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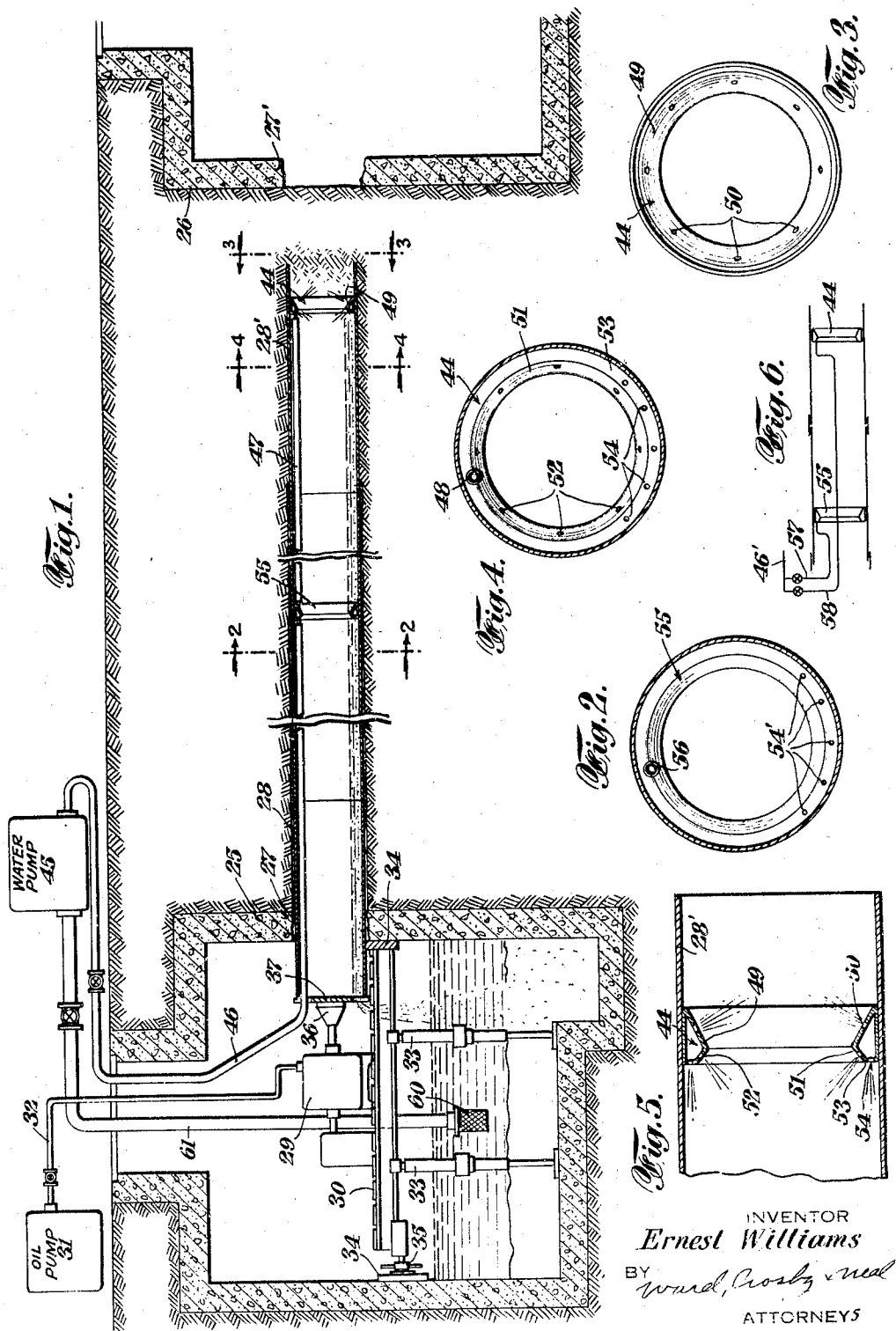
E. WILLIAMS

