

Feb. 16, 1960

L. MUELLER

2,924,948

PILE

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Fig. 4

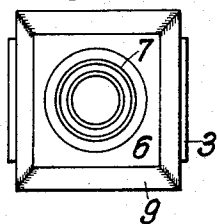


Fig. 5

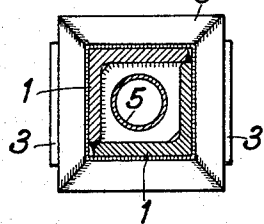


Fig. 6

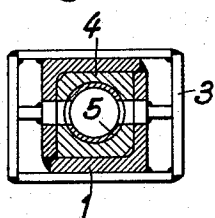
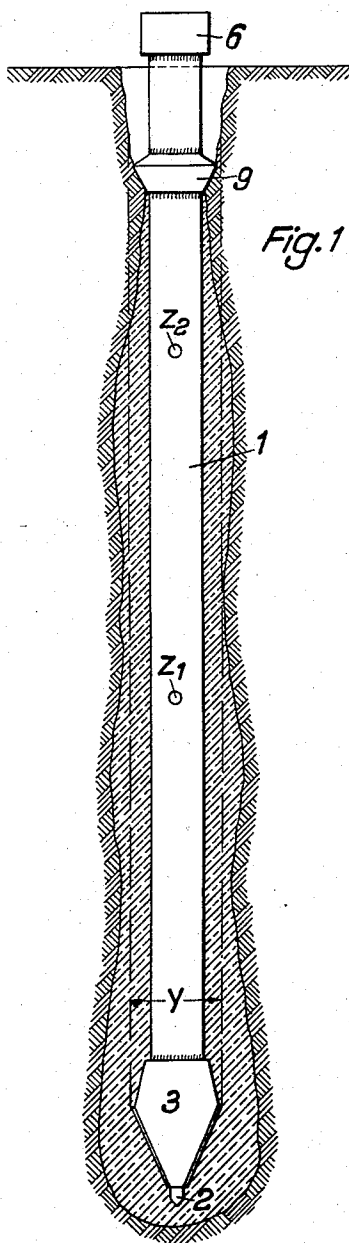
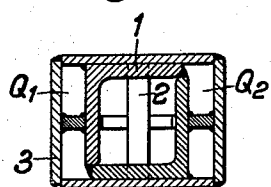


