

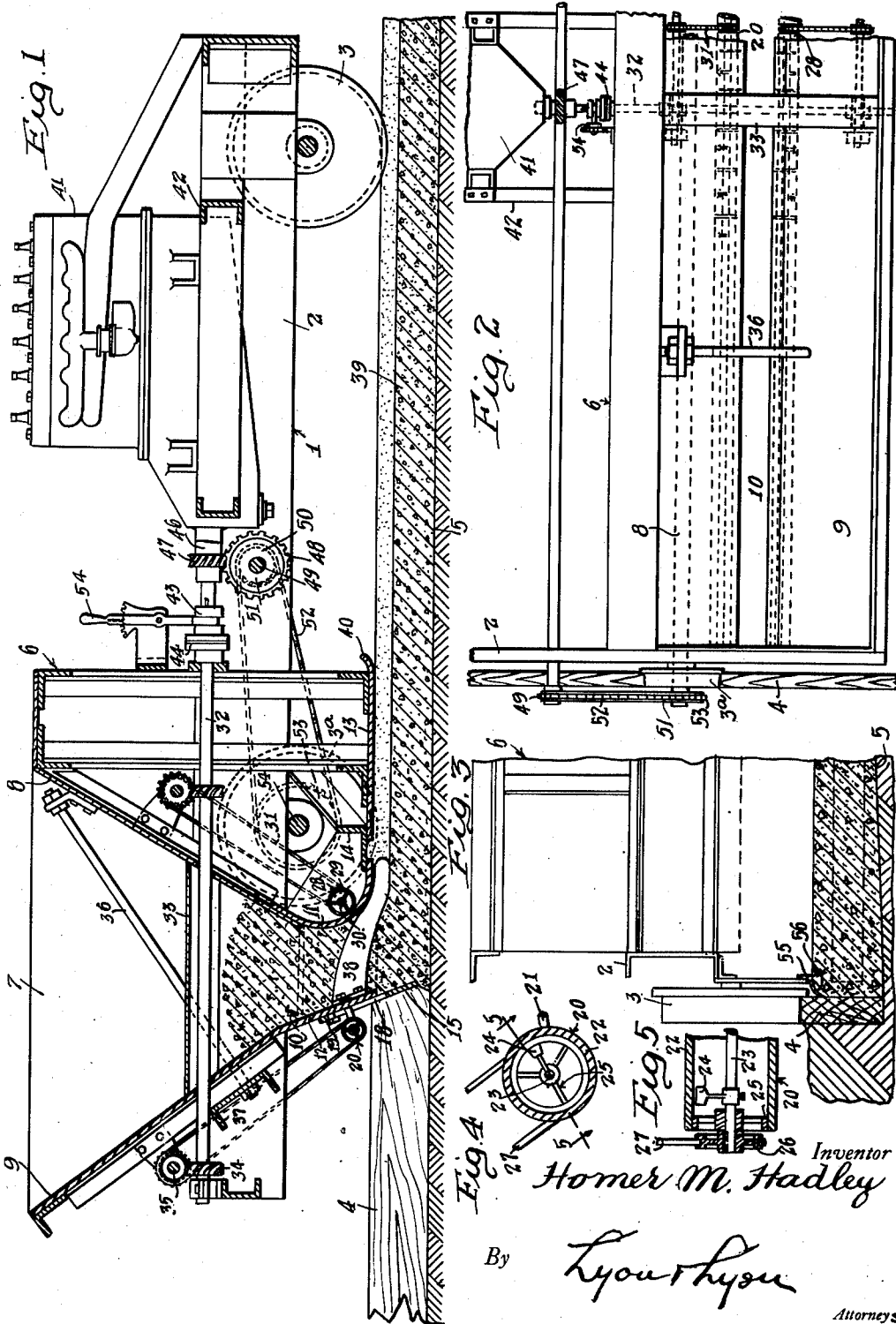
March 2, 1937.

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2,072,479

CONCRETE LAYING MACHINE

Filed Jan. 24, 1934



UNITED STATES PATENT OFFICE

2,072,479

CONCRETE LAYING MACHINE

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Application January 24, 1934, Serial No. 708,062

17 Claims. (Cl. 94—46)

This invention relates to a concrete laying machine, and particularly to a type of machine for this purpose, which involves the use of a hopper that extends transversely to the strip or roadway on which the concrete is to be laid. This hopper is advanced along over the area to be covered with concrete, and as it advances the concrete passes from the discharge outlet and is laid in a strip.

