April 15, 1958 H. P. BURRELL 2,830,443

PILE-DRIVING APPARATUS

Filed Jan. 11, 1955 4 Sheets-Sheet 1

Fig. 1

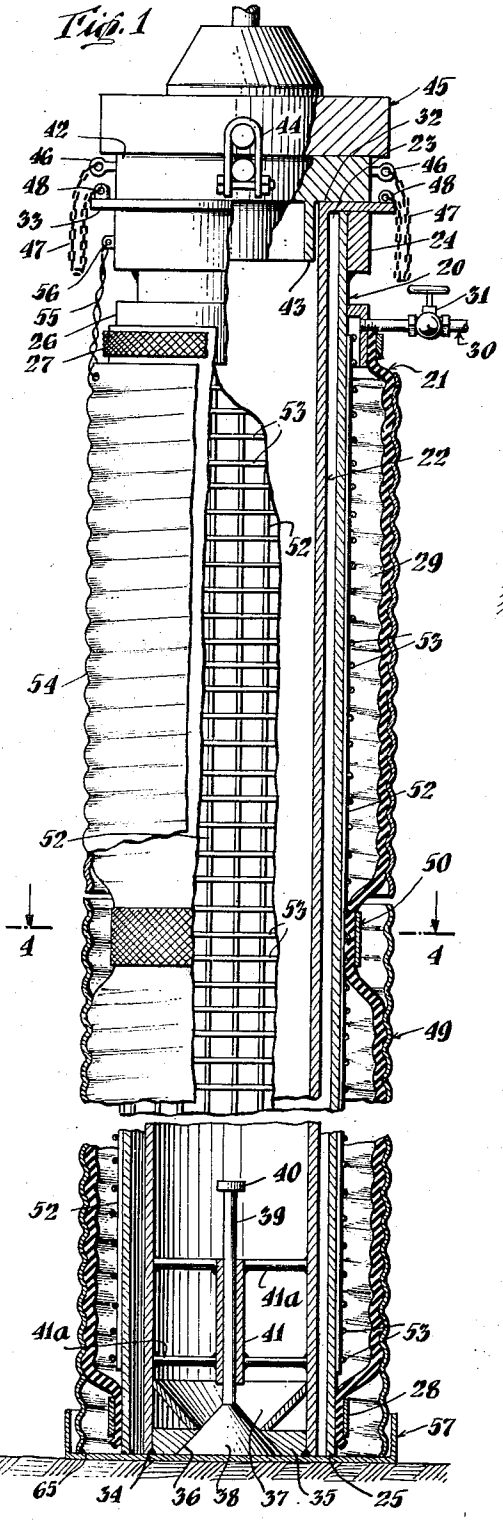
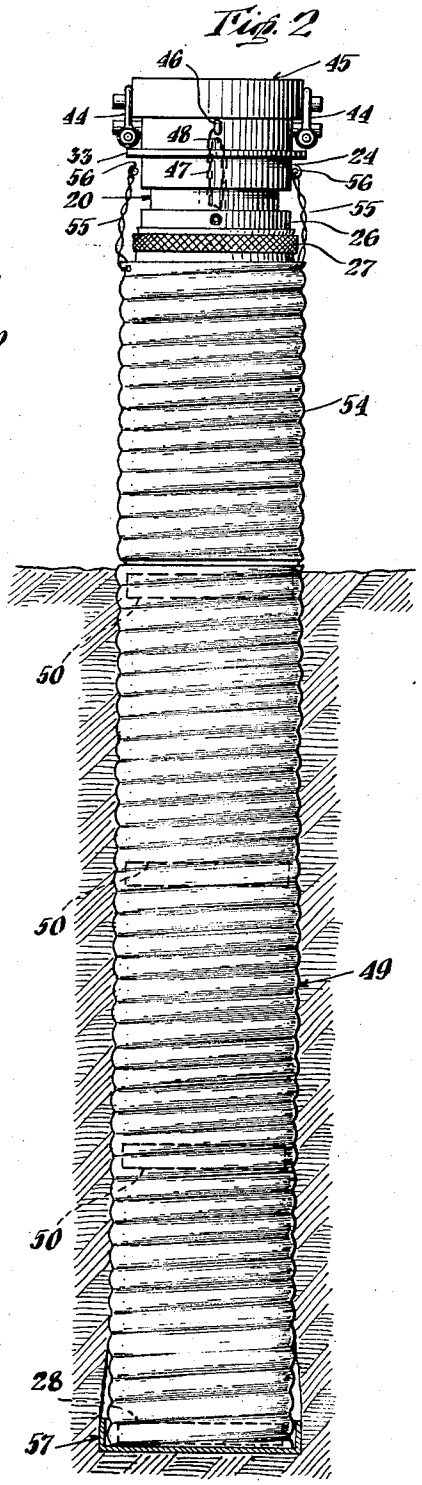


