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Johnson et al.

[11] **3,785,759**

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[54] **MACHINE FOR FORMING A CONTINUOUS SEAMLESS CONCRETE PIPE**

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[52] **U.S. Cl.** **425/59,** 425/64

[51] **Int. Cl.** **E03f 3/06**

[58] **Field of Search** 425/59, 63, 64, 62; 264/32, 33

[56] **References Cited**

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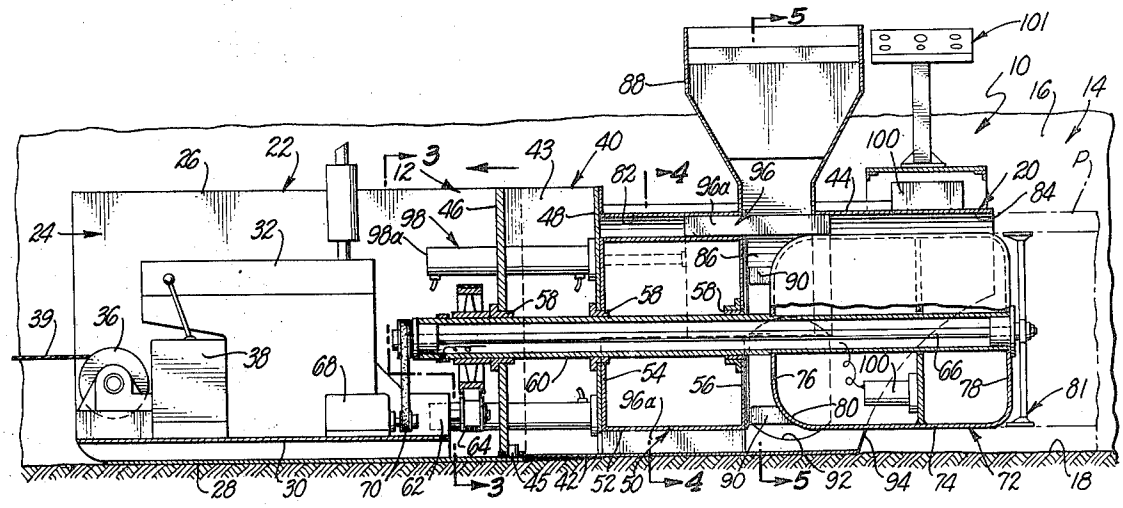
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Assistant Examiner—John McQuade
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[57] **ABSTRACT**

A continuous seamless pipe is formed in a trench from a cementitious mix by advancing through the trench a carriage mounting a trailing cylindrical drum with its axis parallel to the direction line of carriage movement and a diameter equal to the internal pipe diameter, and a cylindrical skirt having a diameter approximating the outer pipe diameter concentrically surrounding the drum to define an intervening rearwardly opening annular cylindrical containing an annular piston. The cementitious mix is fed into the front end of the cylinder and the piston is driven rearwardly through the cylinder to extrude the mix through the open rear end of the cylinder to form the pipe wall and exert a forward reaction force on the carriage for propelling the latter through the trench. The plunger may be segmented to obtain more uniform extrusion about the full cylinder circumference. The drum may be driven in rotary or other motion, and the drum, plunger and/or skirt may be vibrated to compact the extruding mix. A rotary trowel on the rear end of the drum smooths the inner surface of the extruded pipe. The preferred cementitious mix is a low slump concrete which may be extruded to form a seamless concrete pipe without the need to internally support the pipe.