2,325,565

INSTALLATION OF UNDERGROUND DUCTS

Filed Jan. 10, 1941

4 Sheets-Sheet 1



INVENTOR
Ernest Williams
BY *Ward, Crosby and Neal*
ATTORNEYS

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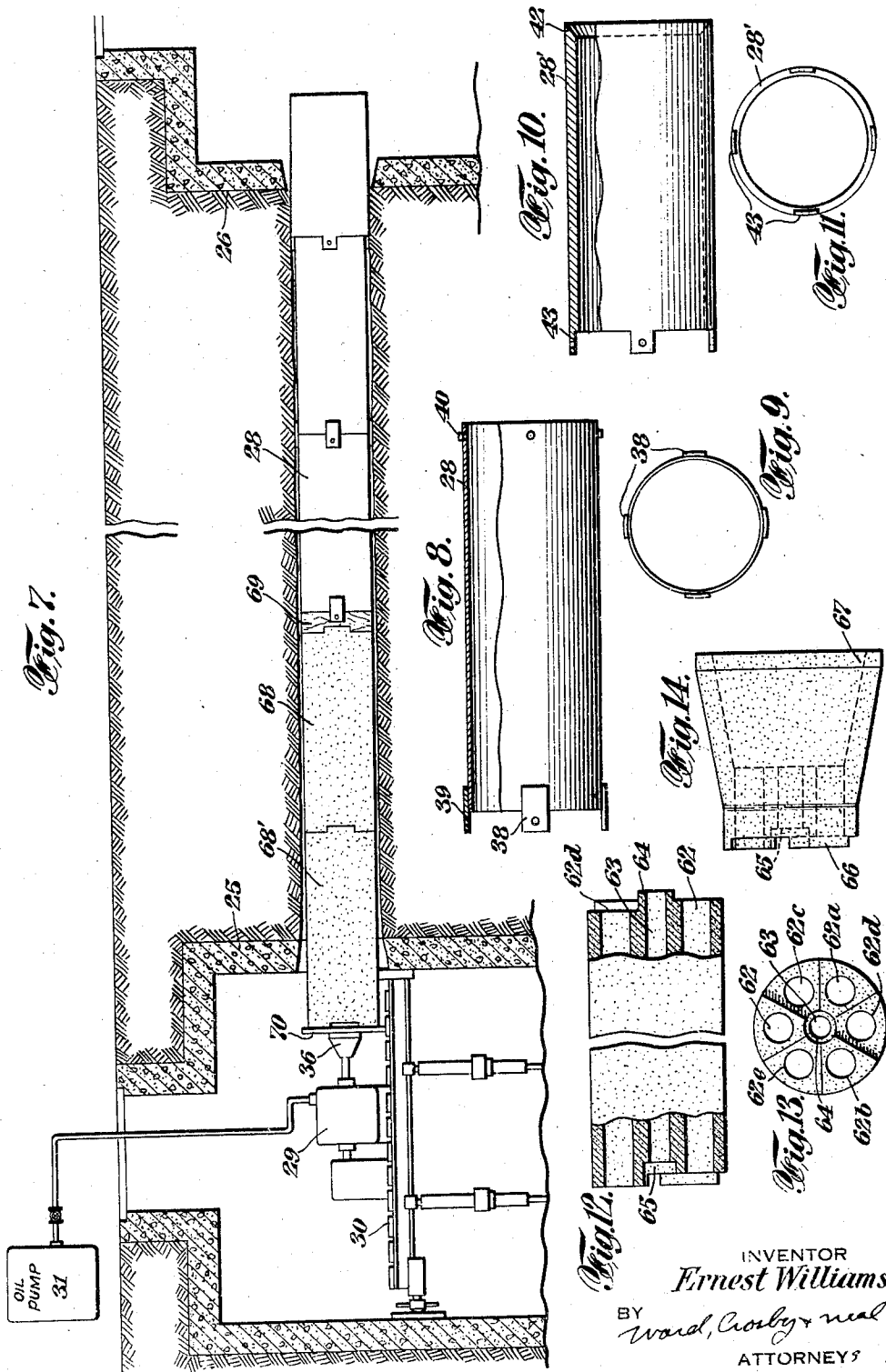
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Filed Jan. 10, 1941

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July 27, 1943.