One of the objects of this invention is to produce a machine of this type having a discharge outlet from the hopper of a form that increases its efficiency, and to provide the same with means for condensing the concrete as it passes down onto the subgrade or other surface upon which the concrete is to be laid.

A further object of the invention is to provide means for bringing mortar in the concrete to the top as the concrete is placed, thereby giving a smooth top surface, and the presence of this mortar in the uppermost layers of the placed concrete also facilitates the dragging of the machine over it as will presently appear.

In machines of this type it is customary to provide side stringers at the side of the subgrade or strip where the concrete is to be laid, and the supporting wheels of the machine run on these stringers. If the machine and its contents have considerable weight, it tends to press the stringers down into the earth, and in this way the support for the stringers may fail. An undue depression of the stringers would depress the level of the laid concrete and would also interfere with the forward movement of the machine, that is necessary to lay the concrete. One of the objects of this invention is to provide a construction for the machine which will enable a considerable part of the weight to be supported on the placed concrete so that the pressure of the wheels on the stringers is greatly reduced, to such an extent that the pressure of the wheels on the stringers will be merely sufficient to insure proper traction of the wheels along the stringers, and this is also advantageous because the weight on the placed concrete tends to further condense it, and levels it off to the desired grade line.

In the operation of the machine a header plate is employed at the forward side of the discharge outlet of the hopper, and the placed concrete gravitates down against this plate. As the machine advances, of course this plate recedes and is constantly followed up by the placed concrete.

An important object of the invention is to

provide efficient means for vibrating the discharge outlet of the hopper and to construct the same in such a way that vibrations at this point are not imparted to the rider plate that rides on the placed concrete.

A further object of the invention is to provide improved means for forming a longitudinal channel or groove in the placed concrete to facilitate the formation of longitudinal "dummy" joints. While in practice more than one of these joints may be employed, depending on the width of the placed concrete strip, it is common to provide simply for forming a single longitudinal groove along the center line of the laid concrete strip.

A further object of the invention is to provide an improved construction for the vibrating means that I employ at the hopper outlet.

A further object of the invention is to provide means for bringing the mortar in the concrete to the upper surface as the concrete is laid, thereby producing a smooth top surface and also lubricating the movement of the machine in advancing it over the placed concrete.

A further object of the invention is to provide a machine so constructed that it will condense the concrete to such an extent as to enable the use of a "mix" of low cement and water content.

Further objects of the invention will appear hereinafter.

The invention consists in the novel parts and combinations of parts to be described hereinafter, all of which contribute to produce an efficient concrete laying machine.

A preferred embodiment of the invention is described in the following specification, while the broad scope of the invention is pointed out in the appended claims.

In the drawing:

Figure 1 is a longitudinal section of the machine in a plane lying near the center line, and illustrating how the hopper supplies concrete in placing the same on the subgrade;

Fig. 2 is a plan of a portion of the machine, certain parts being broken away and shown in cross section. This view is upon a scale about one-half of that used in Fig. 1;

Fig. 3 is a vertical cross section taken at the edge of the concrete strip and showing one end of the machine broken away;

Fig. 4 is a vertical section extending transversely to one of the vibrating devices; and

Fig. 5 is a section taken about on the line 5—5 of Fig. 4 and further illustrating details of the construction of the vibrating devices.

Before proceeding to a more detailed description of the machine, it should be stated that in laying concrete it is desirable to attain a condensing or consolidating of the concrete as the concrete is laid, and it is usually necessary to tamp the concrete after it is laid. This tamping is frequently done by hand. In accordance with my invention, I construct the machine in such a way that the placed concrete is condensed as it is placed, at the same time giving it a smooth top surface on the desired profile line. In addition to this, as the concrete passes down through the hopper outlet, it is subjected to vibration, and furthermore, I shape the hopper outlet so that as the hopper advances, the material is guided down onto the subgrade in such a way that the under side of the machine just in the rear of the hopper, with respect to the direction of advance of the machine, operates as a gigantic trowel, condensing the placed concrete and leveling off its upper face to a horizontal line or to a crown line extending across the roadway. One of the effects of vibrating the shaped rear throat of the hopper, is to bring the mortar in the concrete to the surface, and this operates to produce a smooth upper layer or dressing for the upper surface of the laid concrete.