Fig. 7



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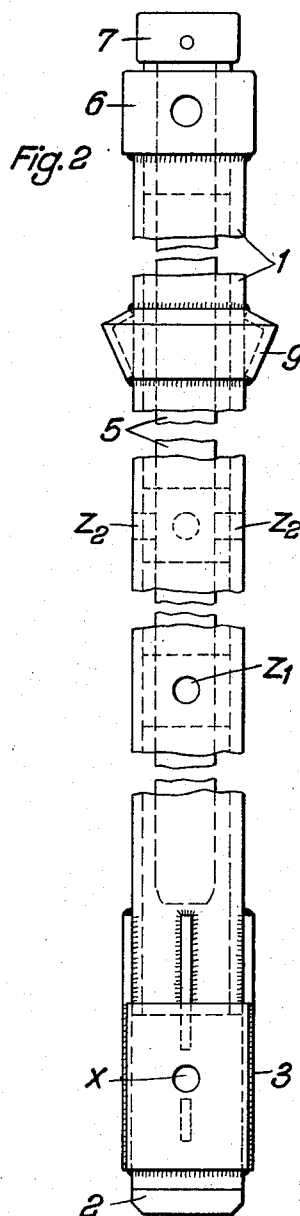
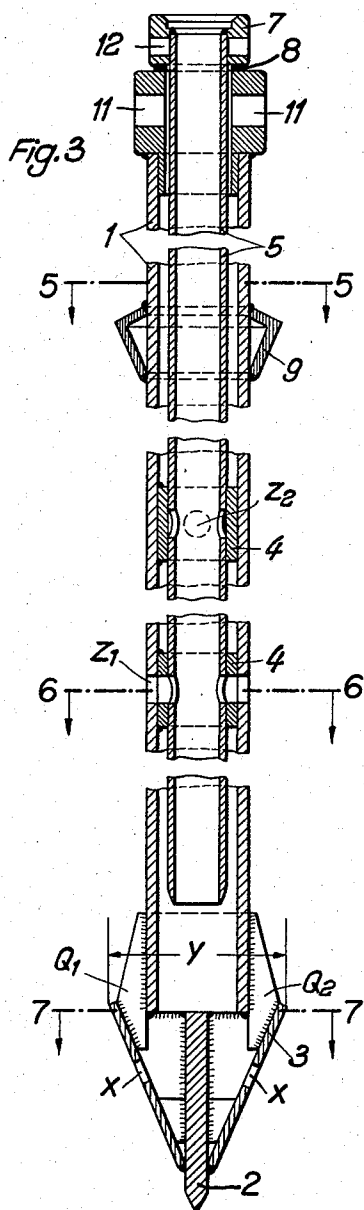
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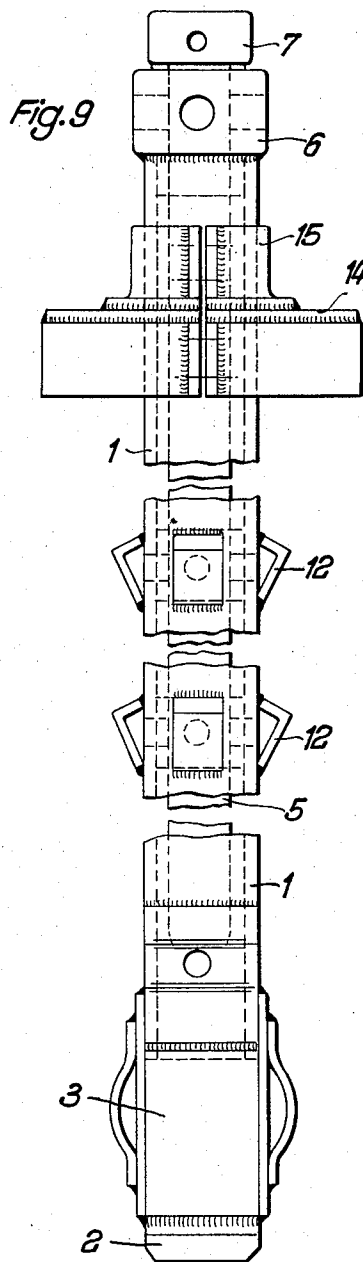
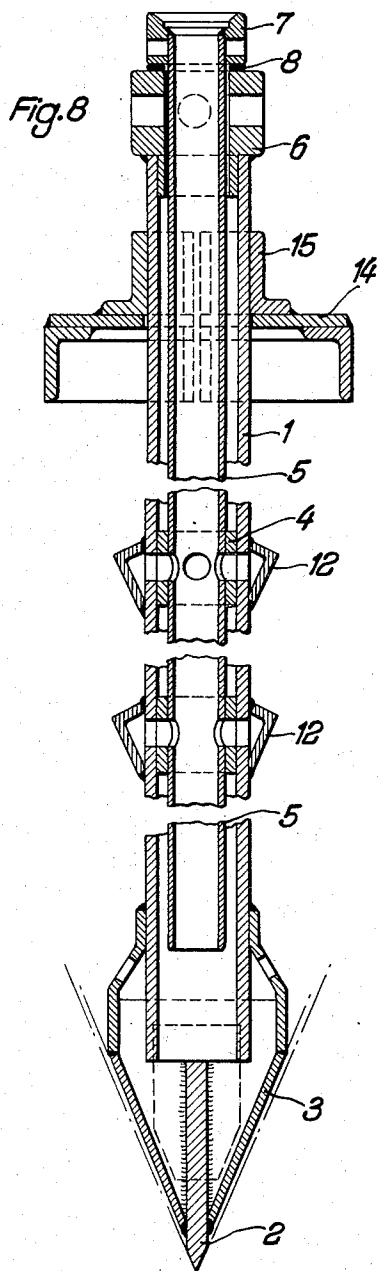