Fig. 2



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Fig. 3

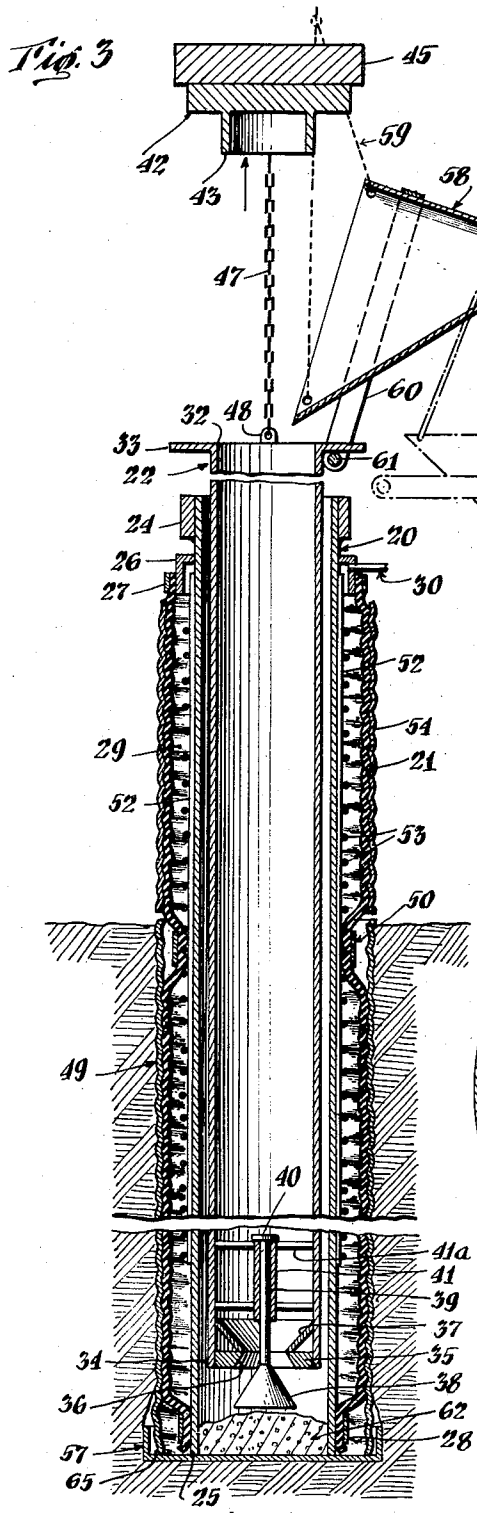


Fig. 5

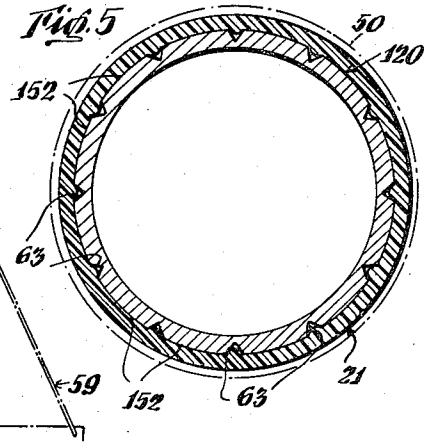
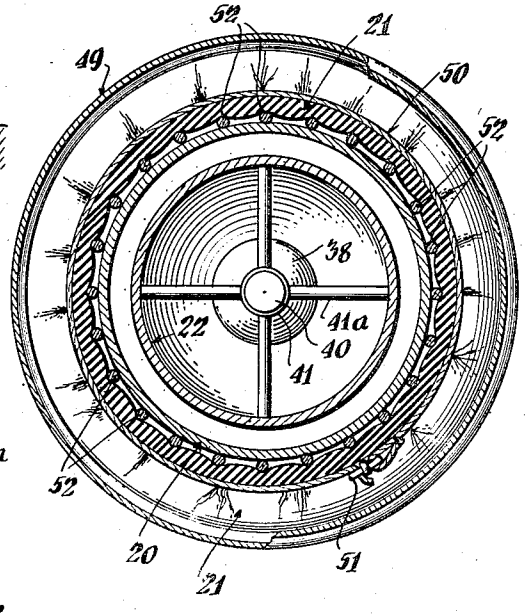