The machine is preferably constructed with a transverse truss that extends across the subgrade or roadway on which the concrete is to be laid, and I provide a construction whereby a substantial part of the weight of the machine and its contents is imparted by this truss to the concrete immediately after it is laid. I also provide a construction for the frame of the machine which will enable substantially all of the weight of the loaded hopper to be carried on this truss.

Referring more particularly to the parts, 1 represents the frame of the machine which preferably includes two side members or bars 2. These side members are preferably formed of steel channels (see Fig. 3). The frame 1 is supported on wheels 3 and 3a that run on side stringers 4 set up at the sides of the subgrade 5. The side bars or side beams 2 are connected to a transverse truss 6 that is preferably of box type (see Fig. 1) built up out of structural steel. The machine is intended to be advanced along the stringers or rails 4 from right to left as viewed in Fig. 1. The hopper 7 for the machine is located forward of the transverse truss 6 with respect to the direction of advance, and its ends are connected to the side members 2, while the rear side plate 8 of the hopper may be secured to the truss.

The wheels 3 are in two pairs, and one pair, the wheels of which are indicated specifically by the reference numeral 3a, are located near the transverse truss and so that the left ends of the side members 2 are left unsupported by the stringers. In this way the weight of the hopper and its load is imparted to the truss.

The hopper may be of any suitable construction but preferably comprises an inclined forward plate 9; and the plate 8, which is the rear plate of the hopper, is so inclined that these plates converge downwardly toward the discharge outlet 10 of the hopper. The discharge outlet constitutes a contracted throat formed between a rear throat plate 11 and a forward throat plate 12.

The forward throat plate 12 preferably has its lower edge located at or just above the level of the laid concrete. It is preferable above because there can then be no tendency to dampen the vibration by contact with the roadway. The

throat plate 11 is convex on the side toward the concrete in the outlet and, while it is possible to construct it with straight faces, I prefer to give it substantially the curved form illustrated in Fig. 1 so that it presents a curved face on a large radius, and this curve is substantially tangent to the upper face of the laid concrete and substantially in the plane of the lower face of a screed in the form of a saddle plate or rider plate 13 that rests on the placed concrete. The rear edge of the plate 11 is not connected to the angle iron 14, (see Fig. 1). This gives it more freedom in vibrating. The plate 13 may be attached to the under side of the transverse truss and preferably forms the bottom plate for the truss.

It has been found in the practical operation of a concrete laying machine embodying this invention, occasionally there is a tendency for the laid concrete to bulge upwardly as it emerges from under the rear edge 40 of the screed plate 13. It is believed that this is due to the transmission of pressure from the concrete in the hopper through the laid concrete directly under the plate 13, and it is believed that by increasing the length of the plate 13 in the direction of the travel of the machine, this tendency can be overcome. In other words, it is desirable that the rigid screed plate 13 that is traveling forward at a fixed level have considerable width in the direction of travel, thereby providing a considerable zone under the plate 13 where the concrete is subjected to pressure, but not to directly applied vibratory impulses. For this reason the fact that the plate 11 is not connected to the plate 13, is highly advantageous.

It has also been found in practice, that the frequency of the vibratory impulses imparted to the throat plate 11, is very important. Some concrete was laid with the shaft of the vibrating device 28 driven at about 2400 R. P. M., and this produced unsatisfactory results in condensing the concrete. The speed of the shaft of this vibrating device was then increased to approximately 5000 R. P. M., and the result of the vibratory impulses at this frequency was very satisfactory in condensing the concrete.

The forward edge of the rider plate 13 is preferably located slightly to the rear of the rear edge of the rear throat plate 11, so that these two plates are not in contact with each other, so that vibration imparted to the throat plate 11 will not be imparted to the plate 13.

In the present instance, the adjacent edges of the throat plate and the rider plate 13 are located on the under side of the horizontal flange of an angle iron 14 that extends transversely of the machine between the hopper and the truss, to which angle iron the forward edge of rider plate 13 is preferably connected.