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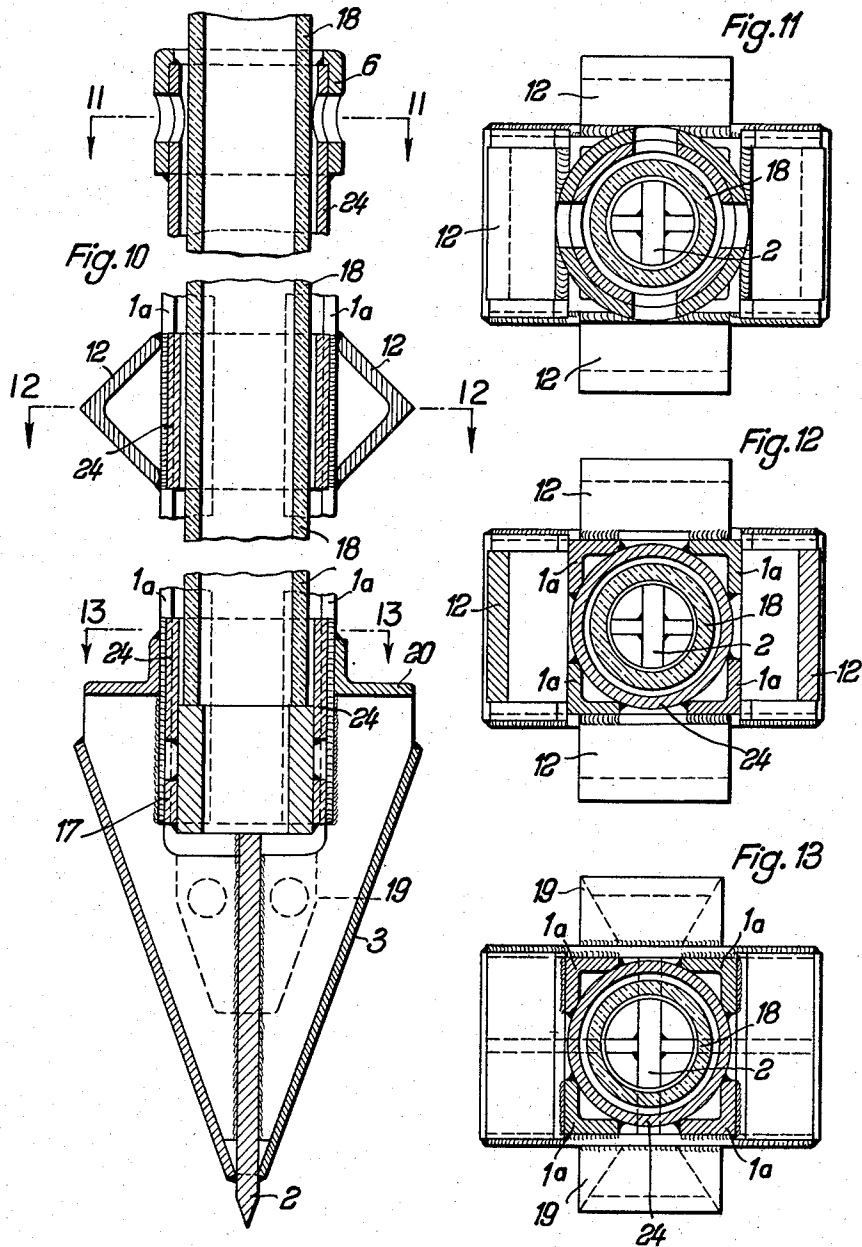
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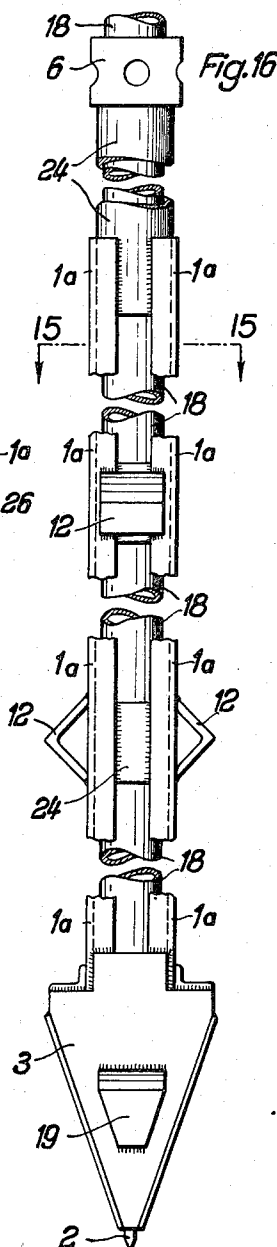
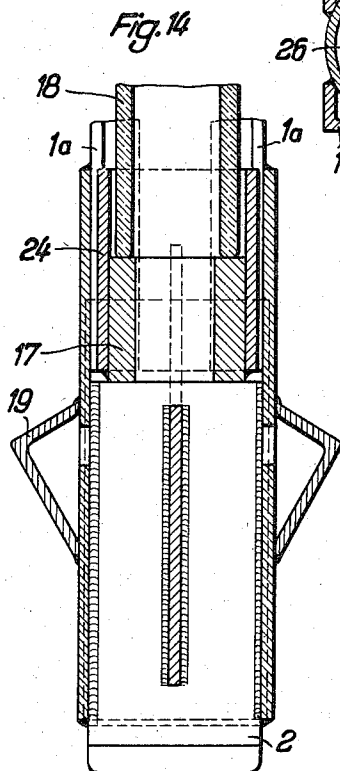
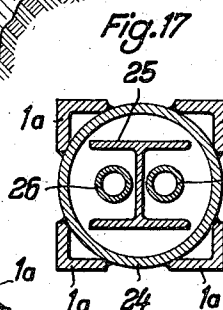
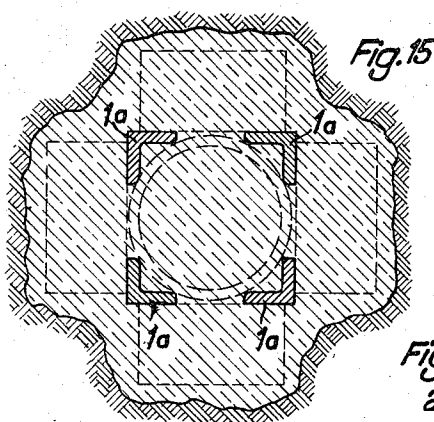
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PILE

