured to diagonal frame 428 and the other end of cylinder portion 468 is secured as by welding to a lever 470. The lever 470 is then pivotally connected to a connecting rod 472 which is resiliently connected to a bracket 474 secured to impart rotation to a shaft 476 and a crank portion 478 secured thereto. As shown in FIG. 14, crank member 478 is linked to a connecting rod 480 which extends down into pivotal connection with bar clamping assembly 482.

Bar clamping assembly 482 consists of a pair of meshed gears 484 and 486 having respective clamp prongs 488 and 490 secured thereto, and each being held in meshed, movable relationship about pivot points 492 and 494. Thus, it can readily be seen that inward movement of lever 470 to turn crank member 478 downward or in clockwise direction will move connecting rod 480 to force clamp 490 downward, the gears 492 and 494 coacting to bring clamps 488 and 490 together. As shown specifically in FIG. 12, a second clamp assembly 496, 90° displaced, is also controlled to clamp in like manner. This is also effected by rotation of shaft 476 which is connected to a crank lever 498 to impart downward motion to a connecting rod 500 thereby to close clamp 496. The clamp assembly 496 is identical to the clamp assembly 482 of FIG. 14, i.e. it includes coactive gears similar to gears 492 and 494.

The second cam wheel 462 has still another function as controlled by a cam lobe 510. The cam lobe 510 provides a cyclical outward movement of a roller linkage 512 which is welded to a vertical lever 514. The vertical lever 514 is pivotally connected at a pivot point 560 on

diagonal frame 428 such that it moves a resilient connecting rod 518 and linkage 520 to initiate movement of a crow's foot 522 (FIG. 12) into position for the binding or twisting operation as will be further described below. An additional cutter element 524 is secured to the outer edge of second cam wheel 462 in such placement that it effects a wire severing operation at the bottom of its traverse as will also be further described.

Still a third cam wheel 526 is connected for rotation with main drive shaft 440 to provide further cyclical functions in the binder tying operation. Referring also to FIG. 15, third cam wheel 526 is formed to have a cam race 528 formed by a pair of similarly shaped raised portions or lands 530 and 532 which form a raceway for a roller 534 as carried by an elbow linkage 536. The elbow linkage 536 is pivotally secured at a pivot point 538 to the diagonal frame 428, and elbow linkage 536 also extends upward for pivotal connection at a point 540 to a connecting rod 542. Thus, it can be seen that rotation of third cam wheel 526 results in a longitudinal reciprocation of connecting rod 542 to impart rotation in varying degrees to a crank 544 rotating about a shaft 546. The third cam wheel 526 operating through cam raceway 528 and connecting rod 542 provides the primary control of the needle assembly 552 as will be further described below. Additionally, a cam lobe 550 attached to the outer edge of third cam wheel 526 serves to close the jaws of a wire gripper 554 also to be further described below.

FIG. 16, a further progressive section through FIG. 12, shows a third cam wheel 526 with interconnection to the needle 552 and wire gripper assembly 554. It should be restated that the movement of needle 552 is derived from cam action as shown in FIG. 15; that is, connecting rod 542 turns crank 544 which is secured to turn crank shaft 546 and, noting FIG. 16, it can be seen that shaft 546 is again affixed to rotate a crank 556. Movement takes place relative to stationary members consisting of an upright post member 558 suitably welded to main frame 422 and extending a rigidly connected support brace 560 which, in turn, has an upwardly turning support arm 562 welded securely thereto. The support brace 560 is also welded to a sleeve member 564 which provides the support for crank shaft 546 carrying the primary input rotation. The crank 556 is pivotally connected to a push rod 566 which, in turn, is connected to an elbow linkage 568. The elbow linkage 568 has a central connecting point 570 pivotally connected to stationary brace 560 and its other end is pivotally connected to the upper end of needle 552.

A more central point 572 of needle 552 is pivotally connected to a linkage 574 which leads down to a pivotal connecting point 576. The pivotal connecting point 576 provides a tie point for a pivotal linkage 578 having its other end tied to upright brace 558, as well as to a connecting rod 580 which provides the function of moving wire grabber assembly 554 into position as will be further described. Also, a lever rigidly attached to linkage 574 provides connection for a return spring 582 held in tension by a suitable connection 584.