8 Claims, 7 Drawing Figures



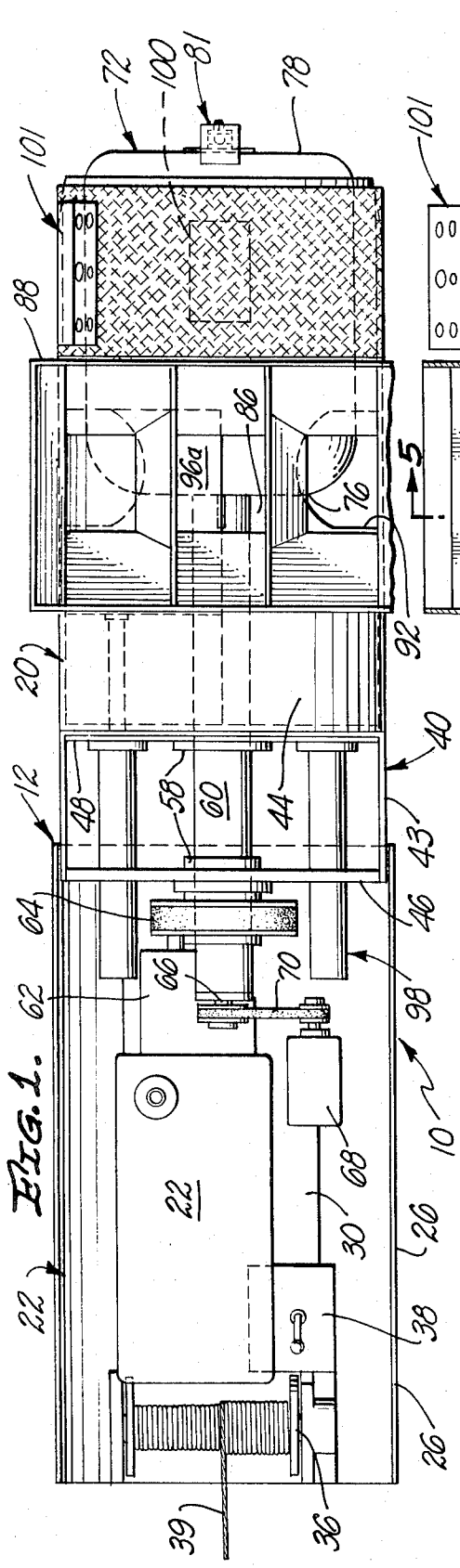


FIG. 1.

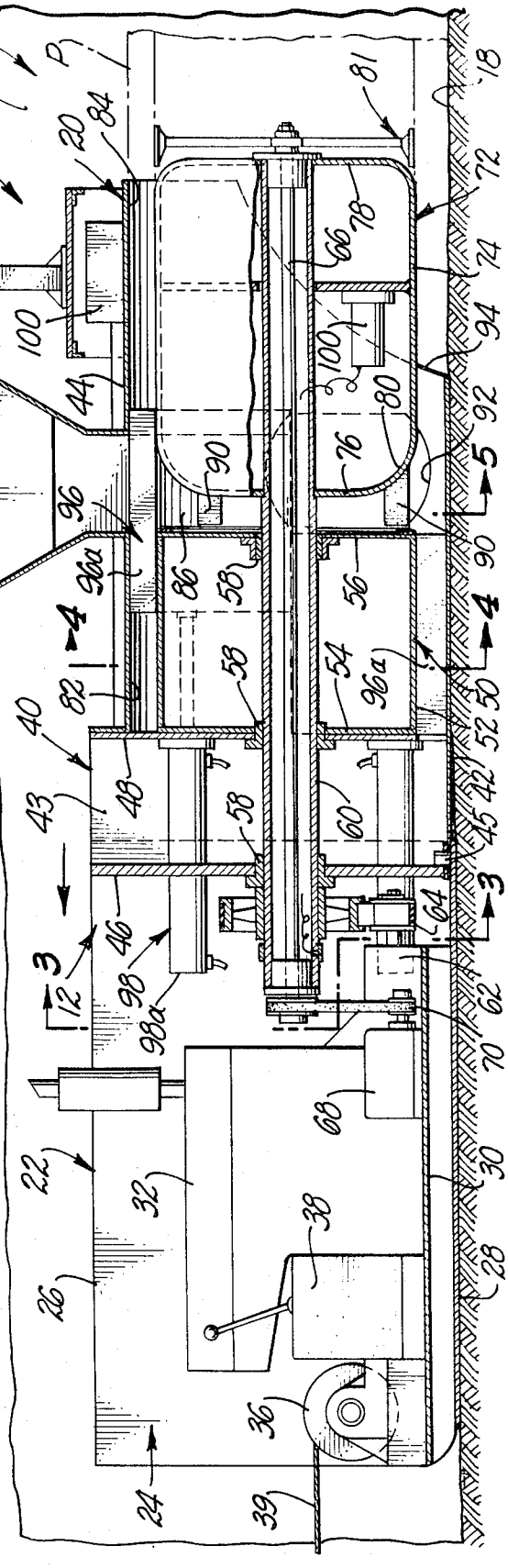


FIG. 2.

FIG. 3.

