March 2, 1948. E. W. RIEMENSCHNEIDER ET AL 2,437,043

COLLAPSIBLE PILE DRIVING MANDREL

Filed Nov. 2, 1945 3 Sheets-Sheet 1

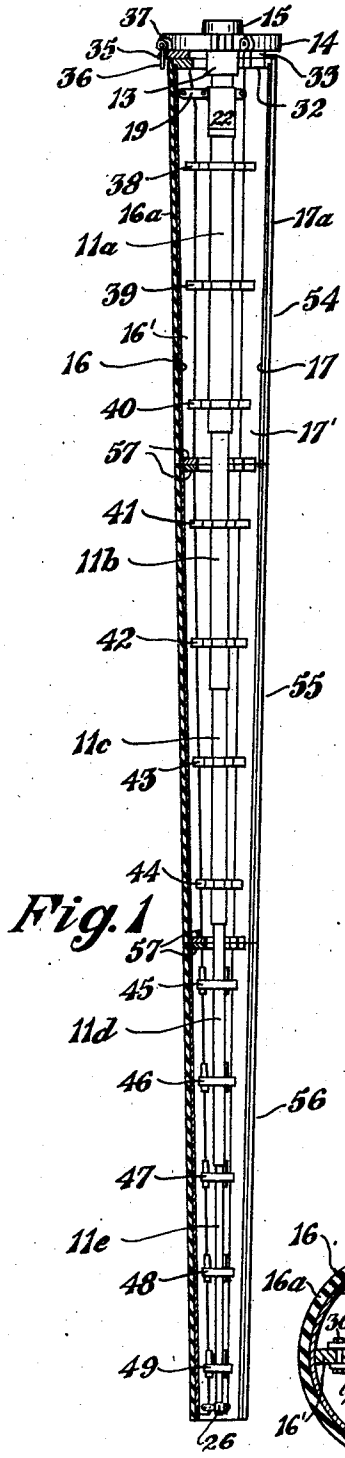
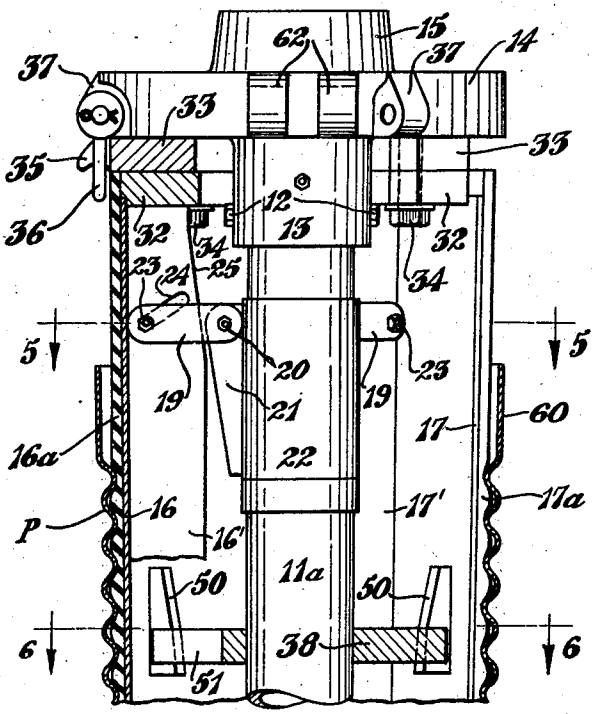


Fig. 1



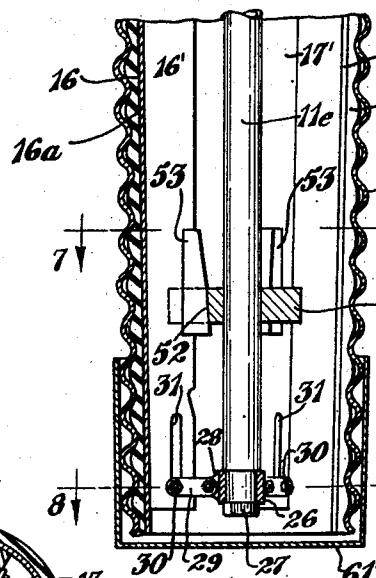


Fig. 2

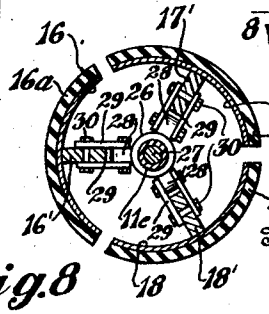


Fig. 8

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COLLAPSIBLE PILE DRIVING MANDREL