The rigid support arm 562 also pivotally supports an elbow-shaped roller arm 582 such that contact with cam lobe 550 forces resilient connection point 584 downward to depress push rod 586, this tending to close the jaws of wire grabber 554. As shown in FIG. 17, the main body of wire grabber 554 includes a notch 588 in the bottom edge and a clamping jaw 590 is secured thereon by pivotal connection 592. The descending push rod 586 is then secured in the upper side of clamping jaw 590 such that its downward depression will close jaw 590 about pivot point 592 to hold the wire which will have been inserted in notch portion 588. The upper side of clamping jaw 554 is extended as a flanged portion 594 to serve as a connecting point for receiving the clamping assembly positioning rod 580 in pivotal manner.

It may be noted that certain parts of the needle moving linkages are double and disposed in side by side relationship. This can be noted in FIG. 14 where the linkage 568 is a double piece, this being desirable to maintain a uniform and balanced linkage giving proper linear response in high stress situations. Thus, input rotation from shaft 546 to crank 556 will tend to move elbow linkage 568 counter-clockwise such that it allows the needle to move first outward and downward and then to move inward and upward such that the end 598 of needle 552 carrying the binder material or wire 600 will have encircled below the intersection of a longitudinal bar 16 and a transverse bar 20 to hold the end of binder wire 600 in position for gripping by wire grabber 554. This attitude completes the initial step of the binding or wire tying operation.

FIG. 19 shows a still further progressive section across the tying machine 420 of FIG. 12, this section showing the binder twisting mechanism in greater detail. Thus, main frame 422 includes an inverted U-shaped frame 602 which provides support for a twisting assembly 604, including crow's foot 522 as well as the associated rack gear 458 (FIG. 12). A channel member 606 suitably secured on top of upright frame 602 provides a raceway for rack gear 458 which is moved reciprocally therein by connecting rod 454 and the pivotal linkage 452 as previously described. Connecting rod 454 is connected to pivot post 456 which is rigidly secured to the end of rack gear 458 and, also, a rack return spring 608 is suitably secured from pivot point 456 back to a post 610 affixed at the side of the upright frame structure.

The binder material 600 is fed in through an eyelet 612 which is suitably secured on a vertical member 614 of upright brace 602 so that the binder material 600 will be properly fed to needle 552 (FIG. 17). Any of various forms of binder material may be used; however, it has been found that the tying mechanism operates to very good advantage when utilizing standard baling wire as supplied in long-length coil form. The size and gauge of the binder wire 600 is not critical since the tying mechanism 420 is adapted to handle any of various gauges of wire while still performing a tight tie. A wire cutting assembly 616 extends a cutting head 618 into the proximity of the tying area to cut off clamped wire before each twisting operation. As shown in FIG. 20, wire cutting mechanism 616 may consist of a first scissor arm 620 which is pivotally secured at a post 622 affixed to main frame 442. A second scissor 624 is pivotally secured to scissor arm 620 in such a manner as to leave cutting jaw 626 in an open position when scissor 624 is held in its normal position, i.e. movably retained on pivotal linkage 628 as held by a tension spring 630. Wire cutting or closing of cutting jaws 626 is effected by means of the cutting actuator 524 on cam wheel 462 (FIG. 15) contacting the scissor arm 624 at about the point 632 to urge the cutting jaw 626 momentarily closed. As can be seen in FIG. 15, the cutting actuator 524 will contact scissor arm 620 at about the bottom of the cycle of second cam wheel 462 as previously described.

Referring again to FIG. 19, the twisting assembly 604 is operated by two co-acting actuating sources. First, a pivot arm 634 is moved in a clockwise direction about a pivot post 636 to effect inward swing of crow's foot 522 into a tying or twisting position in the area where the reinforcing bars cross and the tying wire 600 is fed. Actually pivot bar 634 is a rigidly secured extension of pivot bar 520 which is actuated by second cam 462, cam lobe ridge 510, roller arm 512 and the mechanism shown particularly in FIG. 15. This same combination of structure is shown in perspective view in FIG. 21. Thus, the pivot arm 634 is attached to a connecting rod 638 which is pivotally attached to a tension cam 640. Tension cam 640 then extends a pivotal attachment 642 therebelow for affixture to a connecting rod 644 which is movably secured to a suitable bracket 646 attached to main frame 422. The tension cam 640 is rotatably connected by means

of a bolt or such fastener 648 each that rotation of tension cam 640 (as by clockwise motion of pivot arm 634) will tend to pull crow's foot 522 inward proximate the tying position as pivoted by connecting rod 644, and this will also tend to rotate a contact portion 650 of tension cam 640 in clockwise direction to effect the securing of the wire in crew's foot 522 as will be described immediately below.