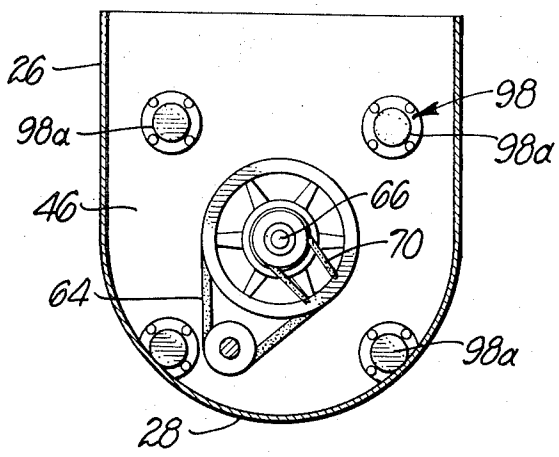


FIG. 4.

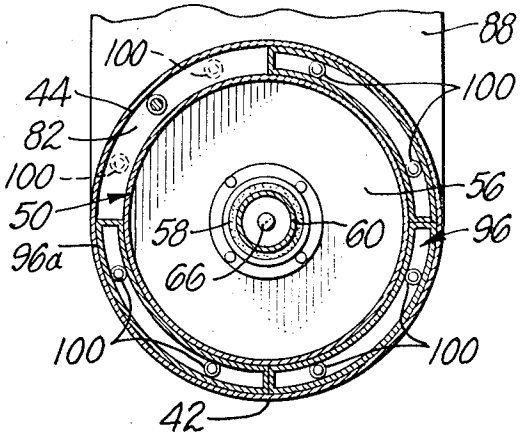


FIG. 5.

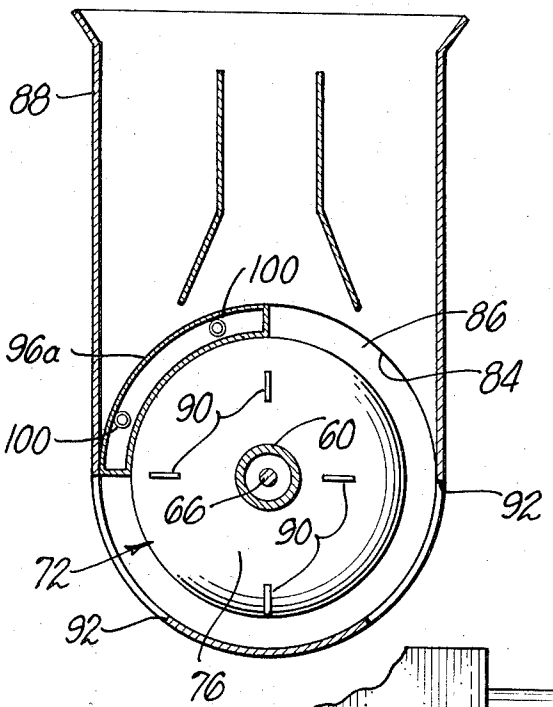


FIG. 7.

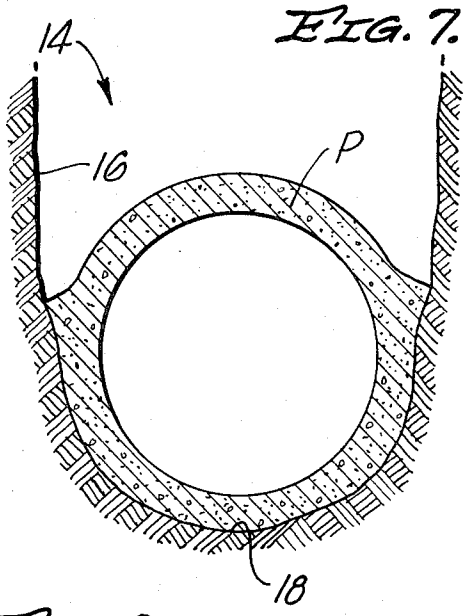
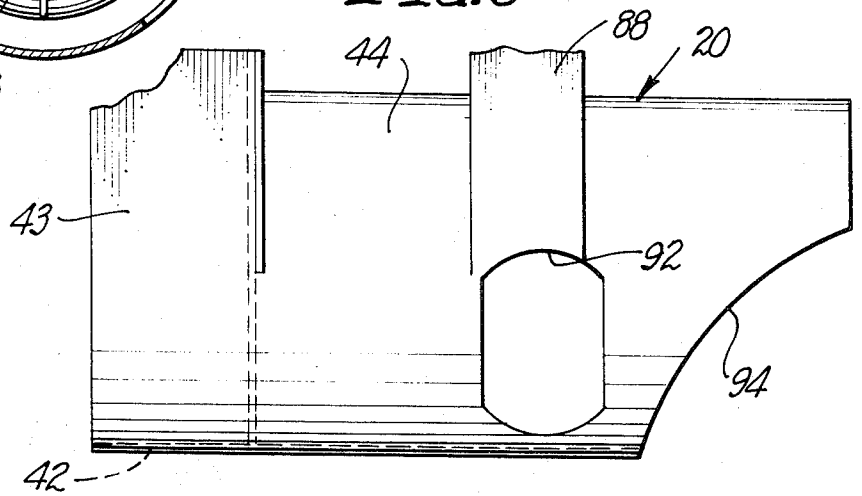