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7 Claims. (Cl. 61—57)

This invention concerns piles.

Piles for building foundations are known, in which the lower end of the pile shaft is fitted with a pile foot whose upper cross-sectional surface is greater than the cross-section of the hollow pile shaft. When driving the pile in, there is created between the pile shaft and the soil displaced by the pile foot, a hollow space which simultaneously with the driving in of the pile is filled from above with a filler such as gravel or concrete, in order to increase the friction between the pile and the soil.

It is an object of the invention to provide a pile suitable for foundation purposes and for securing building units, which pile may also be driven without difficulty into the ground of a site which is interspersed with large stones or other large obstructions to the driving operation, and whose outer casing of and internal filling with concrete may be produced quickly, cheaply and reliably in the soil of the site immediately after the driving operation by using simple apparatus for injecting concrete under pressure.

According to the present invention a pile comprises a hollow shaft, and a wedge-shaped foot secured to the lower end of the shaft, the upper cross-sectional area of the foot being greater than the cross-section of the hollow shaft and said foot being formed with outlet openings at its upper end whereby concrete may be forced under high pressure from above into the shaft to emerge firstly from said outlet openings to enter from below into the hollow space which is produced around the pile shaft between the latter and the compressed soil when the pile is driven in, said concrete rising in said hollow space around the pile shaft, whereby owing to the high pressure of the concrete the soil surrounding the hollow space is further compressed, and the hollow space is unevenly enlarged corresponding to the varying resistance of the soil strata through which the pile passes.

The invention results in a substantial increase of the loading capacity of the pile, because the concrete jacket created in the soil and firmly connected with the shaft of the pile, supports the latter over its entire length in the ground.

The friction between the concrete jacket and the soil, on which the loading capacity and the tensile resistance of the pile is substantially based, is particularly high in the pile constructed in accordance with the invention, because on the one hand the irregular cross-section of the concrete jacket considerably increases the bearing surface thereof relative to the soil, and on the other hand because owing to the extensive compression of the soil there is created an increased adhesive friction between the soil and the concrete jacket.