Fig. 4



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Fig. 6

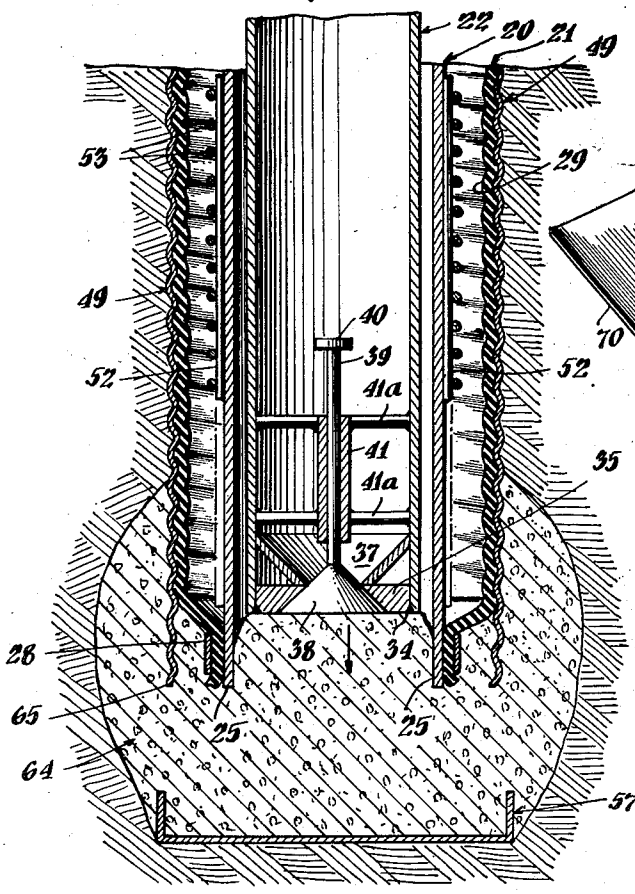


Fig. 8

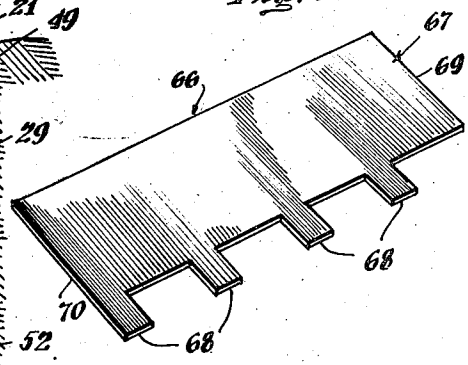


Fig. 9

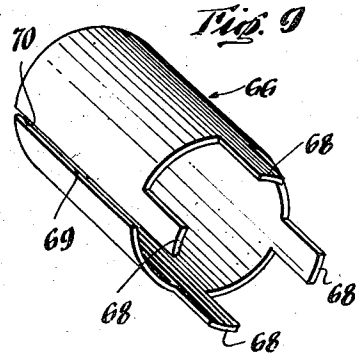


Fig. 10

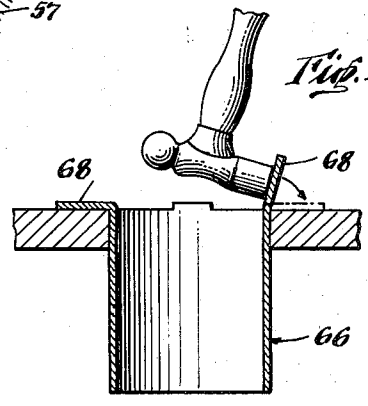
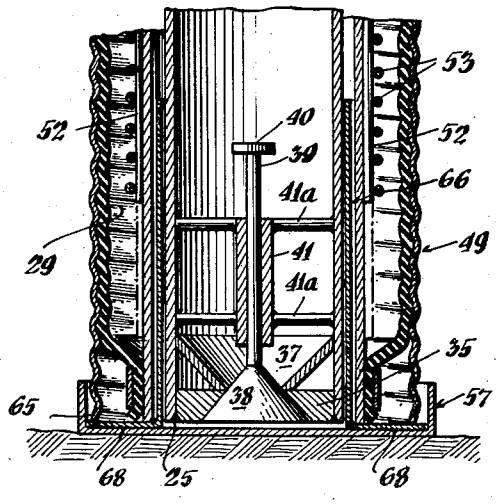


Fig. 7



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Fig. 11

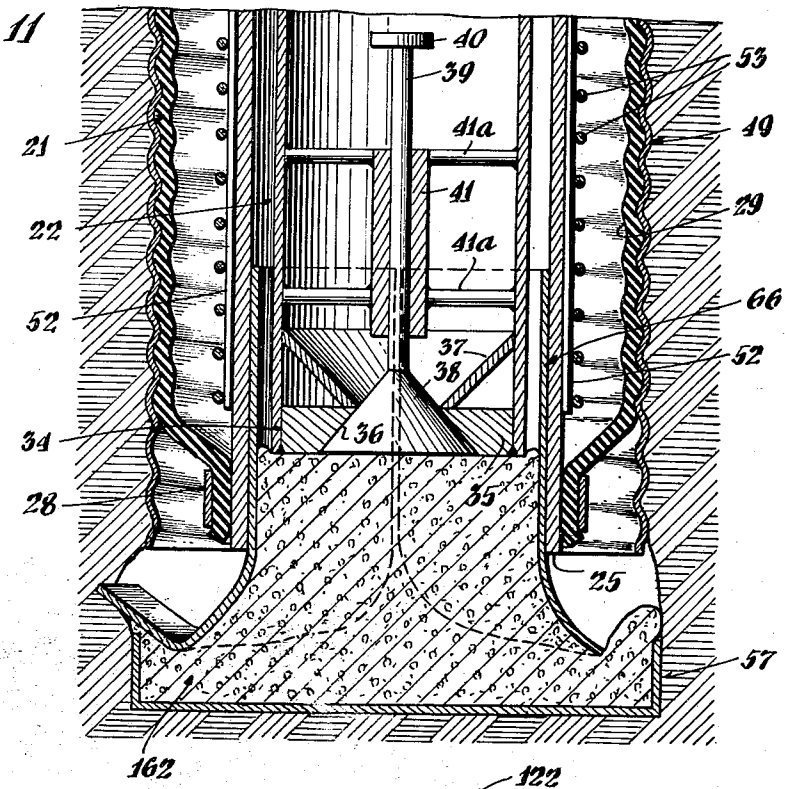
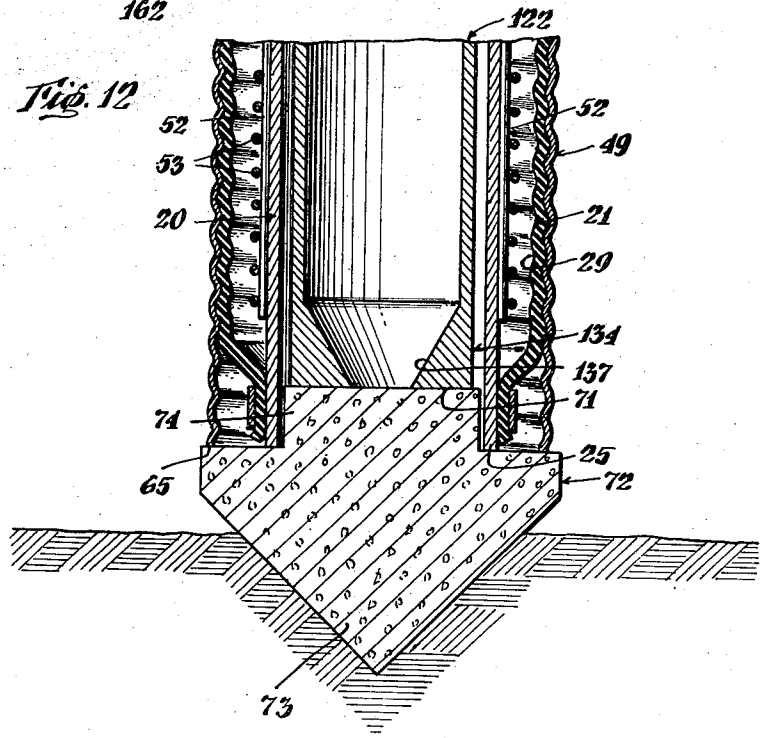


Fig. 12



United States Patent Office 2,830,443 Patented Apr. 15, 1958

2,830,443

PILE-DRIVING APPARATUS

Harold P. Burrell, Noroton, Conn.

Application January 11, 1955, Serial No. 481,088

3 Claims. (Cl. 61—79)

The present invention relates to apparatus for driving the casting shells of armored cast-in-place concrete piles and a method of forming the latter.

A general object of the present invention is to provide unique mandrel equipment which may be easily and efficiently expanded within a casting and armoring shell to clamp the latter thereto for effective driving with light travelling equipment while maintaining ground pressure on the shell, with provision of an interior feeder passage for ready delivery to the bottom of the mandrel means of charges of unset footing concrete, the mandrel equipment also including tamping means for compacting such concrete charges into a base or footing mass at the bottom of the shell prior to mandrel removal, and a novel method of driving and forming shell-armored cast-in-place concrete pile having a desired tamped base or footing of concrete of excellent load-bearing characteristics. The term concrete as used herein is intended to cover any suitable footing material, such as stone, gravel or slag, whether used plain or mixed with binder.