FIG. 6



MACHINE FOR FORMING A CONTINUOUS SEAMLESS CONCRETE PIPE

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates generally to the art of pipe fabrication and more particularly to a novel method and machine for extruding a cementitious material to form a continuous seamless pipe in a trench.

2. Discussion of the Prior Art

Subsurface pipe lines are used for a variety of purposes, such as irrigation, sewage disposal, flood control and others. At the present time, such pipes are commonly constructed by excavating a trench and placing within the trench precast concrete pipe sections which are joined end to end to form a pipe. This method of pipe construction is quite time-consuming and costly and becomes more so as the pipe diameter increases.

U.S. Pats. Nos. 2,731,698, 3,091,013 and 3,338,546 disclose an improved method of subsurface concrete pipe construction. This construction method involves the use of a pipe forming or extruding machine which moves forwardly through a trench and extrudes an annular ribbon of concrete or other cementitious mix to form a continuous seamless pipe behind the machine as the latter advances.

SUMMARY OF THE INVENTION

The present invention provides an improved pipe forming machine of the general class described. The forming machine has a carriage movable forwardly through the trench which is to contain the pipe. At the rear of the machine is a cylindrical drum having its axis parallel to the direction line of carriage movement and a diameter equal to the internal diameter of the pipe. Concentrically surrounding the drum is a thin-walled cylindrical skirt having a diameter approximating the outer diameter of the pipe. The drum and skirt define an intervening annular rearwardly opening cylinder about the drum.

Mounted on the carriage forwardly of the drum for reciprocating movement through the cylinder is an annular plunger. Actuator means such as hydraulic ram means drive the plunger back and forth through the cylinder. Preferably, the plunger is divided into independently movable segments powered by separate hydraulic cams. Between the plunger and the drum is a reservoir for containing a cementitious mix which is fed to the reservoir through a hopper. On the rear end of the drum is a rotary troweling device. The preferred cementitious mix is a semi-dry relatively low slump concrete mix, such as medium aggregate, sand, cement and selected admixtures. The invention will be described in connection with the use of such a concrete mix in the pipe forming machine. As will appear from the later description, however, other cementitious mixes may be used in the machine consisting of any suitable aggregate and binder.

In operation, the pipe forming machine is propelled slowly through the trench while it receives concrete mix through its hopper from a supply vehicle which moves along the trench machine. The annular plunger of the machine is driven in a reciprocating stroke through the annular cylinder about the machine drum. During each rearward stroke, the plunger displaces concrete mix from the reservoir into the cylinder as well as through openings in the skirt and finally extrudes the concrete through the rear open end of the cylinder to form a generally cylindrical pipe wall. The plunger then retracts forwardly to effect entry of more concrete mix into the cylinder, after which the plunger is again driven rearwardly through the cylinder to extrude an additional length of pipe.

The plunger is driven rearwardly with substantial force to extrude and compact the concrete mix to form a virtually self-sustaining pipe wall. This force produces a forward reaction force on the machine carriage which aids in propelling the carriage forwardly through the trench. An additional propulsion means, such as a winch, is provided for supplementing the reaction force produced by the plunger.