Filed Nov. 2, 1945 3 Sheets-Sheet 2

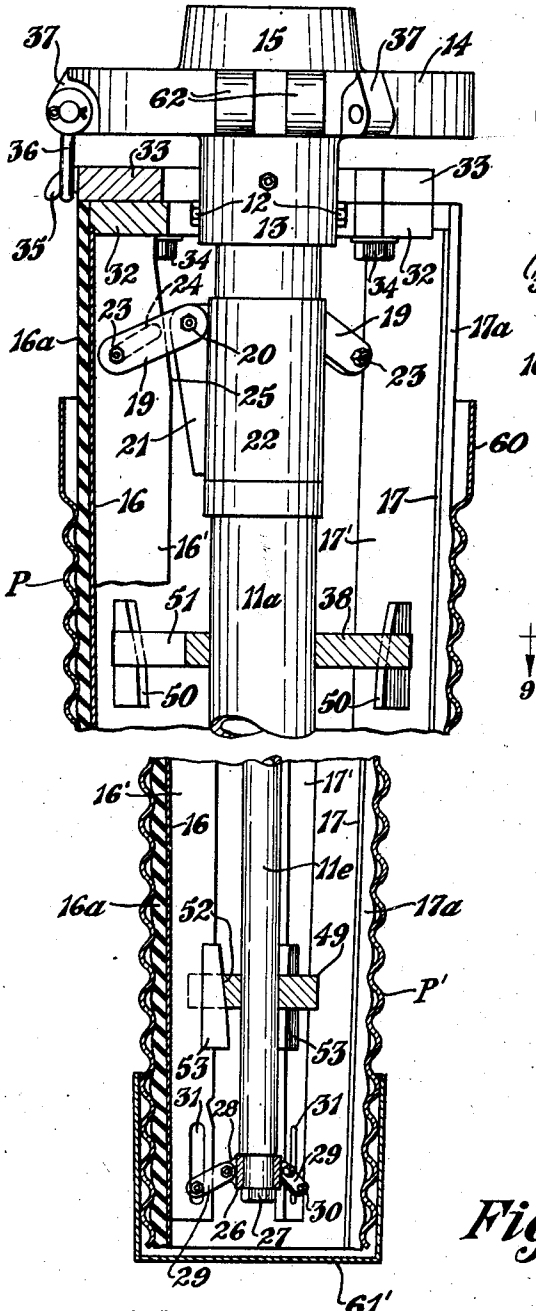


Fig. 3

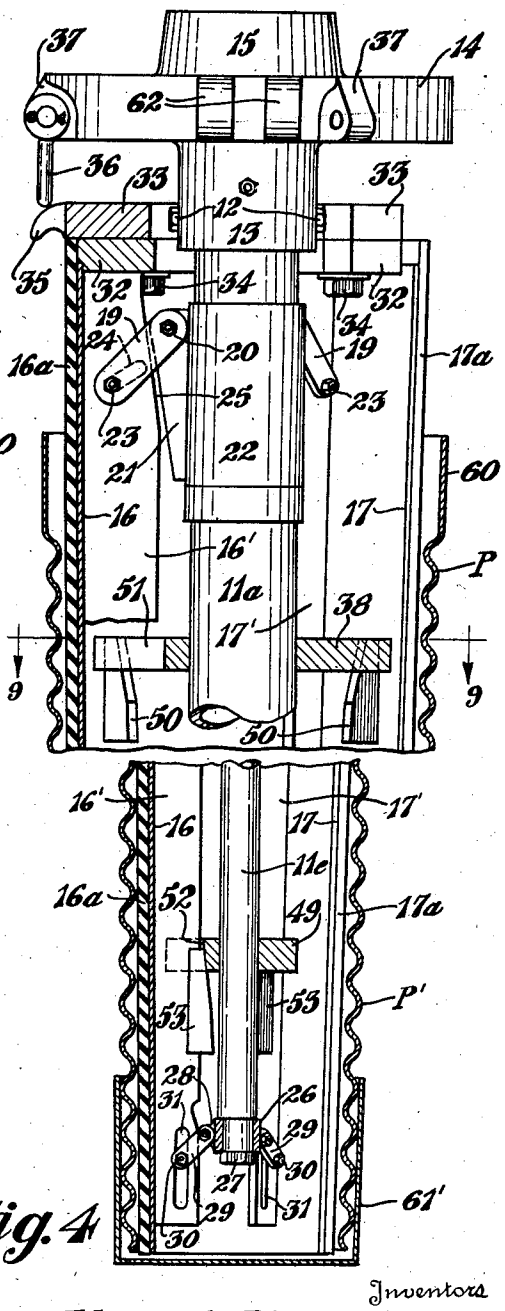


Fig. 4

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COLLAPSIBLE PILE DRIVING MANDREL