According to one convenient embodiment of the invention, wedge-shaped clearing projections are formed at spaced intervals on the outer wall surface of the pile shaft, by means of which the hollow space formed around the shaft when driving in the pile is continually cleared of soil and stones entering therein. Moreover, the projec-

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tions rip open the outer wall of the hollow space at various points, thus causing an irregular formation of bulges in the concrete jacket, by which the loading capacity of the pile is increased to a considerable extent.

The invention will be described further, by way of example, with reference to the accompanying drawings, in which:

Fig. 1 is a sectional elevation of a pile constructed in accordance with the invention, driven into the ground and enclosed up to the top with concrete,

Fig. 2 is a front elevation of the pile, to an enlarged scale,

Fig. 3 is a longitudinal section through the pile,

Fig. 4 is a plan view of the pile,

Fig. 5 is a cross-section taken on the line 5—5 of Fig. 3, Fig. 6 is a cross-section taken on the line 6—6 of Fig. 3, Fig. 7 is a cross-section taken on the line 7—7 of Fig. 3,

Figs. 8 and 9 are a vertical longitudinal section and a plan view respectively of a further embodiment of the invention,

Fig. 10 is a fragmentary longitudinal section of a further form of pile having an inserted ramming shaft,

Fig. 11 is a cross-section through the pile head taken on the line 11—11 of Fig. 10,

Fig. 12 is a cross-section through the pile shaft at the level of a distance piece and a pair of clearing projections taken on the line 12—12 of Fig. 10.

Fig. 13 is a cross-section through the pile shaft directly above the displacing pile foot, taken on the line 13—13 of Fig. 10,

Fig. 14 is a longitudinal section through the pile foot and parallel to the pile shoe,

Fig. 15 is a cross-section through the completed pile and compressed concrete taken on the line 15—15 of Fig. 16,

Fig. 16 is a side elevation of the pile and

Fig. 17 is a cross-section showing yet a different construction of ramming shaft.

At the lower end of the hollow pile shaft 1 of Figs. 1 to 7, made of steel section, the length of which is chosen to correspond with the depth to which the pile is to be driven and whose cross-section is dimensioned to correspond with the proposed static stress which the pile is intended to undergo, there is axially welded to the pile shaft or rigidly connected therewith by other means, a pile foot 3. The pile shaft 1 may consist of a plurality of steel sections or only of an integrally formed hollow steel section.

A pile shoe 2 is fixed in the pile foot 3 axially of the shaft 1 (welded therein), in such a manner that its obtuse upper end abuts against the pile shaft 1, and its lower sharp edge projects freely downwards from the pile foot 3. By forming the pile foot in this manner it is possible for the pile, while being driven in to split large stones against which it might strike.

The pile foot 3 is composed either of suitably shaped steel flats or steel plates welded together as in Figs. 2, 3 and 7, or, if a large number of steel piles are required for a foundation, it may alternatively be constructed in the form of a casting of a special steel.

The pile foot 3 is of a hollow formation and wedge-shaped in such a manner that at least two opposite faces of the foot project laterally beyond the cross-section of the pile on either side to such an extent that between the pile shaft 1 and the two lateral faces there are created several free cross-sectional areas Q_1 and Q_2 sufficiently large to allow concrete forced into the pile to pass through. In the lateral faces there are also conveniently provided bores x through which the concrete may also pass from the pile foot 3 in a downward direction.

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The maximum width y of the pile foot is determined by a general consideration of the type of soil in the stratas, taken singly and in combination, of the ground through which the pile has to penetrate when being driven in.

At the upper end of the pile shaft 1, the pile head or hoop 6 of steel is welded on to the pile shaft 1. The pile head is bored in a longitudinal direction relative to the pile shaft 1, so that an inlet pipe 5 for the compressed concrete may be inserted therethrough and into the shaft 1.