A more specific object of the invention is to provide such mandrel equipment which is characterized by a hollow rigid mandrel tube sheathed with inflatable chamber means for secure clamping and support thereon of the usual type of corrugated steel shell to be driven effectively into the ground with the mandrel tube, the latter having loosely telescoped thereinto a core tube providing a footing concrete feeder conduit and having a tamping bottom end for compacting and shaping masses of footing concrete delivered therethrough into a load-bearing base for the pile prior to removal of the mandrel and core tubes and subsequent filling of the shell with concrete.

Another object of the present invention is to provide hollow driving mandrel means in the form of a rigid driving tube having an elongated imperforate section surrounded by a shell-supporting sheath of elastic material defining therebetween an expandable and collapsible chamber with the tube being provided exteriorly, in at least one locality and preferably a plurality thereon; with circumferentially-spaced lands so that when one or more cinching bands snug the sheath at such localities to the tube thereat for anchorage to the tube to resist during driving undue distortable and damaging longitudinal drag fluid passages are maintained along the lands whereby all cinch band-defined sections of the sheath are properly inflatable and deflatable.

A further object of the invention is to provide for such a hollow driving mandrel a hollow core tube which may be loosely and withdrawably telescoped thereinto to provide a through feeder conduit through which charges of unset concrete may be fed to the vicinity of the bottom of a casting and armoring shell driven by the mandrel, the bottom end of the core tube being so shaped and/or constructed as to provide a passaged concrete tamping means for effectively compacting unset footing concrete after being delivered therethrough, and prior to any

required removal of mandrel means for subsequent casting of the pile core.

Prior to the present invention two general methods have been employed in forming shelled cast-in-place concrete piles which may be identified as (1) the blocked mandrel method and (2) the casing pipe procedure. In the blocked mandrel method the shell is clamped upon an expanded driving mandrel which has a blocked interior preventing feed of material therethrough, and the shell is driven by the mandrel with maintenance of pressure between the shell and ground. Such driving of the shell may be accomplished by light and readily portable equipment such as a crawler crane, but once the shell has been driven into place its form cannot be altered as by adding a useful enlarged base. In the casing pipe procedure a heavy driving pipe having a closing boot pan is driven into the ground by heavy equipment; the shell is then dropped into it and the casing pipe is drawn up from about the shell. The casing pipe does provide a feeder conduit for delivery of footing concrete prior to the setting of the shell thereinto but when the casing pipe is withdrawn from about the shell there may be such soil suction and disturbance as to reduce or destroy the potential load-bearing quality of the pile to be cast in the shell and in any event the soil-to-shell pressure is undesirably low. In fine water-bearing sand and other loose soil material suction produced by withdrawal of the casing pipe may withdraw the soil material from below the pile point or formed footing. These and other difficulties of the prior art procedures are efficiently minimized and avoided by the present invention.

A still further object of the present invention is to provide structural embodiments of the apparatus and parts thereof which are readily constructed and assembled and permit efficient use and operation thereof in the practice of varied procedures best suited to different conditions.

Other objects of the invention will in part be obvious and will in part appear hereinafter.

The invention accordingly comprises the several steps and the relation of one or more of such steps with respect to each of the others, and the apparatus embodying features of construction, combinations of elements and arrangement of parts which are adapted to effect such steps, all as exemplified in the following detailed disclosure, and the scope of the invention will be indicated in the claims.

For a fuller understanding of the nature and objects of the invention reference should be had to the following detailed description taken in connection with the accompanying drawings, in which:

Fig. 1 is a side elevational view, with parts broken away and in section, of an embodiment of the pile driving apparatus of the present invention, showing a casting and armoring shell clamped thereon and with the assembly resting upon the ground prior to driving;

Fig. 2 is a side elevational view of the structure shown in Fig. 1 to a smaller scale, showing the assembly in driven position in the ground;

Fig. 3 is an axial section, with parts broken away, of the driven assembly depicted in Fig. 2, illustrating manipulation of anvil and core tube structure thereof permitting dumping into the latter of charges of unset footing concrete and delivery thereof to the vicinity of the bottom of the shell;

Fig. 4 is an enlarged cross-sectional view of the assembly shown in Figs. 1, 2 and 3 taken through one of the sheath-snugging cinch bands and illustrating maintenance thereat of longitudinally-extending sheath fluid passages or flow ducts by one form of land means;

Fig. 5 is a cross-sectional view similar to Fig. 4, with

parts broken away and omitted, of another form of land which may be used to maintain sheath fluid passages or flow ducts at a cinch band;

Fig. 6 is an enlarged axial section of the bottom portion of Fig. 3, illustrating the formation of a tamped bulbous base or footing of concrete for the pile shell with drive of the latter thereinto;

Fig. 7 is an axial section of the bottom portion of Fig. 1, showing the incorporation therein of slip tube means to reduce drag on the mandrel tube during tamping;

Fig. 8 is a perspective view of a blank from which the Fig. 7 slip tube means may be formed;

Fig. 9 is a perspective view of the Fig. 7 slip tube means as formed by shaping the Fig. 8 blank into tubular form;

Fig. 10 is a pictorial section, with parts in elevation, illustrating the manner in which the unfinished slip tube means of Fig. 9 may be completed for use as illustrated in Fig. 7;

Fig. 11 is an enlarged axial section similar to Fig. 6 illustrating the formation of a pile base or footing with an assembly in which the Figs. 7 to 9 incl. slip tube means is incorporated; and

Fig. 12 is an axial section of the bottom portion of a modified form of pile driving apparatus and pile shell assembly illustrating an embodiment of core tube tamping means different from that shown in Figs. 1, 3, 6, 7 and 11 and showing how a precast pile point may be used to advantage with any of the depicted forms of driving apparatus.