The forward throat plate 12 is preferably inclined substantially as shown, and at its lower portion I provide a header plate 15 which, in the operation of the machine is held fixed in a depressed position as indicated in Fig. 1 with its lower edge projecting down to a point at or near subgrade 5.

This header plate 15 is mounted so that it can be adjusted to any level, or when desired, it may be fixed in a raised position with its lower edge located above the level of the upper surface of the placed concrete. For this purpose the upper portion of the plate 15 is provided with vertical slots 18 receiving clamping studs 19 mounted in the plate 12, which enable the header plate 15 to be clamped in any position desired.

This plate 15 projects a considerable distance below the lower end of the hopper 7, see Fig. 1, and is supported at its upper portion only so that its lower portion can vibrate freely.

Means are provided for imparting vibration impulses directly to this plate 12. For this purpose I may provide a vibrating device 20 which is mounted on short posts or bolts 21 that pass through some of the slots 18. The body of the vibrating device is preferably in the form of a horizontal tube or pipe 22 within which a continuously driven shaft 23 is mounted, said shaft being provided with a plurality of eccentrically mounted weights 24. I prefer to provide a number of these weights located substantially equidistant throughout the length of the shaft. At suitable points in the tubing 22, spiders 25 are provided forming bearings for the shaft. The end of the shaft may be driven in any suitable manner. In the present instance, I have illustrated a belt pulley 26 driven by a belt 27 from above, as will be described hereinafter.

On the rear and upper side of the rear throat plate 11 I provide a vibrating device 28 (see Fig. 1) which has substantially the same construction as the vibrating device already described. The casing or tubing 29 of this vibrating device may be welded or otherwise attached directly to the throat plate 11. This may be done by spot welding at a number of points throughout the length of the tube or any other suitable means that attaches the tube at a number of points throughout the length of the throat plate 11. This insures that the vibration impulses will be imparted to the throat plate throughout its entire length. The shaft 30 of this vibrating device may be driven in any suitable manner but preferably by means of a belt 31.

The two vibrating devices are preferably driven from a common driving shaft 32 that may be located on the center line of the machine. This shaft extends through the hopper, and within the hopper may be covered by an apron 33 in the form of a bent plate, the ends of which are welded or otherwise secured to the plates 8 and 9 of the hopper. The belts for driving the vibrating devices may be driven from this shaft 32 through spiral gears 34 and 35.

In order to tie the forward plate 9 of the hopper to the rear plate 8, I prefer to provide two or more tie rods 36 which are preferably disposed in an inclined direction, as indicated in Fig. 1. The lower ends of these tie rods may pass through a transverse channel bar 37 under the plate 9. These tie rods assist in supporting the strains on the plate 9 and transfer the load on this plate over to the plate 8 near its point of connection to the girder.

Sometimes it is desirable to form a longitudinal channel or groove in the placed concrete to facilitate the formation of a longitudinal "dummy" joint. In order to enable this to be accomplished, I provide means in the form of a plate or arm 38 (see Fig. 1). The forward end of this plate or arm 38 is attached to the inner side of the forward throat plate 12. Toward its rear end, this arm is offset downwardly so that its lower edge is below the level of the upper face of the laid concrete. As the machine advances, this arm or marker will form a longitudinal groove in the placed concrete. As illustrated, the rear end of this arm 38 is located forward of the rider plate 13. If, in operation, it is found that the pressure exerted by the rider plate 13 tends to close the groove formed by the arm 38, then this

arm 38 may be made over-size in thickness or, if desired, it can be extended sufficiently to have its rear end located at or beyond the right hand, or rear, edge of the plate 13.

In order to enable the machine to be backed up on the placed concrete 39, if this should ever become necessary, I prefer to provide the rear edge of the plate 13 with an upwardly turned curved flange 40. This flange will act like a sled runner and will prevent scraping up the upper face of the placed concrete when the machine is moved back. Before backing up, of course, the header plate 15 should be bolted up in a raised position.