Filed Nov. 2, 1945 3 Sheets-Sheet 3

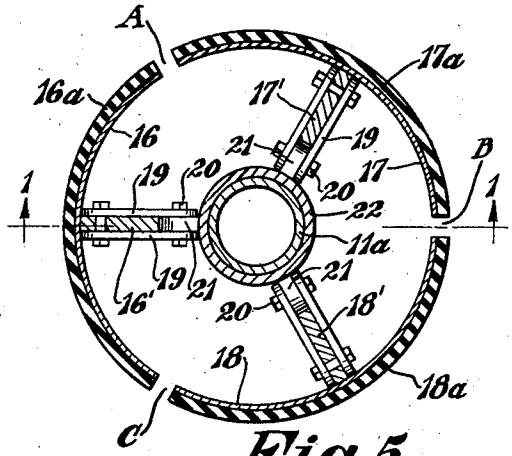


Fig. 5

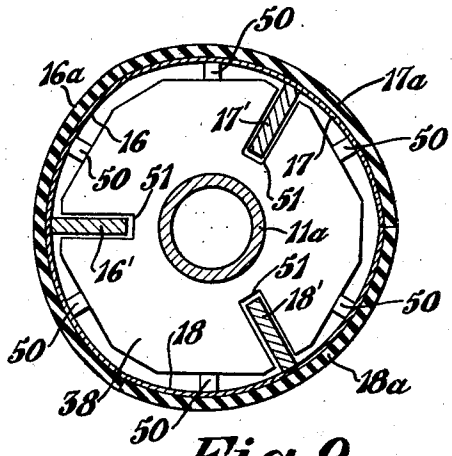


Fig. 9

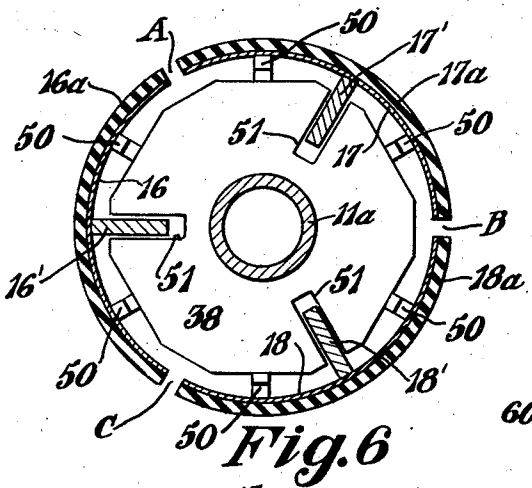


Fig. 6

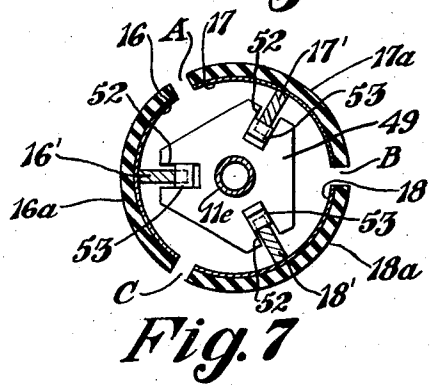


Fig. 7

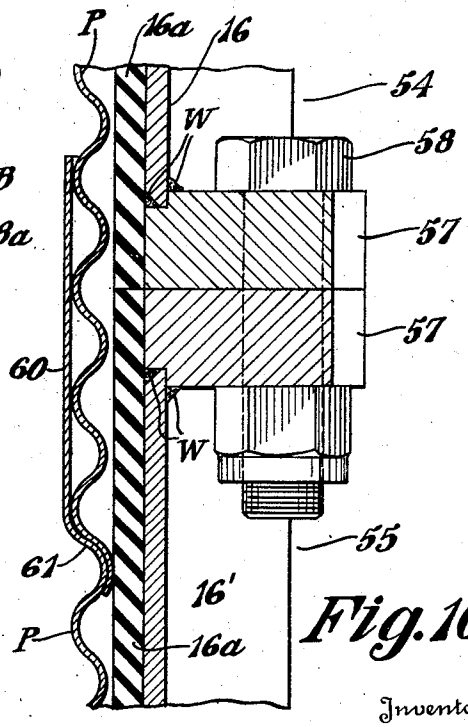


Fig. 10

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COLLAPSIBLE PILE-DRIVING MANDREL