The drum of the machine supports the pipe wall internally as it is formed and smooths the inner wall surface as the drum moves forwardly. Additional smoothing of the inner wall surface, if necessary, may be accomplished by the rotating trowel at the rear of the drum. A primary feature of the invention resides in the use of a low slump concrete mix in the present machine. This low slump concrete enables extrusion of a seamless concrete pipe without the necessity of supporting the pipe internally until the concrete sets. According to another important feature of the invention, the drum, skirt and extrusion plunger mount vibrators for compacting the concrete mix as it is extruded so as to enhance the self-sustaining ability of the pipe wall.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a top view of a pipe forming machine according to the invention;

FIG. 2 is a longitudinal section through the machine;

FIG. 3 is a section taken on line 3—3 in FIG. 2;

FIG. 4 is a section taken on line 4—4 in FIG. 2;

FIG. 5 is a section taken on line 5—5 in FIG. 2;

FIG. 6 is a side elevation of the shield of the machine; and

FIG. 7 is a section through a pipe extruded by the machine.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The pipe forming machine 10 selected for illustration in the drawings has a carriage 12 which is movable forwardly in the direction of the arrow in FIG. 2 through a trench 14. The trench has generally vertical side walls 16 and a rounded bottom wall 18. Machine carriage 12 has front and rear sections 20 and 22 which can pivot laterally relative to one another, as explained below, to facilitate movement of the carriage around a curve.

Front carriage section 22 has a frame 24 with upstanding side walls 26 and a rounded bottom wall 28, constructed of boiler plate of the like. The frame is shaped and dimensioned in transverse cross-section to conform approximately to the cross-section of the trench 14. Mounted on the bottom wall 28 is a platform 30 supporting a motor generator set or prime mover 32, in this instance an internal combustion engine. Engine 32 drives a winch 36 through a transmission 38. As will be explained presently, the winch 36 is utilized to move the pipe forming machine forwardly through the trench 14 by attaching the winch cable 39 to an anchor located some distance ahead of the machine.

The rear carriage section 20 has a frame 40 constructed of boiler plate or the like in a manner similar

to the front carriage section. The front end of the rear section has a cross-section similar to that of the front section including a rounded bottom wall **42** and upstanding side walls **43.** The remaining rear portion of the frame forms a cylindrical skirt **44** whose bottom portion is a continuation of the bottom frame wall **42** and whose axis coincides with the axis of curvature of the latter wall and the bottom wall **28** of the front carriage section **22.**

The front end of the rear carriage section **20** fits within the rear end of the front carriage section **22** so as to overlap the latter section a small amount. The front end of the rear section is sized to provide a small clearance between the overlapping side walls **26, 43** of the sections. The overlapping bottom walls **28, 42** of the sections are joined by a pivot **45.** This pivot permits the two carriage sections to pivot laterally relative to one another through a small angle such that the pipe forming machine may travel around curves in the trench **14.** The pivot is arranged to permit uncoupling of the two carriage sections for ease of transportation from one job site to another.

Extending across the front end of the rear carriage section **20** and welded or otherwise rigidly joined to the bottom and side frame walls **42, 43** of the section are spaced parallel frame walls **46, 48.** A hollow cylinder **50** is welded or otherwise rigidly joined to the rear side of the rear wall **48.** Cylinder **50** has a cylindrical wall **52** and end walls **54, 56.** Mounted in the walls **46, 48, 54, 56** are shaft bearings **58.** Cylinder **50** and bearings **58** are aligned on the axis of the rear cylindrical skirt **44** of the rear carriage section **20.**

Rotatably supported in the bearings **58** is a hollow shaft **60.** Shaft **60** extends forwardly of the front frame wall **46** into the front carriage section **22** and rearwardly of the rear cylinder end wall **56** through the cylindrical skirt **44** along the axis of the skirt. The front end of shaft **60** is driven from the engine **32** through a speed reducer and clutch mechanism **62** and a belt or chain drive **64.** Extending centrally through and rotatably supported in the shaft **60** is an inner shaft **66.** The front end of shaft **66** is driven from the engine **32** through a speed reducer and clutch mechanism **68** and a belt or chain drive **70.** It is significant to note here that the belts or chains of the drives **64, 70** may be removed to permit uncoupling of the carriage sections **20, 22.**