The machine may be pulled along by a tractor or may be advanced by any other suitable means, proper provision being made for driving the shaft 32 to actuate the vibrating devices. In the present instance, I provide for driving the vibrators and for advancing the machine by providing a gas engine 41 which may be mounted on special framing 42 under the engine. The engine is placed with its shaft extending longitudinally and in alignment with the shaft 32 so that it can drive a clutch member 43 in the form of a sleeve, the forward end of which will clutch up to a clutch member 44 to drive the shaft 32. In the rear position of the clutch sleeve 43, the clutch is open and the machine can advance without operating the vibrating devices. A sleeve 45 rigid on the engine shaft, carries a spiral gear 47 for driving a large sprocket gear 48. This sprocket gear 48 drives a cross shaft 49 through a reduction gear 50. The shaft 49 carries a sprocket wheel 51 for driving a sprocket chain 52 and this chain drives a sprocket wheel 53 on a cross-shaft 54, that carries the wheels 3a running on the side stringers 4.

The clutch sleeve 43 is provided with a suitable hand lever 54 for operating it.

In order to finish off the edges of the placed concrete 39, I prefer to provide each end of the hopper with a curved forming plate 55 (see Fig. 3). This forming plate is bent to a small radius and its outer edge lies against the inner face of the adjacent stringer. With this construction it will be evident that as the concrete is laid its upper edge will be formed into a rounded shoulder 56 adjacent the stringers 4.

In the operation of the machine, it will be noted that as the concrete descends through the discharge outlet 10, the column of concrete passing down the hopper is subjected to a condensing effect due to the weight of the concrete in the column, and to the fact that the outlet forms a contracted throat. In addition to this, the vibration of the rear throat plate 11 will tend to bring the mortar of the mix to the top, so that there is a tendency to increase the mortar content of the mix directly under the rider plate 13. This tends to produce a smooth upper surface for the placed concrete. As the machine advances, the forward face of the rear throat plate 11 acts as a rounded nose which compresses the concrete and presses the concrete down under it as the rider plate 13 passes along over the placed concrete.

The vibrating of the forward outlet plate is also advantageous, as it increases the vibration in the column of concrete and also tends to bring cement out to the face of this plate. This tends to increase the proportion of cement in the lower layers of concrete that are laid on the subgrade. This is most desirable.

The plate 13 has a sufficient area to insure that a considerable part of the weight of the machine

with its loaded hopper will be supported on the laid concrete. This reduces the weight of the machine resting on the wheels 3a, and this reduction in weight on the stringers is sufficient to

insure that they will not be displaced downwardly into the earth as the machine advances, so as to stall the machine and prevent the generation of sufficient traction for advancing the machine.

However, if it is found in practice that there is insufficient traction exerted at these wheels 3a, it will be obvious that a driving mechanism can be attached at the rear end of the engine so as to drive the two rear wheels 3.

It will be noted that the outlet is substantially unobstructed throughout its entire length. This facilitates the passage of the concrete through the contracted throat, and assists in attaining the condensing effect that the throat has due to its contracted form, and this effect is augmented by the vibrations given to the throat plate or throat plates.

By reason of the fact that the rear portion of plate 11 is unsecured to any fixed part, it vibrates throughout its entire length with great freedom.

It is understood that the embodiment of the invention described herein, is only one of the many embodiments this invention may take, and I do not wish to be limited in the practice of the invention, nor in the claims, to the particular embodiment set forth.

What I claim is:

1. In a concrete laying machine, the combination of a hopper with a front wall and a rear wall, and having an outlet, means for supporting and advancing the hopper over the area on which the concrete is to be laid so as to place the concrete through the said outlet, said outlet having a rear throat plate with an extension having a convex face in contact with the concrete as it passes through the outlet, said extension extending down from a point substantially in the plane of the said rear wall and curving rearwardly on the rear side of the outlet with respect to the direction of advance of the hopper, said outlet operating to lay the concrete directly onto the subgrade, and a vibration device for imparting rapid vibratory impulses to the rear side of the throat plate in a plane normal to the plane of the throat plate, said throat plate operating to transmit said impulses in a radial but generally horizontal direction through the mass of concrete to condense the concrete as it passes through the outlet.

2. In a concrete laying machine, the combination of a hopper having an outlet, means for supporting and advancing the hopper over the area on which the concrete is to be laid so as to place the concrete through said outlet, said outlet having a rear throat plate forming a continuation of the wall of the hopper and located on the rear side of the outlet with respect to the direction of advance of the hopper, said throat plate having a convex face in contact with the concrete, and means for vibrating the rear throat plate to condense the concrete as it passes through the outlet, said outlet operating to lay the concrete directly onto the subgrade, said hopper having a forward throat plate on the forward side of the hopper with respect to the direction of advance, and means for imparting rapid vibratory impulses to the throat plate, said throat plate transmitting said impulses through the mass of concrete to condense the same.