Welded at spaced intervals into the hollow pile shaft 1 are distance pieces 4. These distance pieces 4 are also bored longitudinally relative to the pile shaft, so that the inlet pipe 5 for the compressed concrete may also be passed therethrough. Through the pile shaft 1 and the distance pieces 4 there are provided vertically of or inclined relative to the longitudinal axis of the pile shaft, bores Z_1 and offset relative thereto, further bores Z_2 , through which the concrete may enter from the pile shaft 1 into the hollow space, between the shaft and the surrounding soil, caused by the displacement of the latter by the pile foot 3 when the pile is driven in.

Towards the upper end there is welded around the pile shaft 1 on the outside thereof, a sealing gland or collar 9, the width and position of which below the upper edge of the pile also depends on the building foundation and the nature of the soil layers (stratification) through which the pile is driven.

The compressed concrete inlet pipe 5 extends through the pile head 6 right down into the pile shaft 1 and may be rotated therein about the longitudinal axis common to both. Welded to the upper end of the inlet pipe 5 there is a pipe head 7, and provided between the latter and the pile head 6 is the annular packing ring 8. The inlet pipe 5 for the compressed concrete is interchangeable, i.e., it is not made individually for each pile, but for use with a number of piles of identical length and cross-section.

The mode of operation and the purpose of the present invention are as follows:

First of all, the steel pile, with the inlet pipe 5 for the compressed concrete removed, is driven into the ground. When sinking the pile into the ground, the wider displacing pile foot 3 compresses the soil around the pile shaft 1, and by displacing the soil around the pile or around the shaft thereof, it creates a more or less large hollow space. The latter generally has a cross-section which tapers towards the top, and experiments have proved that a pile foot 3 which is wedge-shaped on two sides only, as illustrated in the drawing, clears an approximately equally wide hollow space around the pile shaft, although theoretically it would only be possible for a hollow space to be created over the wide faces of the wedge-shaped pile foot by displacement of the soil. Thus, in most cases it is sufficient for the pile foot 3 to be wedge-shaped on two sides only and not on four sides. Shortly before completing the driving operation at the last downstroke of the pile, the packing gland or collar 9 provided at the upper end also becomes effective to carry the soil from the upper edge of the hole made by the pile, which collapses when driving the pile in, along with it for a short distance, and thus compresses it to such an extent that a plug of soil is formed in the uppermost section of the hole, which plug seals towards the top the hollow space cleared by the foot 3 around the shaft 1 during the driving operation.

After driving in the steel pile, the inlet pipe 5 for the compressed concrete is introduced in the pile shaft 1 through the head 6, and with its pipe head 7 is urged against the head 6 by the interposition of a packing ring 8. Concrete is then forced into the pile through the inlet pipe 5 by means of known concrete injecting apparatus, viz. at first only into the lower part of the pile.

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Thus, the concrete fills the lower part of the pile shaft 1 and the pile foot 3 and is discharged from there through the areas Q_1 and Q_2 , and also through the bores x from the pile foot 3 into the surrounding soil. The concrete thus forms a bulge as shown in Fig. 1, around the pile foot and the lower part of the pile shaft and then rises also with increasing resistance in the hollow space around the pile shaft 1. With the increase in pressure which occurs, the inlet pipe for the concrete is turned through about 60° , whereby the bores Z_1 in the lower part of the pile shaft 1 are uncovered to allow the concrete to emerge from the pile shaft into the soil. If the operational pressure increases again, then the inlet pipe 5 is again turned through a certain angle. The concrete then emerges from the pile shaft through the bores Z_2 and rises in the hollow space around the pile shaft up to the sealing gland or collar 9. With the supply pressure of the concrete at a low value, the inlet pipe 5 is slowly drawn out of the pile head 6, and the pile 1 itself is thus also filled internally with concrete. The pile is now surrounded externally as well as internally by concrete, thus rendering corrosion of the steel impossible. At the same time, however, the concrete jacket around the steel pile considerably increases the loading capacity of the pile owing to the substantial increase of the pile cross-section and the extensive wall friction which arises between the concrete jacket and the soil.

The step-by-step filling of the hollow space around the pile shaft 1 by means of the concrete injected through the bores Z_1 and Z_2 or additional bores not only ensures a complete encasing of the pile shaft 1 with concrete, but also promotes the formation of bulges in this concrete jacket, by means of which the loading capacity of the steel pile may in turn be increased to a not inconsiderable extent.