Referring to the drawings, in which like numerals identify similar parts throughout, it will be seen from Figs. 1 to 4 incl. that an embodiment of the present invention may comprise a mandrel tube or pipe **20**, an expandable and collapsible sheath **21** of elastic material thereon and a core tube or pipe **22**. The mandrel pipe is an elongated, rigid, drivable, unblocked steel tube or the like which, for example, may be about 12.75" O. D. and of uniform diameter, having a wall thickness of about 0.5", a weight per foot of about 65.4 lbs. and a length of about 60'. The mandrel tube **20** has an open top end **23** preferably surrounded by a reinforcing band **24** welded thereto and serving with the top end edge of the tube as abutment means. The bottom end **25** of the mandrel tube **20** is open and the tube interior is unblocked or unobstructed, as shown, for telescopic reception of the core tube **22**.

The major portion of the drive or mandrel tube **20** extending from just below the reinforcing band **24** substantially to the bottom end **25** constitutes an imperforate section of appreciable length intervening the open bottom end and the open top end **23** with the latter serving as a driving end. This imperforate section carries thereon the expandable and collapsible sheath **21** of suitable elastic material having its upper end secured to the drive tube in a fluid-tight manner by a head ring **26** to which the sheath may be clamped by a head band **27**. The bottom end of the sheath **21** is suitably clamped in a fluid-tight manner to the exterior surface of the mandrel tube **20** by a foot band **28**. Thus, the sheath **21** and the imperforate section of appreciable length of the driving tube **20** covered thereby together define an intervening inflatable and deflatable chamber **29**. The sheath may have a wall thickness of about 0.5" and may be formed of reinforced rubber or other suitable elastic material with the reinforcing provided by fabric preferably extending lengthwise to limit longitudinal elongation while permitting free transverse expansion. Fluid under pressure, preferably air, is fed to the chamber **29** by a suitable conduit **30** which, as shown, may be connected through the head ring **26**, and this conduit is provided with a valve **31**. With the conduit **30** suitable connected to a source of air under pressure manipulation of the valve **31** will permit the air to flow into the chamber **29** and expand the sheath and such valve may be of a two-way type with an outlet leading to atmosphere to permit deflation of the sheath.

The core tube **22** which is telescoped into the mandrel tube **20** may be about 10.75" O. D. with a wall thickness of about 0.365", having a weight per foot of about 40.5 lbs. and, as shown, extends the full length of the mandrel tube. The upper end **32** of the core tube **22** is open and preferably is provided with a laterally-extending circumferential flange **33** to overlie the upper end **23** of the mandrel tube and its reinforcing ring **24** to serve as the complemental abutment means, limiting downward telescope of the core tube within the mandrel tube. Since the core tube **22** is to serve as a conduit, its bottom end **34** has a through passage which, in the embodiment of Figs. 1 to 4 incl., preferably is valved. Also, the bottom end **34** of the core tube **22** is to serve as tamping means and thus in the embodiment of Figs. 1 to 4 incl. it is partially closed by a cross plate **35**, having an outlet passage **36** extending therethrough in the form of a downwardly facing frusto-conical valve seat. Preferably, a frusto-conical funnel element **37** is mounted in the core tube **22** above cross plate **35** so as to direct material to the passage provided by valve seat **36**. A conical valve head **38** is mated with the valve seat **36** and preferably is carried on the bottom end of an axially-slidable rod or stem **39** headed at **40** to provide a limiting stop. The stem **39** is preferably slidably supported in an axially-arranged section **41** of tubing supported by suitable spider means *41a*, *41a* from the inner wall of the core tube, as best seen in Fig. 1.

The mandrel tube **20** and the core tube **22** telescoped thereinto are surmounted by an anvil **42** preferably in the form of a heavy circular plate having a coaxially-extending element or skirt **43** loosely receivable in the upper open end **32** of the core tube. The anvil **42** may be linked by any suitable means, such as clevises **44**, **44**, to the base **45** of a steam hammer carried by relatively light portable pile-driving equipment, such as a crawler crane, so that when the hammer is lifted the anvil will be elevated therewith. The anvil **42** preferably carries loops, eyes or other projections **46**, **46** which may be connected by suitable sections **47**, **47** of flexible tying means, such as lengths of chain or cable, to the top end of the core tube **22**, e. g., the lateral flange **33** thereof, by any suitable means, such as ears **48**, **48**. Thus, after the anvil **42** is lifted by the hammer base **45** until the flexible ties **47**, **47** become taut, further lift of the anvil with the hammer head raises the core tube **22** while providing a gap between the upper end of the latter and the anvil for supply to the core tube interior of footing material.

As will be more fully explained hereinafter, the mandrel tube **20** is to carry clamped thereto, by the sheath **21** when inflated, the usual type of casting and armoring corrugated shell **49** which is to serve as a form for the cast-in-place concrete pile. Such shell **49** may be a standard 16" cylindrical steel shell having a helical or spiralled shallow and relatively wide groove to form a corrugated tube, as shown in the drawings, and which may be the product identified by the trade name of "Helcor" shell. Into the corrugations of this shell **49** the wall of the sheath **21**, when inflated, may penetrate about half way or about 0.25" securely to clamp the shell upon the mandrel. For practical reasons, the maximum length of a cast-in-place armored concrete pile is limited to a length of about 60' and thus the mandrel tube **20** will preferably be provided in a length which may be no more than a few feet longer than 60'. Since it is intended that the shell **49** be carried into the ground with drive of the mandrel tube **20** against the resistance provided by the drag of the shell against the soil, it is a purpose of the present invention to avoid application of undue shear and strain on the sheath **21** and its end anchorages, particularly the one at the bottom provided by the band **28**. For this purpose, the sheath **21** is anchored to the mandrel tube **20** at axially-spaced points which may be about 10' apart, more or less, such

as by cinch bands 50—50, each of which encircles the sheath and snugs it to the exterior of the mandrel tube to subdivide the space between the mandrel tube and inflatable sheath, intervening the end anchorages for the latter, into a plurality of longitudinally-succeeding compartmental sections. Such a cinch band 50 may be formed of webbing and, if desired, provided as a strap having suitable fastening or buckle means 51, as illustrated in Fig. 4.