The twisting assembly 604 is actuated for its twist operation by the rack driven gear 460 (FIG. 12) which, in turn, is affixed to apply rotational drive to a shaft 652. The rotation is then applied through a rotary joint 654 to a shaft 656 and finally to the crow's foot 522 and an associated crow's foot clamp 658. The shaft 656 is rotationally held by a bushing member 660 retained by a bracket 662 which is pivotally fastened to a pair of hanger straps 664 and 666, each secured as by welding beneath the upright frame member 602. An arm 668 is welded to the bracket 662 to extend therebelow and pivotally support a pair of lever arms 670 which rest on the upper shoulder of tension block 658. Tension block 658 is supported above crow's foot 522 and a shaft 672 by means of a compression spring 674 which tends to hold tension block 658 upward in relaxed position. The tension arms 670 are secured to together at their end 676 and so positioned that contact end 650 of tension cam 640 will urge them downward to force tension block 658 down into contact with crow's foot 522 to clamp the binding wire therein, this being effected in coordinated manner only after pivot arm 634 has moved far enough in the clockwise direction to place crow's foot 522 about the threaded wire. An adjustment screw 678 (FIG. 19) provides means for setting the coordination of positioning of crow's foot 522 with the depression of the bar 670 and therefore the clamping block 658.

FIG. 22 is a perspective view of a portion of the tying mechanism 420 which shows the complete drive and actuation system for applying twisting power to crow's foot 522, i.e. rotation of shaft 652 (see also FIG. 21). Thus, the rotation of shaft 652 is received directly from the rack driven gear 460 rotatably held by a right-angle bracket 680 which is secured as by welding to upright frame member 602. The gear 460 is driven by movement of rack gear 458 which is slidably retained in the channel member 606. Channel member 606 is formed with a flange and retaining attachment 682 which serve to keep rack gear 458 in the slide channel. Also, the other end of channel member 606 is formed with a ridge 684 shaped to mesh with the movable pivot bracket 456, the ridge 684 serving as a slide guide when pivot bracket 456 is urged along channel member 606 under force of connecting rod 545, pivotal bar 452, etc.

Operation

The bar tying machine 10 may be positioned in proper placement across a prepared road bed or such to proceed through a tying sequence thereby to prepare paving reinforcement bars. In an exemplary application, employing a widely accepted specification, a two-lane pavement slab would be required to contain thirty-nine equally spaced longitudinal reinforcement bars. Thus, thirty-nine such longitudinal reinforcement bars, e.g. $\frac{3}{4}$ " standard reinforcement steel, may be arranged longitudinally in the roadbed. Such steel is generally obtained in the sixty foot lengths and it is then necessary to continually splice the individual lengths together to provide thirty-nine continuous lengths of reinforcement steel.

The transverse reinforcement steel may be a standard form of $\frac{1}{2}$ " bar cut approximately to the width of the road bed. A plurality of such transverse bars 20 can be carried on the tray 114 (FIG. 2) of bar tying machine 10, and one transverse bar 20 at a time will be allowed to pass downward through the openings 120 to rest on bar guide 124 in a standby position.

Each of the longitudinal bars 16 is initially led over

the forward bar 106 and through respective ones of guide discs 140. Thereafter, each of the longitudinal bars 16 is led rearward beneath the tie unit carriage 80 and on rearward under upper roller 172. The reinforcement steel then proceeds from upper roller 172 over the lower or rear roller 66 whereupon it is allowed to rest back on the surface of the roadbed as a tied reinforcement mat as will be further described below.

Once the longitudinal steel bars 16 are properly run through the bar tying machine 10 and resting upon individual ones of the bar guides 140, the bar tying machine 10 is capable of automatic, programmed operation. That is, an initial starting of the drive system energizes hydraulic motor 176 (FIGS. 2 and 6) to drive bar tying machine 10 forward along the road bed. It should be mentioned too, that on the initial start a transverse steel bar 20 should be placed across holding notches 154 to properly fill out the operation on its first programmed tying sequence. Thus, the weight of longitudinal steel bars 16 bearing or guide discs 140 will cause the guide discs 140 to revolve as bar tying machine 10 progresses forward. Rotation of guide discs 140 and therefore rotational shaft 142 also cause rotation of the disc 222 of program assembly 220 (FIGS. 8A and 8B). Once bar tying machine 10 starts in a forward direction it is then allowed to move forward until program disc 222 and, therefore also, the guide disc 140 have made one half of a revolution. Respective adjustable cam lobes 234 and 240 will then effect their characteristic actuations. During this one-half of a revolution the transverse bar 20 from notches 154 will have been carried rearward along belt 160 to be stopped in the tying position below carriage 80.