Only one inlet pipe 5 for the concrete is required for driving a plurality of piles of identical dimensions. It is not a component part of the steel piles themselves, but serves merely to control the step by step injecting of the concrete into the steel pile and round same.

When driving steel piles of the type described herein into very compact and tenacious sticky soils such as fatty loam, clay and the like, for promoting the uniform formation of a hollow space around the pile shaft 1 (by the pile foot 3) smaller wedge-shaped displacing shoes are also on the narrow faces of the pile foot 3.

In the embodiment of Figs. 8 and 9 wedge-shaped clearing lugs 12 are mounted on the outer wall surfaces of the pile shaft at spaced intervals. These lugs 12 are located, in the embodiment shown in the drawing, at those points where transverse openings of the pile shaft are provided. The lugs have an angular cross-section such that they cover the transverse openings in the manner of a roof. They prevent the entry of soil into the internal space of the pile, while the concrete forced in through the pipe 5 may emerge through the lugs which are open at the side.

On the upper part of the pile shaft 1 there is adjustably and detachably arranged a sealing member 14. The sealing member 14 is composed of two halves and carries a collar 15, which is clamped to the pile shaft by means of the connecting screws by which the two halves of the sealing member are connected.

The pile shaft of the embodiment according to Figs. 10 to 16 is formed from four steel angle bars 1a, which are interconnected by means of intermediate members 24 acting as spacers. The uppermost intermediate member at the top end of the pile shaft is formed substantially longer than the other intermediate members, for allowing a sealing member, e.g. the sealing member 14 described above with reference to Figs. 8 and 9 which is split longitudinally, to be fixed to said uppermost intermediate member. For forming a pile head there is welded to the upper end of the uppermost intermediate member 24 a reinforcing ring or hoop 6. In the lower-

most intermediate member 24, which extends into the pile foot 3, there is welded a thrust member 17, on which is mounted a hollow ramming shaft 18 inserted in the pile shaft when driving in the pile. Formed one above the other on the pile shaft there are wedge-shaped clearing lugs 12 arranged in spaced relationship and staggered relative to one another. Attached to the wedge-shaped plates forming the foot 3 are clearing lugs 19, which prevent the soil from entering through the lateral concrete outlet bores of the pile foot. The hollow foot 3 is covered at the top by means of two steel angle members 20, so that soil similarly cannot enter the pile foot from above during the driving operation.

When driving in the pile, the pile driver strikes the ramming shaft 18 projecting from the pile head 6 and the former transmits the driving force to the pile shoe 2 and the pile foot 3 by way of the thrust member 17. The pile shaft formed by the four steel angle bars 1a and the intermediate members 24 are thus not subjected to a direct thrust, but drawn into the ground by means of the pile foot in the hollow space cleared in the soil by said foot and are consequently only subjected to tractive stresses.

When the pile has been driven in, concrete is forced under high pressure through the hollow ramming shaft 18, first of all into the hollow pile foot, and subsequently while withdrawing the ramming shaft 18 from the pile shaft in easy stages, into the latter and into the hollow space created in the soil.

In place of the annular intermediate members 24 provided on the pile shaft at spaced intervals, it is also possible to utilise a spiral reinforcement extending over the whole length of the pile shaft of round or flat or strip steel, which is electrically welded or connected in any other suitable manner with the section or round steel bars forming the pile shaft.

It is also possible to fit on the upper end of the ramming shaft 18 which projects from the pile head, a tensioning device by means of which the pile shaft formed from light steel round sections may be stretched or pre-stressed after the driving operation has been completed. Again, thin steel round sections or steel wires may also be employed to form the pile shaft, thus producing a kind of prestressed concrete in the pile when moulded with concrete.

The ramming shaft to be inserted in the pile shaft may also be produced from a solid section, e.g. a wide flange girder, as shown in Fig. 17. It is possible over the whole length of such a solid section ramming shaft to connect one or more concrete supply pipes 26, through which the concrete is supplied under pressure to the pile foot and the pile shaft.