3. In a concrete laying machine, the combina-

tion of a frame having wheels at each side, stringers laid on the ground alongside of the area on which the concrete is to be laid, and forming a track for the wheels independent of the laid concrete, said frame including a truss extending transversely to the stringers, a hopper for the concrete having an outlet below, and supported on the said frame so that the weight of the loaded hopper is imparted to the truss, and a substantially horizontal screed plate rigid with the truss and below the same operating to ride on the laid concrete and to impose upon the laid concrete a considerable portion of the weight of the machine and its load, thereby relieving the wheels from a portion of the load to prevent undue depression of the stringers when the machine advances, and thereby insuring the maintenance of the upper surface of the laid concrete to the desired grade line, said outlet being substantially unobstructed throughout its length and having a curved rear throat plate with its rear edge substantially in the plane of said plate.

4. In a concrete laying machine, the combination of a transversely extending hopper with a discharge outlet below, means for supporting and advancing the hopper so as to place the concrete through said outlet, said outlet having a throat through which the concrete passes, said throat having a rear throat plate located on the rear side of the outlet with respect to the direction of advance of the hopper, said rear throat plate having a convex face on its forward side in contact with the concrete passing through the throat for guiding the concrete into placed position, and a rigid saddle plate rigid with the hopper and riding on the placed concrete.

5. In a concrete laying machine, the combination of a transversely extending hopper with a discharge outlet below, means for supporting and advancing the hopper so as to discharge the concrete through the said outlet, said outlet having a rear throat plate with a convex face disposed toward the concrete passing through the outlet, a saddle plate rigidly held in position and riding on the placed concrete, the lower end of said rear throat plate being substantially aligned with the forward end of the saddle plate but unattached thereto, to permit independent vibration of the throat plate, and vibrating means extending longitudinally of the hopper and mounted on the upper and outer side of the throat plate.

6. In a concrete laying machine, the combination of a hopper with a discharge outlet below, means for supporting and advancing the hopper in a direction extending transversely to the longitudinal axis of the hopper, so as to discharge the concrete through the said outlet, a header plate mounted on the forward side of the hopper at the outlet and against which the concrete placed on the subgrade rests, and means for securing said header plate in a depressed position or in an elevated position.

7. In a concrete laying machine, the combination of a hopper with a discharge outlet below, and capable of being advanced over the area on which the concrete is to be laid, said outlet having a throat with a forward throat plate located forwardly with respect to the direction of advance of the machine, said outlet having a rear throat plate with a forward face located in a substantially inclined direction operating, by the advancing movement of the machine, to guide the concrete down past the throat to lay the same, a saddle plate located substantially at the level of the upper surface of the laid concrete, and

vibrating means attached to each throat plate for vibrating the concrete to condense the same as it passes down through the throat.

8. In a concrete laying machine, the combination of a hopper with a discharge outlet below, means for advancing the hopper in a direction extending transversely to the longitudinal axis of the hopper, so as to lay the concrete, a truss supporting the hopper, extending longitudinally of the hopper on the rear side with respect to the direction of advance of the machine, said hopper having a forward wall on its forward side, and means connecting the said forward wall to the rear side of the hopper so that the weight of the mixed concrete in the hopper is imparted to the rear side of the hopper and to the truss, and a saddle plate rigidly held at a fixed level under the truss riding on the placed concrete and imparting a portion of the weight of the truss and hopper to the same.

9. In a concrete laying machine, the combination of a hopper with a discharge outlet below, means for advancing the hopper in a direction extending transversely to the longitudinal axis of the hopper, so as to lay the concrete, a truss supporting the hopper, extending longitudinally of the hopper on the rear side with respect to the direction of advance of the machine, said hopper having a forward wall on its forward side, and tension members connecting the said forward wall to the rear side of the hopper at intermediate points on its length, so that the weight of the mixed concrete in the hopper is imparted through the tension members to the rear side of the hopper and to the truss, a screed plate under the truss riding on the placed concrete, and vibrating means located at the said outlet for vibrating the concrete as it passes down through the same.