Referring to FIG. 8A, when guide discs 140 have made their one-half of a revolution, cam tab 224 will have actuated switch arm 228 downward to disable forward drive of tying machine 10 and to enable application of power for traverse of the carriage 80. Also, as adjustable cam lobe 238 actuates roller arm 250, the upper switch 246 is actuated to disable application of power to the steering hydraulics, the hydraulic cylinder 192 and linkage of FIG. 7. Simultaneously, the lower cam lobe 240 actuates roller arm 252 to close lower switch 248 such that it energizes hydraulic cylinder 136 to rotate the lever shaft 130 thereby raising the plurality of pickup levers 128. The raising of pickup levers 128 then brings the next transverse bar 20 from a standby position up into a notch of guide discs 140, the notch (after the first half revolution) would be notch 156. The interrelationship of pickup levers 128 and guide discs 140 is shown to good advantage in FIG. 5.

After forward advance of bar tie machine 10, when stopped by program assembly 220, one of the transverse bars 20 will have been moved along belt 160 into the tying area beneath the center of carriage 80. Referring more particularly to FIGS. 9 and 10, the carriage 80 will be positioned on one side or the other of the frame of bar tying machine 20. The program bar 288 will be rotated to one or the other of two 90° displaced positions. This depending upon which side the carriage 80 is positioned for the start of the particular tying sequence. Thus, as shown in FIGS. 9 and 10, carriage 80 was positioned on the right side to start the tying sequence and the approach of carriage 80 to the right side on the prior tying sequence had cause roller 298 to rotate the helical surfaced bearing member 292 such that program bar 288 was rotated as shown in FIGS. 9 and 10. That is, program bar 288 is rotated with alternating program blocks 320 disposed with its actuating tab 310 in a horizontal orientation, this placing each of the actuating tabs 310 in line to actuate roller arm 314 of control switch 312. The program blocks 320 serve to periodically actuate switch 312 through the leftward traverse of carriage 80 such that the carriage 80 stops and performs ties at each successive stopped position occupied by tying units 78 and 260. The carriage drive hydraulic cylinder 262 is intermittently re-

energized to move carriage 80 further leftward until the next contact with a program block 320.

As may be noted in FIG. 10, a single control switch 312 serves to control both of tie units 78 and 260 as well as the traverse of carriage 80 in each direction across bar tying machine 10. When carriage 80 reaches the end of its sideways traverse (e.g. towards the left side) the tab 280 on the under side of carriage 80 contacts roller 286 of pivot arm 284 to urge actuating arm 282 inward such that it effects a switch control for carriage direction. Thus, as shown in FIG. 11, the urging of left actuating arm 282 would close carriage direction switch 392 such that ensuing carriage drive will be towards the right side of bar tying machine 10. The next tying sequence would find carriage 80 moved rightward across bar tying machine 10 such that the tab 278 would contact roller 276 of pivot arm 274 to urge actuating arm 234 inward and this would cause similar actuation of carriage direction switch 394 to prepare carriage 80 for its next ensuing traverse in the opposite direction, back leftward across bar tying machine 10.

The contact with pivot arms 284 and 274 and their respective actuating arms 282 and 234 serves also to signal the end of a tying sequence by enabling forward drive of bar tying machine 10. Thus, as shown in FIG. 8A, the right side actuating arm 234 forces actuating arm 228 inward to free it from contact with cam tab 224 while at the same time effecting drive enable switching, i.e. drive enable switch mechanism 374 of FIG. 11. Thus, switch 232 (FIG. 8A) may be a form of double actuation switch device capable of delivering both the drive enable 374 and carriage direction 392 functions in the program sequence. It may be noted that each of the end program blocks 324 and 326 is formed to have a cam actuating tab in both rotational positions of program bar 288. This is desirable since the standard form of reinforcement array, or at least the one we are using as this example, includes thirty-nine longitudinal bars, and the employ of such as double-tabbed program blocks 324 and 326 at each end enables tying of the odd longitudinal bar 16 first whereupon the traverse sequence of pairs-tying then begins with the second and nineteenth longitudinal bars.