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Application November 2, 1945, Serial No. 626,194

4 Claims. (Cl. 61—79)

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The invention relates generally to apparatus for driving tubular piles or shells into the ground, and more particularly to a collapsible core or mandrel which fits within and frictionally engages the shell during the driving operation, and which is collapsible radially for withdrawal from the shell after it is driven.

Prior collapsible mandrel constructions have been adapted for driving tapered tubular piles by frictional engagement of radially expansible steel segments with the pile shell, but in order to obtain sufficient frictional engagement, the shell is required to have a substantial amount of taper. Where relatively long piles are required, such amount of taper becomes impracticable, because the upper end of such pile is necessarily of excessively large diameter. Obviously, straight or cylindrical tubular piles cannot be driven with such constructions because of the lack of sufficient frictional engagement.

In the case of circumferentially corrugated piles, prior collapsible mandrel constructions have had their segments correspondingly corrugated to fit into each of the pile corrugations, so that the driving impact on the mandrel is taken by its engagement with the corrugations, and the shell is driven without distorting or damaging the corrugations. While such constructions function satisfactorily with corrugated shells, they are very expensive to make because the mandred segments must be accurately shaped to fit all of the individual corrugations of the shell. Such mandrel is adapted for use with only one size of corrugations, and cannot be used for driving plain or smooth piles.

It is a general object of the present invention to provide a novel and improved collapsible mandrel which is adapted to drive straight or tapered tubular piles which may be plain, fluted or circumferentially corrugated.

Another object is to provide a collapsible mandrel which is adapted to fit a corrugated pile for driving the same, without requiring the mandrel segments to be corrugated.

Another object is to provide an improved mandrel construction which maintains good frictional contact with the pile shell during driving, regardless of the degree of taper of said shell.

A further object is to provide an improved mandrel construction for driving a corrugated pile shell, in which uniform frictional contact is insured over the entire surface of all the corrugations.

Another object is to provide an improved collapsible mandrel for driving a corrugated pile shell, in which each corrugation is backed up during driving so as to prevent distortion or damage to the shell.

A still further object is to provide an improved collapsible mandrel which functions to cushion

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the shock of the driving hammer on the various parts of the mandrel.

Finally, it is an object of the present invention to provide a novel and improved collapsible mandrel which overcomes the disadvantages of prior constructions; which is adapted to be made in longitudinal sections without limiting the length per section or of the assembled sections; and which is inexpensive to manufacture and use, and has a long life.

These and other objects, which will be apparent to those skilled in the art from the following description are accomplished by the parts, construction, arrangements, combinations, and sub-combinations, which comprise the present invention, the nature of which is set forth in the following general statement, and preferred embodiments of which are set forth in the following description and illustrated in the accompanying drawings; and which is particularly and distinctly pointed out and set forth in the appended claims forming part hereof.

In general terms, the nature of the invention may be stated as including a collapsible pile driving mandrel having a center shaft, a plurality of circumferentially arranged segments or leaves surrounding said shaft, cooperating means on the shaft and segments for forcing the segments radially outward when the shaft is driven downwardly, the segments having resilient rubber facings for frictionally engaging a pile shell in expanded position, and cooperating means movably connecting the segments to said shaft for radially collapsing said segments when the shaft is raised upwardly relative to the segments.

Referring to the drawings forming part hereof,

Figure 1 is a longitudinal sectional view of a collapsible mandrel embodying the invention and shown in expanded position, said section being taken substantially on line 1—1, Fig. 5;

Fig. 2 is an enlarged fragmentary sectional view similar to Fig. 1, showing the mandrel expanded into engagement with a corrugated tubular pile shell;

Fig. 3 is a view similar to Fig. 2 showing the mandrel partially expanded in pre-driving position;

Fig. 4 is a similar view, showing the mandrel in collapsed position for withdrawal from the shell;

Fig. 5 is a cross sectional view as on line 5—5, Fig. 2, with distant parts removed;

Fig. 6 is a cross sectional view as on line 6—6, Fig. 2, with the pile shell removed;

Fig. 7 is a cross sectional view as on line 7—7, Fig. 2, with the pile shell removed;

Fig. 8 is a cross sectional view as on line 8—8, Fig. 2, with the pile shell and bottom cap removed;

Fig. 9 is a cross sectional view as on line 9—9, Fig. 4, with the pile shell removed; and

Fig. 10 is an enlarged fragmentary longitudinal

sectional view showing one of the joints between longitudinal sections of the mandrel segments.