Since all sections of the sheath 21 between succeeding cinch bands 50, 50 must be inflated to assure maximum and efficient clamping anchorage of the shell 49 upon the mandrel, provision must be made for fluid connection between the succeeding sections. In accordance with the present invention, such fluid connections between succeeding compartmental sections of the inflatable sheath 21 are readily provided by forming longitudinally-extending lands on the exterior surface of the mandrel tube 20 at least at the locality of each cinch band 50 so that when the sheath is cinched tightly to the outer edges or faces of the lands, free passage is maintained along the sides of the lands for flow of air. As proposed in Figs. 1, 3 and 4, such longitudinally-extending lands may be provided as a series of circumferentially-spaced, longitudinally-extending rods 52—52 which may be of a diameter of about 0.125". Preferably, such longitudinally-extending lands provided by the rods 52—52 are arranged substantially over the entire exterior surface of the imperforate section of the mandrel tube 20 which is surrounded by the sheath 21 so that the latter may be cinched up or tied at any desired or selected point by any of the cinch bands 50. Preferably, the land rods 52—52 are provided as elements of a relatively heavy mesh construction or standard screen wrapped about the exterior surface of the mandrel tube 20 and having its transverse elements 53—53 also of about 0.125" rod stock extending circumferentially about the mandrel tube. Such mesh construction may be readily applied to the exterior surface of the steel mandrel tube 20 in a relatively simple manner, such as by wrapping a rectangular section of such screen thereabout and spot-welding it at various points to the exterior surface of the mandrel tube. The circumferentially-extending rod elements 53—53 not only serve to tie the longitudinally-extending rod elements 52—52 together to simplify their mounting upon the exterior surface of the mandrel tube 20 but also as projecting elements which will more securely anchor the wall of the sheath 21 to the mandrel tube at a cinch band tie, as the cinch band, when tightened up, will force the circumferential rods into the elastic sheath wall. Since the circumferential rods 53—53 are located outward of the longitudinally-extending rods 52—52, as shown, they do not interfere with the maintenance of flow ducts at least along the sides of the longitudinally-extending rods. It will be understood from Fig. 4 that with a relatively thick sheath wall of limited elasticity, tightening of the cinch band 50 about the sheath 21 possibly will not cause the sheath wall to be distorted to a degree of direct contact with the exterior surface of the mandrel tube 20 at any point but merely to bulge toward it, as depicted. In any event, should the sheath wall be of such limited thickness or of such elasticity as to cause the cinch band 50 to distort its interior surface to contact of the exterior surface of the mandrel tube 20 at a snugging or tying locality intermediate of the longitudinally-extending land rods 52—52, the sheath material will not be caused to flow to contact of all of the side surfaces of the longitudinal rods and thus flow ducts will be maintained along the sides of the latter.

In operation and use of the embodiment of the invention shown in Figs. 1 to 5 incl. for driving and setting armoring shells of cast-in-place concrete piles, the pile-driving apparatus of the present invention may be set up in the manner proposed in Fig. 1. Let it be assumed

that an armoring shell 49 is to serve for the casting of a pile about 45' long, and with the soil of such looseness that the drag imposed upon the shell to be driven by the mandrel requires tying anchorage of the sheath 21 to the mandrel at only three points. Cinch bands 50—50 will be applied to the lower 45' length of the sheath at points about 15' apart. The shell 49 is then slid over the tied bottom portion of the sheath 21 which, of course, is in deflated condition. In order to avoid tendency for the sheath to swell to the bursting point when inflated above the top end of the shell 49, it is preferably confined by a previously applied top shell section which may be loosely tied to the mandrel, such as by loops 55, 55 of wire extending through holes punched in the top edge of the shell section 54 and extending through suitable ears 56, 56 preferably mounted on the reinforcing band 24. The anvil 42 will be tied to the hammer base 45, such as by clevises 44, 44, and the anvil then lowered for telescopic reception of its axially-extending flange 43 into the open top end 32 of core tube 22. The ties 47, 47 are then applied loosely to connect the anvil to the core tube and the whole assembly is rested within a flanged boot pan 57 resting upon the surface of the soil, as depicted in Fig. 1. The valve 31 is then manipulated so that conduit 30 feeds air under pressure from a source of say about 15 p. s. i. g. to inflate the sheath 21 and expand it into clamping contact with the inner wall of the pile shell 49 and the protective shell section 54. The air under pressure flows past the cinch bands 50—50 from section to section of the sheath 21 via the flow ducts along the sides of the lands provided by the longitudinally-extending rods 52—52 and thus the shell is securely tied to the mandrel.

Repeated blows on the hamer base 45 which react against the anvil 42 drive the mandrel tube 20 into the ground with the boot pan 57 leading it and with the pile shell 49 carried into the soil with maintenance of pressure between the shell and the soil. Assume in this manner that the pile shell 49 and the boot pan 57 are driven by the mandrel assembly to the position depicted in Fig. 2.

If it is now desired to provide the pile with a footing or base of concrete of good load-bearing characteristics, the hammer base 45 will then be raised to carry with it the anvil 42 to an elevated position, such as that depicted in Fig. 3. During this time the flexible ties or chains 47, 47 become taut to raise the core tube 22 to an elevated position so that its bottom tamping end 34 is raised a distance of, for example, about 3' above the boot pan 57. The apparatus is then readied for supply of unset footing concrete and the tamping thereof into a pile base.

It will be understood from Fig. 3 that the raised anvil 42 is positioned an appreciable distance above the top end 32 of the core tube so that the latter is open and accessible. A charge of unset, relatively dry concrete may be supplied to the open top end of the core tube by any suitable means, such as a dump bucket 58, which may be carried by any suitable crane cable harness, such as that indicated at 59. The dump bucket 58 may be provided with suitable trip mechanism, such as a pair of laterally-spaced arms 60 tied together by a transverse rod 61, which may be caught under the edge of the sector of the lateral flange 33 on the top end of the core tube 22 or any projection provided thereon for that purpose. As a result, the dump blucket 58 will be tipped as indicated in full lines in Fig. 3 to deliver its contents down the core tube 22. When the core tube 22 was lifted by the ties 47, 47, force of gravity caused the valve head 38 to drop out of the valve passage 36 and open it with the valve stem head 40 serving as a limiting stop. The dumped charge of concrete will fall down the core tube 22 and be guided by the funnel section 37 to and through the outlet passage provided by valve seat 36 to collect at 62 on the boot pan, as depicted in Fig. 3.