The operation of the tie apparatus 420 as employed at each of tie units 78 and 260, is best described with reference to FIGS. 23 through 28 and other figures as noted. FIG. 23 shows the disposition of the operating components of a tie mechanism 420 prior to actuation of the tie mechanism. That is, a transverse bar 20 is supported beneath a longitudinal bar 16 is held by the support belts 162 (FIG. 5), the intersection of transverse bar 20 and longitudinal bar 16 being approximately centered in the tie area beneath tie mechanism 420. Referring to FIG. 12, under control of program control switch 312 on carriage 80 as well as a respective one of tie unit drive controls 412 or 408 (FIG. 11), the hydraulic motor 430 is energized to begin rotation of drive chain 436 and main drive shaft 440 to effect the tying operation. Thus, rotation of shaft 440 causes rotation of second cam wheel 462 (See also FIG. 15) to move pivoted cam roller arm 466 outward such that push rod 472 is moved to rotate shaft 476 and respective clamping assemblies 482 and 496 are clamped closed. Thus, even though the transverse bar 20 and longitudinal bar 16 were only in approximate alignment, clamping by assemblies 482 and 496 assures that the bars will intersect exactly at the right tying location beneath tieing mechanism 420.

As main drive shaft 440 continues to rotate, the tie components proceed toward that attitude shown in FIG. 24. Thus, as shown in FIG. 17, third cam wheel 526 rotates to effect several positioning moves. First, roller 534 is urged outward and connecting rod 542 pulls lever 544 and pivot shaft 546 through a clockwise (as viewed in FIG. 16) rotation. Such rotation of pivot shaft 546 then turns pivot shaft 556 and connecting rod 566 such that the needle 552 is forced along a path first outward and

then downward, generally following the movement depicted by black arrow 553. This same movement of needle 552 effects lengthwise movement of linkage 574 such that the pivot point 576 urges connecting rod 580 toward flanged portion 594 of wire gripper 554, this tending to move wire gripper 554 inward toward the tie area. As rotation of shaft 546 and, therefore, double linkage 568 continues, the needle 552 reaches its position encircling beneath the reinforcement bar intersection as shown in FIG. 24. In this attitude the needle 552 holds the end of wire 600 into position in the bottom notch 588 of wire gripper assembly 554. Thereafter, upward actuation of roller arm 583 by cam lobe 550 on third cam wheel 526 forces push rod 586 downward, this closing clamping jaw 590 to hold the end of wire 600.

Still further rotation of third cam wheel 526 causes needle 552 to complete its cycle as elbow 568 snaps over its center or balance relationship with respect to linkage 574 such that needle 552 returns back, and upward to pull wire 600 taut around the bottom of the intersecting reinforcement bars. This attitude also allows relaxation of push rod 580 which, as tensioned by spring 581, pulls flange 594 so that wire gripper assembly 554 exerts tension on the end of wire 600 on the other side of the reinforcement bar intersection. This then places the operating components in that attitude shown in FIG. 25. That is, wire 600 has been threaded around and under the reinforcement bar intersect, and the opposite ends are pulled upward by means of needle 552 and wire gripper assembly 554.

The next step of the typing operation is for the crow's foot 522 to be brought in to encircle opposite sides of wire 600, this attitude being shown in FIG. 26. This is effected by means of second cam wheel 462 as shown in FIG. 21. Thus, as second cam wheel 462 rotates, the camming ridge 510 urges roller arm 512 and lever 514 such that push rod 518 effects pivoting of lever 520 about pivot point 636. This in turn, moves pivot arm 634 and connecting rod 638 to pull the crow's foot 522 inward and down to effect a rotation of twisting assembly 604 about the axis formed beneath bracket 662 and hanger straps 664 and 666 welded to the bottom side of upright frame 602. This then, brings the crow's foot 522 inward whereupon the tines of crow's foot 522 catch and hold each side of wire 600 as shown in FIG. 26. A continued motion of connecting rod 638 to rotate the tension cam 640 brings contact portions 650 into bearing relationship on end 676 of tension arm 670, this tending to urge crow's foot clamp 658 downward such that it clamps each end of wire 600 within crow's foot 522 in tightly held manner.