Similar numerals refer to similar parts throughout the several views of the drawing.

The embodiment of the improved collapsible mandrel shown by way of example in the drawings and described herein is adapted for driving a tapered tubular pile shell, and is shown as applied to a tapered tubular shell having circumferential corrugations. It is to be understood that the collapsible mandrel comprising the invention is equally well adapted for driving plain tapered tubes or tapered tubes having longitudinal flutes, without departing from the scope of the invention defined in the claims. Likewise, it is to be understood that the collapsible mandrel of the present invention can be designed for fitting into and driving a straight cylindrical tubular pile shell, without departing from the scope of the invention.

It is pointed out that while the embodiment of collapsible mandrel shown in Fig. 1 has collapsible segments each of which is made up of three longitudinal sections joined together as one unit, the number and length of the longitudinal sections can be varied as desired to produce mandrels of a large variety of lengths, and having various degrees of taper.

The novel collapsible mandrel preferably includes a center longitudinal shaft or core which may be made up of a plurality of tubular sections joined together. As shown, the shaft may consist of tubular sections decreasing progressively in diameter from the relatively large diameter section *11a* at the top to the relatively small diameter tubular section *11e* at the bottom of the shaft. The tubular section *11b* of the shaft is slightly smaller in diameter than *11a*, and may have its upper end telescoped into and suitably secured to the section *11a*. In the same manner the relatively smaller section *11c*, is secured to section *11b*, the next smaller section *11d* is secured to section *11c*, and the smallest section *11e* is secured to section *11d*.

The tubular sections *11a*, *11b*, *11c*, *11d*, and *11e*, when secured together, comprise the center shaft of the mandrel which decreases in diameter at intervals from top to bottom. The top section *11a* has secured on its upper end, as by screws **12**, a tubular socket **13** which is part of the base plate **14** of a usual pile driving head. The upper boss **15** of the base plate **14** preferably fits within an adapter which mounts an anvil block above the boss **15** for receiving the blows of the driving hammer and transmitting them through the mandrel. The construction of the driving head per se forms no part of the present invention.

The improved mandrel includes a plurality of circumferentially arranged segments **16**, **17** and **18** which are mounted on the center shaft for movement radially thereof. As shown in Figs. 5, 6 and 7, we prefer to have three such segments making a substantially complete circle in cross section. In a tapered mandrel according to the invention to be used for a tapered tube as shown in the drawings, the segments **16**, **17** and **18** may be made by slitting a plain tapered tube having substantially the same degree of taper as the tapered pile shells which are to be driven by the mandrel.

As shown in Figs. 5, 6 and 7, the segments **16**, **17** and **18** are made by taking a longitudinal cut of substantial width at three equally spaced locations A, B and C, 120° apart, and when fully expanded as in Figs. 2 and 6, the segments lie in a circle concentric with the center shaft. Thus, when the segments **16**, **17** and **18** are fully collapsed or closed, as shown in Fig. 9, the cross section of the mandrel is non-circular because the spaces A, B and C have been closed to reduce the area of the mandrel while preserving the same radius of curvature of the individual segments. The sectional view of Fig. 9, showing the segments in closed position is taken on the same plane as Fig. 6, which shows the segments fully expanded.

The segments **16**, **17** and **18** are arcuate in cross section and are each preferably provided with longitudinal stiffening ribs **16'**, **17'** and **18'**, respectively, located midway between their longitudinal edges and extending radially inward toward the center shaft. The ribs **16'**, **17'** and **18'** taper gradually from top to bottom, so that the space between their inner edges and the shaft sections is substantially constant throughout, as indicated in Figs. 1, 2, 3 and 4. These ribs may be suitably attached to the inside of the circular segments as by welding.