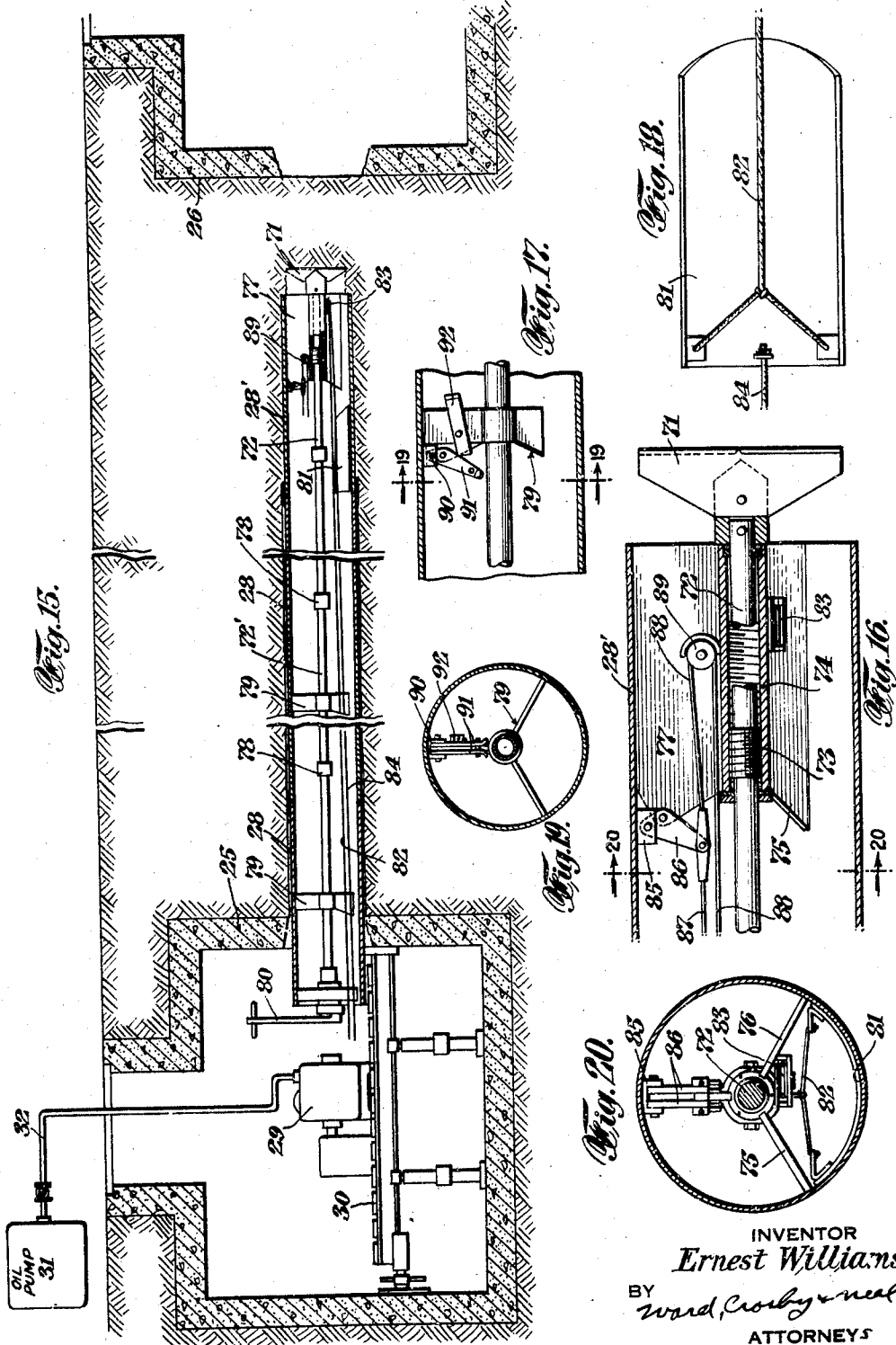
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Filed Jan. 10, 1941