It is also when crow's foot 522 and crow's foot clamp 658 are tightly engaged that the effect of cutting head 619 (FIG. 20) is brought to bear. Thus, in its normally open position the cutting head 618 is disposed adjacent the side of wire 600 as it is held by needle 552. It is then that cutting lobe 524 (FIG. 15) of second cam wheel 462 strikes the inside edge of portion 632 of second scissor arm 624 to close the cutting jaws and cutoff wire 600. Simultaneous with this release, third cam wheel 526 causes complete relaxation of needle 522 as well as release of wire 600 by wire gripper assembly 664 such that the wire twister assembly 604 is free to make its securing twists in the manner shown in FIG. 27. Thus, the opposite ends of wire 600 are held between opposite tines of crow's foot 522 and the crow's foot clamping block 658. Rotation of crow's foot 522 is then effected in the manner shown in FIG. 22. The first cam wheel 446 brings camming surface 447 to bear on roller arm 448 such that pivot arm 452 and connecting rod 454 draw the rack gear 458 across the rack retaining channel 606 to impart rotation to the rack driven gear 460. The gear 460 then transmits its rotation down through shaft 652 and rotational link 654 to shaft 656 such that crow's foot 522 is revolved several times placing a tight wrap around the

intersection of longitudinal bar 16 and transverse bar 20. The second cam wheel 462 then releases roller arm 512 which, in turn, allows withdrawal of crow's foot 522 back to its angularly cocked position. Shortly thereafter, first cam wheel 446 allows retraction of roller arm 448 such that rack return spring 608 returns the rack gear 458 back to its starting position and the operating elements are as shown in FIG. 28, the wire tie being complete.

It should be understood of course that the previously described tying sequence takes place simultaneously in each of tie units 78 and 260 as the units are carried across the array of longitudinal bars 16 to make a tie at every other transverse bar intersection. This of course is variable in accordance with the specification requirements of the steel reinforcement array. While the prior description was directly primarily to a dual-lane steel tying machine, it should be understood that the programming and adjustment flexibility of bar tying machine 10 will allow any of varied automatic wire tying applications. Also, while specific hydraulic energization devices are disclosed herein, it is contemplated that certain applications will require utilization of different power application means where particular characteristic advantages may be derived.

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

What is claimed is:

1. A machine for automatically binding transverse reinforcing bars to similar longitudinal reinforcing bars on situ in a roadbed to be paved, comprising:

frame means supported transversely across said roadbed and being movable therealong;

first means supported by said frame means for holding said longitudinal reinforcing bars at a raised position from said roadbed;

second means supported by said frame means for holding a plurality of said transverse reinforcing bars beneath said raised longitudinal reinforcing bars;

third means supported by said frame means and being periodically actuated to move one transverse reinforcing bar from the second means into a proximate position beneath said raised longitudinal reinforcing bars;

carriage means which is movably supported by said frame means and selectively positionable thereacross; a supply of binding material supported on said carriage means;

binding means supported on said carriage means and being periodically actuated to tightly wrap and secure said binding material about said transverse bar and a selected one of the longitudinal reinforcing bars; and

program means for coordinating said frame means movement, said third means actuation and said binding means actuation.

2. A machine as set forth in claim 1 wherein said frame means is further characterized to include:

wheel means affixed to said frame means on each side;

motor means secured on said frame means; and

drive means connecting said motor means to said wheel means to impart drive power to effect movement of the frame means.

3. A machine as set forth in claim 1 wherein said first means comprises:

guide shaft means rotationally supported by said frame means transversely across and raised above said roadbed; and

a plurality of guide discs secured along said shaft

means to receive respective longitudinal reinforcing bars and to support them at said raised position.

4. A machine as set forth in claim 1 wherein said second means comprises:

retaining means in the form of an elongated tray which is supported by said frame means transversely across said roadbed, said retaining means including a lower slot-like transverse opening which allows one transverse bar at a time to pass therethrough; and

guide means for supporting said one transverse bar.

5. A machine as set forth in claim 3 wherein said second means comprises:

retaining means in the form of an elongated tray which is supported by said frame means transversely across said roadbed, said retaining means including a lower slot-like transverse opening which allows one transverse bar at a time to pass therethrough; and

a plurality of guide means extending from immediately beneath the slot-like opening to a respective one of said guide discs.

6. A machine as set forth in claim 1 wherein said third means comprises:

pick-up shaft means affixed rotatably to said frame and being disposed transversely thereacross;

plural pick-up lever means each secured to said shaft means and extending into contact with said one of said transverse bars; and

power means which is periodically actuated to rotate said pick-up shaft means to raise said lever means such that said transverse bar is moved to said proximate position beneath the longitudinal bars.