Fixed on the rear end of the outer shaft **60** is a hollow cylindrical drum **72,** the rear end of which projects a short distance beyond the rear end of the skirt **44.** Drum **72** has a cylindrical wall **74,** a somewhat dome-shaped front end wall **76** and a flatter rear end wall **78.** As shown most clearly in FIG. **2,** the annular juncture **80** of the drum walls **74, 76** is rounded. The annular juncture of the drum walls **74, 78** is also rounded, though to a smaller radius. Cylinder **50** and drum **72** have the same diameter which is the internal diameter of the pipe to be formed. Fixed on the rear end of the inner shaft **66** is a rotary trowel **81** of the same diameter as the drum **72.**

The skirt **44** of the rear carriage section **20** surrounds the cylinder **50** and drum **72** concentrically and has a diameter approximating the outer pipe diameter. The skirt and cylinder define an intervening annular cylinder **82.** The skirt and drum define an intervening annular cylinder **84.** Between the cylinder **50** and drum **72** is a space **86** providing a reservoir. A hopper **88** rises from the top of the skirt **44** over the reservoir and opens downwardly to the reservoir. The front end of the drum **72** mounts paddles **90** which project forwardly into the reservoir. In the sides of the skirt **44** are ports **92** which open to the reservoir. The rear end of the skirt is cut away at **94.**

Movable through the annular cylinders **82, 84** is an annular plunger **96.** This piston has an axial length approximating the length of the cylinder **82.** Actuator means **98,** in this instance hydraulic or pneumatic ram means, are connected to the plunger for moving the latter back and forth through the cylinders. The plunger is movable between a forward retracted position in the cylinder **82** and a rearward extended position within the rear end of cylinder **84.** During its movement between these positions, the plunger travels through the reservoir **86.**

According to a feature of the invention the plunger **96** is divided into four independently movable segments **96***a.* The actuator means **98** comprise separate hydraulic rams **98***a* for driving the plunger segments back and forth. According to another feature of the invention, the drum **72,** skirt **44** and plunger **96** mount vibration generators **100** for vibrating these parts.

Mounted atop the rear end of the skirt **44** is an operator's station **101.** This station is equipped with controls for engine **32,** winch **36,** clutch mechanisms **62, 68** and rams **98***a.*

In operation of the pipe forming machine, the winch cable **39** is anchored some distance ahead of the machine. The rams **98***a* are actuated to retract the plunger **96.** The reservoir **86** is filled with a semi-dry relatively low slump concrete mix through the hopper **88.** This concrete mix may be supplied to the machine by a concrete transport vehicle which moves along the side of the trench with the pipe forming machine. A system of baffles which are apparent in FIG. **1** and FIG. **5** are placed in the hopper to direct more concrete mix to the sides of the reservoir rather than down the center of the hopper. A major portion of the concrete thus feeds to the ports **92** through which the concrete passes to the outride of the skirt, and to the paddles **90.** This action aids materially in getting the concrete quickly and efficiently into the intervening space between the outer skirt and the trench walls.

After the machine has been thus readied for operation, the winch **38** is operated to wind the cable **39** on the winch drum and thereby advance the machine slowly through the trench **14.** The drum **72** and trowel **81** are driven in rotation. Rotation of the drum drives the drum paddles **90** about the reservoir **86** to constantly mix and agitate the concrete mix in the reservoir to prevent the mix from setting. This paddle rotation also displaces concrete mix from the reservoir through the skirt ports **92** into the region between the skirt **44** and the trench wall.

Actual extrusion of the concrete mix to form a pipe P is accomplished by operating the rams **98***a* to reciprocate annular plunger **96** between its retracted and extended positions. During each rearward stroke of the plunger, the latter displaces concrete mix from the reservoir **86** outwardly through the skirt ports **92** into the region between the skirt **44** and the trench wall and rearwardly through the cylinder **84** until the plunger enters over the rounded forward end of drum **72.** As the plunger enters over the drum, the annular clearance space between the plunger and drum gradually

closes by virtue of the rounded annular end wall portion 80 of the drum. As this clearance space closes, the plunger closes to displace concrete mix through the skirt ports 92 and continues to displace concrete mix, under increased force or pressure, rearwardly through the cylinder 84. The concrete mix is extruded through the rear open end of the cylinder 84 to form the pipe P.