10. In a concrete laying machine, the combination of a pair of substantially parallel frame bars, a transverse truss supported on the side bars, wheels carried by the said bars for running on side stringers, a hopper for the concrete extending parallel with the truss with its ends supported on the side bars and with one of its sides attached to the truss and supported thereby, an opposite pair of said wheels being located adjacent said truss, means for advancing the machine, said truss being located on the rear side of the hopper with respect to the direction of advance of the machine, the forward end of said side bars being unsupported beyond the said opposite pair of wheels, said hopper having means for hanging the weight of the hopper and load in the same on the said truss, said hopper having a discharge outlet forward of the truss, and a rigid saddle plate fixed under the truss and riding on the placed concrete so as to impart a portion of the weight of the truss and loaded hopper to the concrete, to condense and level the same.

11. In a concrete laying machine, the combination of a hopper with a discharge outlet below, means for advancing the hopper in a direction transverse to the longitudinal axis of the hopper, so as to discharge the concrete through the said outlet, said hopper having a throat with a rear throat plate and a forward throat plate, and channeling means attached to the hopper at its forward side with respect to the direction of advance and supported completely thereby, said channeling means extending longitudinally with respect to the direction of advance of the hopper and under the rear throat plate

for forming a dummy joint groove in the placed concrete.

12. In a machine for laying concrete on a subgrade, the combination of a convex plate, means for advancing the convex plate with its convex side against the concrete that is being laid on the subgrade so that the convex plate rides over the concrete and presses the same down onto the subgrade, means for imparting vibratory impulses at a rapid rate to the convex plate to impart vibratory impulses to the concrete for condensing the same, and a substantially horizontal screed plate located to the rear of the rear edge of the convex plate with respect to the direction of advance, said screed plate being unconnected directly to said convex plate so that the vibratory impulses that are imparted to the concrete under the screed plate, come principally through the concrete, said screed plate being held in a fixed horizontal plane and imparting pressure to the laid concrete as the machine advances.

13. In a concrete laying machine, the combination of a hopper having an outlet, means for supporting and advancing the hopper over the area on which the concrete is to be laid so as to place the concrete through the said outlet, said outlet having a rear throat plate with a convex face in contact with the concrete as it passes through the outlet and located on the rear side of the outlet with respect to the direction of advance of the hopper, said outlet operating to lay the concrete directly onto the subgrade, and means for imparting rapid vibratory impulses to the throat plate in a plane normal to the plate, said throat plate transmitting said impulses through the mass of concrete to condense the same as it passes through the outlet.

14. In a machine for laying concrete on a subgrade, the combination of a hopper having an outlet through which the concrete extends in a vertical column supported on the subgrade, means for supporting and advancing the hopper over the area on which the concrete is to be laid, said hopper having a forward throat plate on the forward side of the machine with respect to the direction of advance of the hopper, and means for imparting rapid vibratory impulses to the forward throat plate in a plane perpendicular to the plane of the throat plate, and thereby imparting impulses in a general horizontal direction through the column of concrete to condense the same while supported on the subgrade.

15. In concreting apparatus, the combination of a plate member substantially free to bend and spring, to be advanced over and upon deposited concrete, said plate having its forward portion with respect to the direction of its advance, curved and turned upwardly, and means for imparting rapid vibratory impulses to the plate member normal to the curved surface of the plate member and thereby imparting rapid vibratory impulses to the concrete in contact with said forward curved and upturned portion.

16. In a concrete laying machine, the combination of a hopper for the concrete, said hopper having a throat plate extending downwardly below the lower edge of the hopper for guiding the concrete down and depositing the same directly onto the subgrade, means for supporting said throat plate at its upper edge only so as to leave the same free to vibrate, and means for imparting rapid vibratory impulses to the throat plate in a plane normal to the plane of the plate.

17. In a concrete laying machine, the com-

5 bination of a hopper for the concrete, said hopper having a throat plate supported only at its upper edge with the hopper, and extending downwardly below the lower edge of the hopper for guiding the concrete down and depositing the same directly onto the subgrade, each end of said throat plate being unattached at its other edge so as

to permit free vibration of the throat plate in a direction normal to the plane of the throat plate, and means for imparting rapid vibratory impulses to the same in a plane normal to the plane of the plate.

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