7. A machine as set forth in claim 3 wherein said third means comprises:

pick-up shaft means affixed rotatably to said frame and being disposed transversely thereacross;

plural pick-up lever means each secured to said shaft means and extending into contact with said one of said transverse bars;

plural pulley means affixed to said guide shaft means intersticed with selected, spaced guide wheels;

plural belt means disposed longitudinally around each of said pulley means;

tensioning means holding each of said belt means movably disposed to extend rearward from respective pulley means and in alignment with said longitudinal bars; and

power means which is periodically actuated to rotate said pick-up shaft means to raise said lever means such that said transverse bar is moved upward across said guide discs to be securely held between said plural belt means and said longitudinal bars.

8. A machine as set forth in claim 1 wherein said binding means comprises:

clamping means disposed on said carriage means for periodic actuation to align said transverse and longitudinal bars in proper binding position;

needling means disposed on said carriage means actuable to receive said binding material and lead it under the intersecting transverse and longitudinal bars;

securing means disposed on said carriage means actuable to grip the ends of said binding material which are upwardly emerging on each side of said intersecting bars and to secure said ends together permanently;

cutting means disposed on said carriage means actuable to separate said binding material supply from the tied binding material around said intersecting bars; and

power means disposed on said carriage means and controlled by said program means to be periodically energized to effect proper sequential actuation of said clamping means, said needling means, said securing means and said cutting means.

9. A machine as set forth in claim 3 wherein said binding means comprises:

claimping means disposed on said carriage means for periodic actuation to align said transverse and longitudinal bars in proper binding position;

needling means disposed on said carriage means actuable to receive said binding material and lead it under the intersecting transverse and longitudinal bars;

securing means disposed on said carriage means actuable to grip the ends of said binding material which are upwardly emerging on each side of said intersecting bars and to secure said ends each to the other;

cutting means disposed on said carriage means actuable to separate said binding material supply from the tied binding material around said intersecting bars; and

power means disposed on said carriage means and controlled by said program means to be periodically energized to effect proper sequential actuation of said clamping means; said needling means, said securing means and said cutting means.

10. A machine as set forth in claim 2 which is further characterized to include:

main power means supported on said frame means;

actuation means controlled by said program means to enable said main power source periodically to energize said drive means; and

switching means controlled by said program means to actuate said third means.

11. A machine for automatically binding transverse reinforcing bars to plural longitudinal reinforcing bars, comprising:

frame means to be disposed transversely across said plural longitudinal bars;

main power means mounted on said frame means;

first means supported by said frame means and holding each of said longitudinal bars at a predetermined position;

second means supported by said frame means for receiving a transverse bar and holding it in predetermined position proximate to said longitudinal bars;

carriage means movably supported by said frame means for transverse movement thereacross;

a binding material supply supported on said carriage means;

binding means supported on said carriage means and receiving binding material from said supply; and

binder drive means supported on said carriage means and energized by said main power means to drive said binding means periodically to bind said transverse bar securely to selected one of said longitudinal bars.

12. A machine as set forth in claim 11 which is further characterized in that:

said binding material is wire; and

said binding means are a pair of wire twisting means supported in spaced relationship on said carriage means.

13. A machine as set forth in claim 12 which is further characterized to include:

carriage drive means supported on said carriage means and energized by said main power means to drive said carriage means transversely across said frame means;

program switch means mounted on said carriage means; and

program bar means mounted on said frame means and having a plurality of adjustable programming blocks affixed therealong to actuate said program switch means to de-energize said carriage drive means and to energize said binder drive means.

14. A machine as set forth in claim 13 which is further characterized in that:

alternate ones of said plurality of programming blocks are differently positioned to actuate said programming control switch such that said transverse bar is

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securely bound to every other one of said longitudinal bars.

15. A machine as set forth in claim 11 which is further characterized to include:

wheel means mounted on each transverse side of said frame means; and

wheel drive means supported on said frame means and energized by said main power means to drive said wheel means.

16. A machine as set forth in claim 15 wherein said first means comprises:

first shaft means rotatably supported by said frame means transversely thereacross;

a plurality of guide disc means secured along said shaft means, each such disc means receiving a longitudinal reinforcement bar thereover and bearing downward thereon to rotate said guide disc means proportional to movement of said wheel means;

program disc means secured to one end of such shaft means for rotation therewith; and

program switch means being mounted on said frame means adjacent said program disc means to be actuated by said program disc means after a predetermined amount of revolution to de-energize said wheel drive means.