The means for mounting the segments **16**, **17** and **18** on the center shaft **11**, for radial movement relative to said shaft, preferably includes pairs of links **19** pivotally connected at their inner ends at **20** to ears **21** preferably extending radially from a collar **22** secured to the top section *11a* of the shaft adjacent the socket **13** of the base plate **14**. The outer ends of the links **19** have pivot bolts **23** which extend through inwardly upwardly inclined slots **24** in the stiffening ribs **16'**, **17'** and **18'** respectively.

In the fully expanded position of the segments shown in Fig. 2, the links **19** are substantially horizontal and the pivot bolts **23** engage the outer ends of the slots **24** to fully expand the segments **16**, **17** and **18** respectively. In the collapsed position of Fig. 4, raising the center shaft **11** raises the pivots **20** of the links **19** and causes the pivot bolts **23** to move inwardly in the slots **24**, and collapse the segments radially inward. As shown, the stiffening ribs **16**, **17** and **18** are tapered inwardly at their top ends at **25** to allow the ribs to clear the ears **21** in the collapsed position of Fig. 4.

Preferably, the segments **16**, **17** and **18** are movably connected at their bottom ends to the bottom end of the bottom shaft section *11e*. The connecting means may include a collar **26** secured on the bottom end of shaft section *11e* by means of a bolt **27**, said collar having radially projecting ears **28** at 120° intervals opposite the ribs **16**, **17** and **18**. The ears **28** are connected by pairs of links **29** to the respective ribs **16'**, **17'** and **18'**, the links being pivoted at their inner ends to the ears **28**, and having pivot bolts **30** at their outer ends passing through vertical slots **31** in the ribs.

As shown in Fig. 2, the links **29** are substantially horizontal when the segments are fully expanded with the pivot bolts **30** at the bottoms of slots **31**, and as shown in Fig. 4, the pivot bolts **30** ride upwardly in the slots **31** when the segments are radially collapsed by raising the center shaft *11e*.

Preferably, the top end of each segment is reenforced by a segmental horizontal reenforcing plate **32**, the outer edge of which is welded to the upper edge of the segment. Each segmental reenforcing plate **32** supports a segmental carrier plate **33** secured to the reenforcing plate by bolts **34**. The carrier plates **33** each have a radially extending hook **35** at their central portions, so that the hooks are spaced 120° apart circumferentially, and the base plate **14** is provided with

three depending loops 36 pivoted to ears 37 thereon at 120° intervals, for taking under the hooks 35.

In the expanded position of Fig. 2, the loops 36 engirdle the hooks 35 but do not engage under the same; in the pre-driving position of Fig. 3, the loops 36 engage under the hooks 35 to support the segments in partially expanded position; and in the collapsed position of Fig. 5, the loops 36 are spaced above the hooks 35.

Each of the steel segments 16, 17 and 18 is provided on its outer curved surface with a resilient rubber facing as indicated at 16*a*, 17*a* and 18*a*. The rubber facings are preferably vulcanized throughout to the metal segments, and are of substantially uniform thickness. The rubber facings are soft and compressible so that as the segments are radially expanded the rubber will grip the inner surface of the pile shell and accommodate itself to the configuration thereof, with the result that a strong frictional engagement is provided between the mandrel outer surface and the inner surface of the pile shell being driven.

The means positively forcing or expanding the mandrel segments outwardly preferably includes a series of preferably horizontal wedge plates secured at intervals to the center shaft, and cooperating with circumferentially arranged wedges on the inside of the segments. The number and spacing of these wedge plates may be varied if desired. In the drawings, the shaft section 11*a* has three vertically spaced wedge plates 38, 39 and 40; the shaft section 11*b* has two vertically spaced wedge plates 41 and 42; the shaft section 11*c* has two vertically spaced wedge plates 43 and 44, the shaft section 11*d* has two vertically spaced wedge plates 45 and 46, and shaft section 11*e* has three vertically spaced wedge plates 47, 48 and 49.

Each of these wedge plates engages a circumferentially arranged series of wedges which are secured as by welding on the inner surfaces of the segments 16, 17 and 18. The wedge plate 38 engages at its outer edges a pair of wedges 50 on each segment preferably spaced at equal distances laterally of the central strengthening ribs 16', 17' and 18', as shown in Figs. 2, 3, 4, 6 and 9. Similarly, the wedge plates 39, 40, 41, 42, 43 and 44 engage like wedges similarly arranged at proper vertical locations on the segments.

Each of the wedge plates 38, 39, 40, 41, 42, 43 and 44 are provided with slots 51 extending radially inward from their outer edges for receiving the ribs 16', 17' and 18'. As shown in Fig. 9, the slots 51 are made deep enough to accommodate the ribs in fully collapsed position of the segments.