During this final portion of its extension or extrusion stroke, the plunger 96 imposes a relatively high force or pressure on the extruding concrete mix which compacts the mix. Additional compaction of the extruding concrete mix is accomplished by rotation of the drum 72 and by the vibrating action of the vibration generators 100. This compaction of the mix coupled with its semi-dry low slump characteristics results in an extruded concrete pipe P which is self-supporting and eliminates the need for internal supports within the pipe. In addition to extruding and compacting the concrete mix, the high force exerted by the plunger against the extruded pipe wall produces an opposite reaction force on the pipe forming machine. This reaction force aids the winch 36 in moving the machine forwardly through the trench 14.

When the plunger 96 reaches the end of its rearward extrusion stroke, it is retracted to the forward end of its travel, after which the cycle is repeated. Thus, the Pipe P is effectively extruded in successive but continuous sections during successive rearward extension strokes of the plunger. If necessary, the rate of forward travel of the machine through the trench 14 may be slowed or terminated during the forward retraction or return strokes of the plunger to avoid the formation of discontinuities or weak spots in the pipe wall.

A feature of the invention resides in the fact that the rotating drum paddles 90 and annular plunger 96 cooperate to effect uniform distribution of the concrete mix about the full circumference of the annular cylinder 84. The plunger segments 96*a* may be extended in unison or independently, as required to obtain uniform extrusion of and pressure on the pipe wall about the full pipe circumference.

As the pipe forming machine advances, extruding the pipe P behind it, the inner pipe surface is smoothed by the rotating drum 72 and trowel 81. In this regard, it should be noted that the drum may be driven in other than a rotary motion, such as an oscillating or reciprocating motion or, for that matter, the drum may remain stationary. If desirable or necessary, the machine may be equipped with means for spraying water on the inner pipe surface to enhance this smoothing action.

A major advantage of the present pipe extruding machine resides in the fact that it produces a seamless pipe with a predetermined minimum wall thickness and a smooth walled bore having a high degree of roundness. As noted earlier, the preferred concrete mix for use in the machine is a low slump concrete which permits extrusion of a pipe without the necessity of internally supporting the pipe wall until the concrete sets. Other cementitious materials than concrete may be used, however.

What is claimed is:

1. A machine for forming a continuous seamless cementitious pipe within a trench, comprising:
a carriage movable forwardly through said trench,
a cylindrical drum at the rear of said carriage having its axis parallel to the direction line of carriage movement,
said drum having a diameter approximating the internal diameter of said pipe and a cylindrical length which is a major portion of the overall length of the drum
means for driving said drum in a motion which does not alter the position of the drum axis relative to said carriage,
a cylindrical skirt about and concentric with said drum and having a diameter approximating the outer diameter of said pipe,
said drum and skirt defining an intervening rearwardly opening annular cylinder about the drum having a radial dimension approximating the wall thickness of said pipe,
means for feeding a cementitious mix into the forward end of said cylinder, and
means for feeding said mix rearwardly through and extruding the mix through the rear end of said cylinder during said motion of said drum to form the pipe wall between the drum and the trench walls as the machine moves forwardly through said trench, said feeding means comprising annular plunger means movable axially through and having a radial dimension approximating that of said cylinder, and fluid power actuator means connected between said carriage and plunger means for driving said plunger means back and forth through said cylinder.

2. A pipe forming machine according to claim 1 including:
vibrator means for vibrating said skirt.

3. A pipe forming machine according to claim 1 wherein:
said skirt has openings at the forward end of said drum through which said cementitious mix may flow to the exterior of the skirt.

4. A pipe forming machine according to claim 1 wherein:
said plunger means comprises a number of independently movable segments, and
said actuator means comprises independent actuators for driving said plunger segments independently through said cylinder.

5. A pipe forming machine according to claim 1 including:
paddles on the front end of said drum which rotates with said drum to agitate said mix entering the forward end of said cylinder and distribute the mix uniformly about said cylinder.

6. A pipe forming machine according to claim 1 wherein:
said carriage includes a rear section mounting said drum, skirt, plunger means and actuator means, and a front section,
means on said front section for driving said carriage through said trench, and
pivotal coupling means joining said carriage sections for relative lateral pivoting of said sections.

7. A pipe forming machine according to claim 6 wherein:
said coupling means are disengageable to permit separation of said carriage sections.

8. A pipe forming machine according to claim 1 including:
means for driving said drum in rotation,
a rotary trowel concentrically mounted at the rear end of and having the same outer diameter as said drum, and
means for driving said trowel in rotation independently of said drum motion.

* * * * *