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

lever shaft means rotatably supported transversely across said frame means;

a plurality of lever means secured to said shaft means and supporting said transverse bar thereon; and

pickup lever drive means energized by said main power means to rotate said shaft means such that pickup lever means carry said transverse bar into the proximity of said first means and each of said longitudinal bars.

18. A machine as set forth in claim 17 wherein said second means is further characterized to include:

a plurality of belt means disposed around said first shaft means and in frictional contact therewith;

a plurality of tension pulley means pivotally connected to said frame means and extending said belt means rearward from said first shaft means to support said transverse bar beneath said binding means.

19. A machine as set forth in claim 18 which is further characterized to include:

second program switch means mounted on said frame means and disposed adjacent said program disc means to be actuated by said disc means after a predetermined amount of revolution to energize said pickup lever drive means.

20. A machine as set forth in claim 18 which is further characterized to include:

third program switch means being mounted on said frame means and disposed adjacent said program disc means to be actuated by said disc means after a predetermined amount of revolution to enable said binder drive means.

21. A machine as set forth in claim 20 which is further characterized in that:

said binding material is wire and said binding means are a pair of twisting assemblies supported in spaced relationship on said carriage means.

22. A machine as set forth in claim 21 which is further characterized to include:

carriage drive means supported on said carriage means to be energized by said main power means to drive said carriage means transversely across said frame means;

fourth program switch means mounted on said carriage means; and

program bar means mounted on said frame means and having a plurality of adjustable programming blocks affixed therealong to actuate said fourth program

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switch means to de-energize said carriage drive means and to energize said binder drive means.

23. A machine as set forth in claim 21 which is further characterized in that:

alternate ones of said plurality of programming blocks are differently positioned to actuate said programming control switch such that said transverse bar is securely bound to every other one of said longitudinal bars.

24. A machine as set forth in claim 11 wherein said binding means comprises:

clamping means disposed on said carriage means for periodic actuation to align said transverse and longitudinal bars in proper binding position;

needling means disposed on said carriage means actuable to receive said binding material and lead it under the intersecting transverse and longitudinal bars;

securing means disposed on said carriage means actuable to grip the ends of said binding material which are upwardly emerging on each side of said intersecting bars and to secure said ends each to the other;

cutting means disposed on said carriage means actuable to separate said binding material supply from the tied binding material around said intersecting bars; and power means disposed on said carriage means and controlled by said program means to be periodically energized to effect proper sequential actuation of said clamping means; said needling means, said securing means and said cutting means.

25. A machine for automatically binding transverse rigid bars to plural longitudinal rigid bars, comprising:

frame means including plural, spaced wheels attached to support said frame means;

main power means supported by said frame means; guide means supported by said frame means to hold each said plural longitudinal bars and a transverse bar at a binding position within said frame means, said guide means being rotated at the rate of relative movement of said longitudinal bars;

carriage means transversely movably mounted on said frame means above said binding position;

binding means supported on said carriage means and being periodically actuated to bind said transverse bar and a selected one of said longitudinal bars;

frame drive means energized by said main power means to apply drive power to said frame means wheels; program disc means connected to said guide means for rotation therewith; and

first program switch means supported on said frame means and actuated by said program disc means to disable said frame drive means after predetermined relative movement between said frame means and said longitudinal bars.

26. A machine as set forth in claim 25 which is further characterized to include:

carriage drive means periodically energized by said main power means and being supported on said carriage means to drive said carriage means transversely; second program switch means actuated by said program disc means to enable said carriage drive means; and third program switching means supported on said carriage means to control actuation of said binding means.

27. A machine as set forth in claim 26 wherein said binding means comprises:

clamping means disposed on said carriage means for periodic actuation to align said transverse and longitudinal bars in proper binding position;

needling means disposed on said carriage means actuable to receive said binding material and lead it under the intersecting transverse and longitudinal bars;

securing means disposed on said carriage means actuable to grip the ends of said binding material which

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are upwardly emerging on each side of said intersecting bars and to secure said ends each to the other; cutting means disposed on said carriage means actuatable to separate said binding material supply from the tied binding material around said intersecting bars; and power means disposed on said carriage means and controlled by said program means to be periodically energized to effect proper sequential actuation of said clamping means, said needling means, said securing means and said cutting means.

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U.S. Cl. X.R.