The wedge plates 45, 46, 47, 48 and 49 are of relatively small area, being located within the small end of the mandrel, and are arranged to have the bottoms of slots 52 engage wedges mounted directly on the strengthening ribs 16', 17' and 18', as indicated in the showing of wedge plate 49 in Figs. 2 and 7.

In the small end of the mandrel, the lateral dimension of the segments is such that the wedging force need not be distributed to the segment at laterally spaced points, but can be transmitted directly through the strengthening ribs. Accordingly, as shown in Figs. 2 and 7, the wedges 53 are blocks secured as by welding, into recesses or slots cut in the strengthening ribs 16' and 17' and 18', and are wedgeably engaged by the bottom slots 52 in the wedge plate 49.

For convenience in manufacture and transportation, the mandrel may be made in longitudinal sections of convenient length, three such sections being indicated generally at 54, 55, and 56 in Fig. 1. The joints between the longitudinal sections may be made as shown in Fig. 10, in which the adjacent ends of the segments 16 of longitudinal sections have segmental joint plates 57 welded thereto as indicated at W, said welds being made along matching scalloped surfaces extending circumferentially of the segments, in accordance with good welding practice. The segmental joining plates 57 may be secured together by bolts 58 for joining the longitudinal sections of each segment together to produce a unit of the required length.

As indicated in Figs. 2, 3, 4 and 10, the pile shells P driven by the improved mandrel may be circumferentially corrugated sheet metal tubes. The pile shells are made up of a plurality of longitudinal sections P and P', having their ends telescoped together, and the upper end of each longitudinal pile section being preferably plain or non-corrugated as indicated at 60. As best shown in Fig. 10, the bottom end of one corrugated pile section P fits within the non-corrugated portion 60 of the pile section P' below, and engages the top corrugation 61 thereof.

In the operation of the improved mandrel in driving a pile shell, for example a sectional circumferentially corrugated shell as shown in the drawings, the hammer and driving head assembly are supported in usual fashion by a crane boom and the like, and the mandrel is supported in the pre-driving position of Fig. 3 by engaging the loops 36 of the base plate 14 under the hooks 35 of the carrier plates 33. In this position the entire assembly of the hammer, driving head and mandrel is moved to the location of the pile to be driven and raised sufficiently above the ground level to allow the pile sections P and P' to be placed over the bottom end of the mandrel and moved upwardly thereon until the corrugations frictionally engage the rubber facings of the segments. Obviously, the largest pile section P will be placed over the mandrel first, and then followed by the successively smaller sections P' which have their ends telescoped together as in Fig. 10.

In the pre-driving position of the mandrel the hooks 35 and loops 36 supporting the same are located radially outward of the center gravity of the mandrel segments to which they are attached, with the result that the bottom ends of the segments 16, 17 and 18 tend to swing radially outward away from the center shaft, which movement is limited by the bottom links 29. Thus, as the pile sections are raised upwardly around the mandrel, which raising may be done by a rope and pulley device, as the sections engage the rubber facings they are held in position not only by such frictional engagement, but by the outward swinging tendency of the mandrel segments.

After the pile sections are thus applied to the mandrel, the joints between the pile sections may be sealed if desired, with a plastic material, and a bottom cover or cap 61' is placed over the bottom end of the bottom pile section, with the mandrel inserted therein, for preventing the entrance of dirt and the like from entering the mandrel as the pile shell is driven.

The entire assembly, including the hammer, is then lowered into position in the spot prepared for the pile, and the weight of the hammer is ordinarily sufficient to complete expansion of the

mandrel to the position shown in Fig. 2, although in some cases it may be that the mandrel is not fully expanded until the first blow of the hammer is struck. As shown in Fig. 2, the full expansion of the mandrel squeezes the rubber facings into the individual corrugations of the pile shell so as to substantially fill the spaces within the corrugations.

Thus, each corrugation is supported or backed up during the driving operation so as to uniformly distribute and absorb the driving impact of each stroke of the hammer upon the mandrel. As a result, the shell is driven into the ground without distorting or damaging the individual corrugations, and the rubber facings function to cushion the shock of the hammer blows upon all of the parts of the mandrel, thereby greatly prolonging its life.