I claim:

1. A pile adapted to be driven into the soil for permanent anchorage therein, said pile comprising a hollow shaft having an open trailing end for feeding concrete under pressure into said shaft, a hollow pile foot secured to the leading end of the shaft, said end being the end to be driven into the soil, said pile foot having a peripheral outline larger in transverse cross-sectional area than the transverse cross-sectional area of said hollow shaft whereby a hollow space is progressively formed around the shaft as the same is driven into the soil, the trailing upper surface of said pile foot including an opening for the discharge of concrete from the pile foot into said hollow space, said hollow shaft having longitudinally spaced outlet openings for the discharge of concrete from the shaft, and a sealing collar of larger transverse cross-sectional area than the transverse cross-sectional area of said shaft secured to the trailing end of the shaft encompassing said end, said collar being adapted to abut against the soil surrounding the shaft as the pile is driven to define a hollow enclosed space surrounding the pile shaft between said collar and said foot to cause intrusion of concrete into

the soil surrounding the shaft adjacent to said enclosed space and to confine the concrete within the enclosed space around the pile shaft.

2. The pile according to claim 1 wherein said collar is displaceable along and detachable from said shaft.

3. The pile according to claim 2 wherein said collar has a circular peripheral outline and is comprised of two parts, each of said parts having elements coacting with each other for securing the collar to the shaft.

4. A pile adapted to be driven into the soil for permanent anchorage therein, said pile comprising a hollow shaft having an open trailing end, a hollow pile foot secured to the leading end of the shaft, said end being the end to be driven into the soil, said pile foot having a peripheral outline larger in cross-sectional area than the transverse cross-sectional area of said hollow shaft whereby a hollow space is progressively formed around the shaft as the same is driven into the soil, the trailing upper surface of the pile foot including an opening for the discharge of concrete from the pile foot into said hollow space, said hollow shaft having longitudinally spaced outlet openings for the discharge of concrete from the shaft into said space, said outlet openings being angularly displaced with relation to each other, a removable supply pipe for injecting concrete under pressure into the hollow shaft from the trailing end thereof, and a sealing collar of larger transverse cross-sectional area than the transverse cross-sectional area of said shaft secured to the trailing end of the shaft encompassing said end, said collar being adapted to abut against the soil surrounding the shaft as the pile is driven to define a hollow enclosed space surrounding the shaft between said collar and said pile foot to cause intrusion of concrete into the soil surrounding the shaft adjacent to said enclosed space and confine the concrete within the enclosed space surrounding the pile shaft.

5. A pile adapted to be driven into the soil for permanent anchorage therein, said pile comprising a hollow shaft having an open trailing end for feeding concrete under pressure into said shaft, a hollow pile foot secured to the leading end of the shaft, said end being the end to be driven into the soil, said pile foot having a peripheral outline larger in transverse cross-sectional area than the transverse cross-sectional area of said hollow shaft whereby a hollow space is progressively formed around the shaft as the same is driven into the soil, the trailing upper surface of said pile foot including an opening for the discharge of concrete from the pile foot into said hollow space, said hollow shaft having longitudinally spaced outlet openings for the discharge of concrete from the shaft, wedge-shaped lugs of angular cross-section lengthwise of the shaft secured to the outside of the shaft opposite said outlet openings, said lugs forming roofs over said openings and having lateral apertures for permitting the discharge of concrete through the outlet openings, a sealing collar of larger transverse cross-sectional area than the transverse cross-sectional area of said shaft secured to the trailing end of said shaft encompassing said end, said collar being adapted to abut against the soil surrounding the shaft as the pile is driven to define a hollow enclosed space surrounding the pile shaft between said collar and said foot to cause intrusion of concrete into the soil surrounding the shaft adjacent to said enclosed space and to confine the concrete within the enclosed space surrounding the pile shaft.

6. A pile according to claim 1 and further comprising a shoe secured within said foot, said shoe terminating in a wedge-shaped cutting portion protruding beyond the shaft and the foot.

7. A pile according to claim 6 wherein said foot is tapered lengthwise of the longitudinal axis of the shaft, said cutting portion of the shoe protruding from the narrow end of the foot, the side walls of the foot and

of the cutting portion being angularly disposed with relation to each other.

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