The anvil 42 will then be lowered with the hammer base 45 again to rest upon the core tube top end 32 and each

hammer blow will cause the seat 36 to be pushed downwardly upon the valve head 38 to close the outlet passage and so that the now-closed bottom end of the core tube will serve as a tamping device to drive the boot pan 57 downwardly and compact the charge of concrete thereon. This procedure of supplying a charge of footing concrete and tamping it may be repeated to accumulate a base of desired size and shape. The boot pan will be lost in the so formed base mass and in no way interferes with the load-bearing efficiency of the tamped base. Its loss entails no appreciable economic loss since such boot pans are of low cost.

It will be understood that the flow duct-forming and maintaining, longitudinally-extending lands of the exterior surface of the mandrel tube may be in a variety of forms. For example, as proposed in Fig. 5, a relatively heavy mandrel tube 120 may be provided with a series of circumferentially-spaced, longitudinally-extending grooves 63—63 to provide therebetween longitudinally-extending, circumferentially-spaced raised ribs or lands 152—152 which will serve to provide and maintain flow ducts in the bottoms of the grooves at a snugging or pinching locality for intercommunicating adjacent sections of the sheath 21.

If it is desired to form a bulbous base of footing concrete for the pile, which may be advisable in soft or loose soil or water-bearing sand, the procedure of delivering a charge of footing concrete down the core tube 22 and tamping it with the tamping bottom end 34 of the latter will be repeated to form an accumulated bulbous mass 64 of concrete, as depicted in Fig. 6. Then, the pile shell 49 may have its bottom end 65 driven into the bulbous mass 64 by further hammer blows upon the mandrel tube top end 23 through the core tube flange 33 and the anvil 42, such as to the position indicated in Fig. 6.

After the pile base or footing has been formed and the pile shell 49 set to the satisfaction of the engineer, the successive sections of the sheath 21 are deflated, such as by turning the valve 31 to the bleed or relief position. This frees the mandrel tube 20 from the shell 49. The core tube 22, the mandrel tube 20, and the confining section 54 are then pulled. Thereafter, concrete will be cast into the pile shell 49 to form the cast-in-place concrete pile.

If it is desired to avoid any tendency for footing concrete, while being tamped, to drag the mandrel tube 20 and the shell 49 downward with it by frictional contact with the inner wall of the bottom end 25 of the mandrel tube, this may be avoided by providing liner means preferably in the form of a relatively short tubular section 66 inserted between the inner surface of the mandrel tube and the outer surface of the core tube. The liner means 66 thus may be in the form of a slip tube and may be formed of relatively thin black iron or dead steel. Slip tube 66 may be constructed from a blank, such as that indicated in Fig. 8, consisting of an elongated rectangular sheet 67 having extending from one side edge thereof longitudinally-spaced tabs 68—68. The blank shown in Fig. 8 may then be curved into a tubular section, such as that depicted in Fig. 9, and there is no need to secure together the juxtaposed end edges 69 and 70. In fact, it is desired to leave the end edges free of each other so that such liner means or slip tube may be distorted and spread in the tamped formation of the base to avoid interference with the tamping and forming procedure and it, like the boot pan 57, will be lost in the base mass. The liner means or slip tube 66 may be provided, in the form shown in Fig. 9, and delivered to the job where the tabs 68—68 may be easily bent laterally outward, such as by hammer blows, to form radiating arms which will seat in the flanged boot pan 57 to assure approximately coaxial arrangement therein and proper concentric positioning with respect to the mandrel tube 20 and the core tube 22. When such liner means or slip tube is employed, the core tube may be of smaller O. D. to provide sufficient space between it and the mandrel tube for easy reception of such liner or slip tube.

As indicated in Fig. 11, when such a liner or slip tube 66 is employed and a charge 162 of unset footing concrete is tamped out by the tamping end 34 of the core tube 22, the bottom end of the liner or slip tube, as it slides out of the bottom end of the mandrel tube, desirably begins spreading to permit the desired spread of the tamped concrete and eventually with tamping of successive charges of footing concrete, such liner or slip tube, in distorted condition, is lost in the base mass without having interfered with proper shaping and formation of the latter. If desired, slippage between the mandrel tube 20 and the liner or slip tube 66 may be assured or increased by a few dabs of grease to the exterior surface of the latter before its insertion into the bottom end of the former.

It is to be understood that the tamping means provided on the bottom end of the core tube is not limited to the form proposed in Figs. 1, 3, 6, 7 and 11. For example, as indicated in Fig. 12, core tube 122 may be provided by a thickened wall section 134, the exterior surface of which is substantially cylindrical and coextensive with the cylindrical outer surface of the main portion of the core tube but with its internal diameter progressively decreased so as to provide a funnel-shaped outlet passage 137. As a result, such tamping means provides on the bottom end of the core tube a tamping face in the form of a circular zone 71 of appreciable width which will effectively tamp the footing concrete when successive blows are applied to the core tube 122. Such tamping means as proposed in Fig. 12 may, if desired, be provided by a separate casting fastened to or mounted upon the bottom of the core tube.

It is sometimes desired to use a pre-cast base in the form of a point, such as that proposed in Fig. 12, and it will be understood that the pile-driving apparatus of the present invention, in any of the forms proposed above, is adapted to the use of such a point. As there suggested, a pre-cast point 72 may be in the form of a cast body of concrete having a leading pointed end 73 and a back end in the form of a cylindrical projection 74 which is loosely receivable into the bottom end 25 of the mandrel tube, so as to be driven ahead of the latter. Of course, such point will be of a diameter sufficiently large to assure that the point body below the cylindrical back end projection 74 will extend radially beyond the bottom edge 65 of the pile shell 49 to serve the same purpose as the boot pan 57 during the driving of the shell.