The rubber facings 16*a*, 17*a* and 18*a* provide sufficient positive frictional engagement with the pile sections to drive a plain or non-corrugated tube which may have a very slight degree of taper or may even be a straight cylindrical pile shell. Thus, the diameter of the upper end of a relatively long pile shell may be kept to a desired minimum, in contrast with the condition where a required amount of taper results in an excessively large pile diameter at the top end. Moreover, the rubber facings on the improved mandrel provide for fitting the mandrel into a pile shell having circumferential corrugations of various sizes, because it is not necessary to provide pre-formed corrugations on the outside of the mandrel segments for fitting the corrugations of the pile shell, as is the case with a mandrel having metal facings on its segments.

The improved collapsible mandrel may be made in longitudinal sections of any length, and may have any desired assembled length which may be required by the particular conditions during the driving operation, and the improved collapsible mandrel is inexpensive to manufacture and maintain, and easy to operate.

After a pile shell has been driven to the desired depth by the improved mandrel, as previously described, the driving head is closer to the ground than at any other time, and the lifting loops 36 are therefore ordinarily accessible to a man standing on the ground, although in unusual cases he may be required to climb to an elevation where he can reach the loops. In either case, the loops are swung outwardly free of the hooks 35 and the hammer and driving head assembly raised to a position such as shown in Fig. 4, by attaching a cable or the like to the ears 62 provided at diametrically opposite locations on the base plate 14 of the driving head. As the center shaft of the mandrel is thus raised, the segments thereof will first be forced inwardly by the resilient action of the rubber facings, and then the links 19 and 29 will draw the segments into fully collapsed position, whereupon the entire mandrel may be withdrawn from the pile shell.

As soon as the end of the mandrel clears the top of the driven pile shell, the crane boom is moved slightly to one side and the end of the mandrel set on the ground, so that by lowering the driving head assembly a few inches, the lifting loops 36 will slide over the hooks 35 and drop into the pre-driving position of Fig. 3. Raising the entire assembly will now lift the mandrel in the pre-driving position of Fig. 3 in readiness for driving another pile shell in the manner previously described.

In the foregoing description, certain terms have been used for the sake of clarity, but no unnecessary limitations are to be implied therefrom beyond the requirements of the prior art, because such words are utilized for descriptive purposes and are intended to be broadly construed.

Moreover, the embodiments of the improved construction shown and described herein are by way of example, and the scope of the present invention is not limited to the exact details of construction of the various parts.

Having now described the features of the invention, the construction, operation and use of a preferred embodiment thereof, and the new and useful advantageous results obtained thereby; the novel and improved constructions and arrangements, and reasonable mechanical equivalents thereof which are obvious to those skilled in the art, are set forth in the appended claims.

We claim:

1. In combination, a corrugated pile shell, a mandrel for driving said shell into the ground by engaging the inner surface of the shell, said mandrel including a plurality of circumferentially arranged segments having soft rubber facings, and means for forcing said segments radially outward to squeeze said facings into the corrugations, said facings having sufficient radial thickness to substantially fill said corrugations when the segments are forced radially outward.

2. In combination, a corrugated pile shell, a mandrel for driving said shell into the ground by engagement with the inner surface of the shell, a driving head on the upper end of the mandrel, said mandrel including a plurality of circumferentially arranged segments having soft rubber facings, means for forcing the segments radially outward to squeeze said facings into the corrugations to substantially fill the corrugations, and means on the driving head for supporting the segments in partially expanded pre-driving position with said facings engaging only the inner surfaces of the shell between corrugations.

3. In combination, a corrugated pile shell, a mandrel for driving said shell into the ground by engagement with the inner surface of the shell, a driving head on the upper end of the mandrel, said mandrel including a plurality of circumferentially arranged segments having soft rubber facings, means for forcing the segments radially outward to squeeze said facings into the corrugations to substantially fill the corrugations, and means on the driving head located radially outward of the center of gravity of each segment for supporting the segments in partially expanded pre-driving position with said facings engaging only the inner surfaces of the shell between corrugations.

4. In combination, a corrugated pile shell, a mandrel for driving said shell into the ground by engagement with the inner surface of the shell, a driving head on the upper end of the mandrel, said mandrel including a central shaft and a plurality of circumferentially arranged segments mounted on the shaft and having soft rubber facings, means for forcing the segments radially outward to squeeze said facings into the corrugations to substantially fill the corrugations, means on the driving head for supporting the segments in partially expanded pre-driving position with said facings engaging only the inner surfaces of the shell between corrugations, and

means for moving the segments radially inward as the shaft is raised.

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