It will thus be seen that the objects set forth above, among those made apparent from the preceding description, are efficiently attained and, since certain changes may be made in carrying out the above method and in the constructions set forth without departing from the scope of the invention, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

It is also to be understood that the following claims are intended to cover all of the generic and specific features of the invention herein described, and all statements of the scope of the invention which, as a matter of language, might be said to fall therebetween.

Having described my invention, what I claim as new and desire to secure by Letters Patent is:

1. A pile driving apparatus comprising in combination; an elongated, rigid, drivable, unblocked mandrel tube having an open upper driving end, an open lower end and an intervening imperforate sidewall section of appreciable length; an elongated, interiorly-unobstructed core tube of an outer diameter appreciably less than the inner diameter of said mandrel tube loosely telescoped into said mandrel tube and having an open upper end to receive and deliver to its bottom end charges of unset footing concrete; abutment means on the upper ends of said core and mandrel tubes to limit telescope of the former down

into the latter while permitting ready upward withdrawal of said core tube; tamping means provided on the bottom end of said core tube and having a flow passage extending therethrough to deliver charges of unset footing concrete therebelow; anvil means removably supported by the upper end of said mandrel tube which when lifted to a feed position uncovers the open upper end of said core tube to permit dumping thereinto of charges of unset footing concrete; an elongated, imperforate, inflatable tubular sheath of elastic material covering the imperforate section of said mandrel tube and anchored at its top and bottom ends in a fluid-tight manner to said imperforate mandrel tube section to define therebetween an air chamber, said sheath being expandable upon inflation of said chamber into intimate supporting contact with the inner wall of surrounding pile shell means; air supply and exhaust conduit means exterior of said mandrel tube connected below said anvil means to the upper end of said chamber without interfering with telescope of said core tube into said mandrel tube; at least one cinch band snugged about said inflatable sheath to there clamp the latter to the exterior surface of said mandrel tube section for distributing longitudinal drag by surrounding shell means during driving; and longitudinally-extending lands located on the the exterior of said mandrel tube beneath said sheath extending axially beyond the top and bottom edges of said cinch band providing past the latter along the sides of said lands fluid ways to assure inflation and deflation of all sections of said sheath.

2. A pile driving apparatus comprising, in combination; an elongated, rigid, drivable, unblocked mandrel tube having an open upper driving end, an open lower end and an intervening imperforate sidewall section of appreciable length; an elongated, interiorly-unobstructed core tube of an outer diameter appreciably less than the inner diameter of said mandrel tube loosely telescoped into said mandrel tube and having an open upper end to receive and deliver to its bottom end charges of unset footing concrete; abutment means on the upper ends of said core and mandrel tubes to limit telescope of the former down into the latter while permitting ready upward withdrawal of said core tube; tamping means provided on the bottom end of said core tube and having a flow passage extending therethrough to deliver charges of unset footing concrete therebelow; anvil means removably supported by the upper end of said mandrel tube which when lifted to a feed position uncovers the open upper end of said core tube to permit dumping thereinto of charges of unset footing concrete; an elongated, imperforate, inflatable tubular sheath of elastic material covering the imperforate section of said mandrel tube and anchored at its top and bottom ends in a fluid-tight manner to said imperforate mandrel tube section to define therebetween an air chamber, said sheath being expandable upon inflation of said chamber into intimate supporting contact with the inner wall of surrounding pile shell means; air supply and exhaust conduit means exterior of said mandrel tube connected below said anvil means to the upper end of said chamber without interfering with telescope of said core tube into said mandrel tube; at least one cinch band snugged about said inflatable sheath to there clamp the latter to the exterior surface of said mandrel tube section for distributing longitudinal drag by surrounding shell means during driving; and a plurality of circumferentially-spaced, longitudinally-extending rods located on the exterior surface of and extending through a major portion of the length of said imperforate mandrel section to lie beneath said cinch band and the intervening sheath with maintenance of fluid ways along the sides of said rods past said cinch band.

3. A pile driving apparatus comprising, in combination; an elongated, rigid, drivable, unblocked mandrel tube having an open upper driving end, an open lower end and an intervening imperforate sidewall section of appreciable length; an elongated, interiorly-unobstructed core tube of an outer diameter appreciably less than the inner diameter of said mandrel tube loosely telescoped into said mandrel tube and having an open upper end to receive and deliver to its bottom end charges of unset footing concrete; abutment means on the upper ends of said core and mandrel tubes to limit telescope of the former down into the latter while permitting ready upward withdrawal of said core tube; tamping means provided on the bottom end of said core tube and having a flow passage extending therethrough to deliver charges of unset footing concrete therebelow; anvil means removably supported by the upper end of said mandrel tube which when lifted to a feed position uncovers the open upper end of said core tube to permit dumping thereinto of charges of unset footing concrete; an elongated, imperforate, inflatable tubular sheath of elastic material covering the imperforate section of said mandrel tube and anchored at its top and bottom ends in a fluid-tight manner to said imperforate mandrel tube section to define therebetween an air chamber, said sheath being expandable upon inflation of said chamber into intimate supporting contact with the inner wall of surrounding pile shell means; air supply and exhaust conduit means exterior of said mandrel tube connected below said anvil means to the upper end of said chamber without interferring with telescope of said core tube into said mandrel tube; at least one cinch band snugged about said inflatable sheath to there clamp the latter to the exterior surface of said mandrel tube section for distributing longitudinal drag by surrounding shell means during driving; and a wrap of relatively heavy mesh means on the exterior surface of and extending over the major portion of said imperforate mandrel section and beneath said elastic sheath, said mesh means having circumferentially-spaced, longitudinally-extending rod elements adjacent said mandrel section surface and mandrel-encircling, axially-spaced rod elements on the outside of said longitudinally-extending rod elements with the latter providing longitudinal fluid ways beneath said sheath and cinch band and said mandrel-encircling rod elements providing sheath-anchoring projecting means which embeded into said sheath upon tightening of said cinch band.

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