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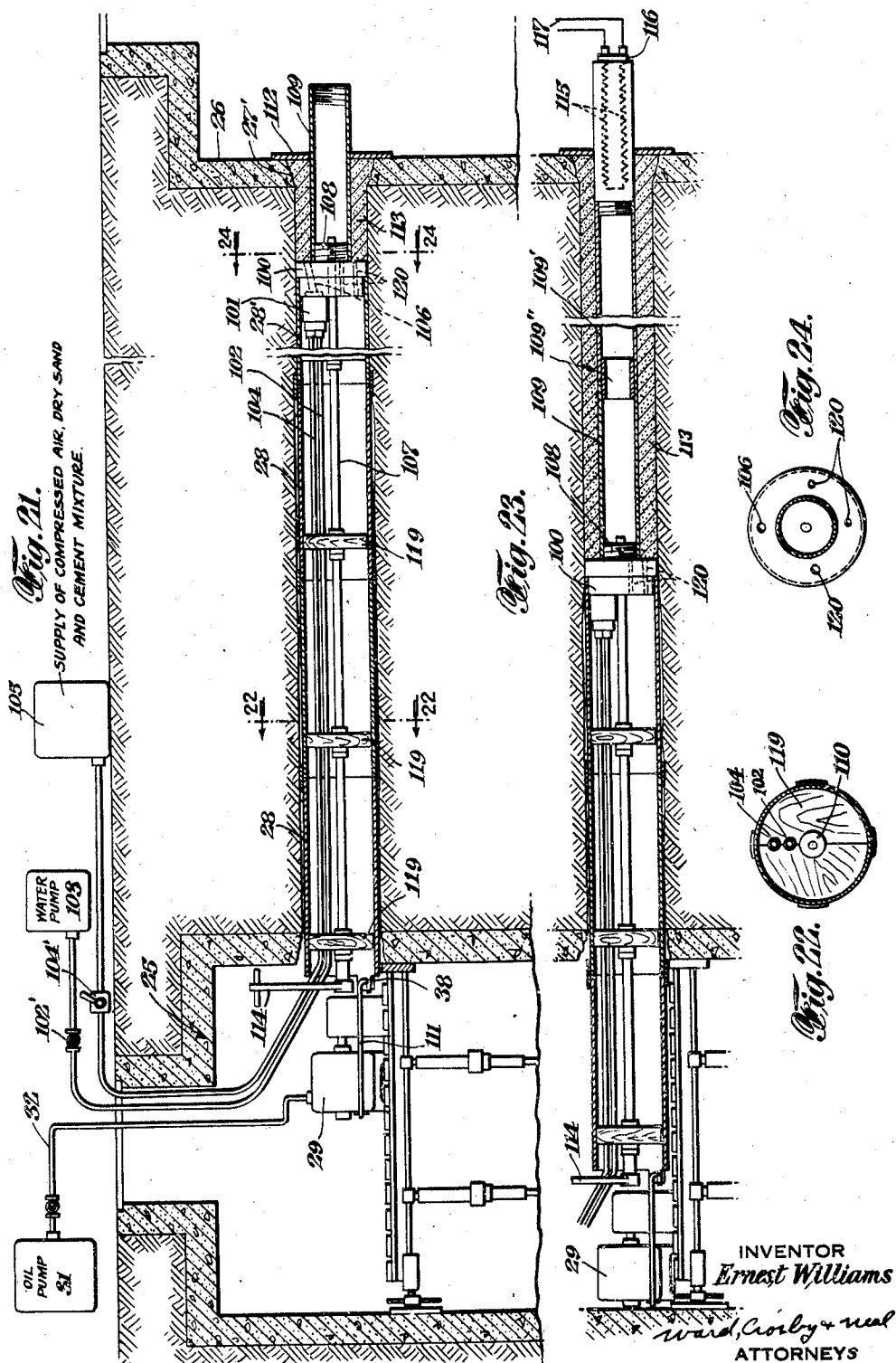
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UNITED STATES PATENT OFFICE

2,325,565

INSTALLATION OF UNDERGROUND DUCTS

Ernest Williams, Jackson Heights, N. Y., assignor
to Consolidated Edison Company of New
York, Inc., New York, N. Y., a corporation of
New York

Application January 10, 1941, Serial No. 373,949

3 Claims. (Cl. 61-42)

This invention relates to methods and apparatus for installing underground ducts, of such types for example as may be used for electrical cables or other purposes.

Under various circumstances it is advantageous to be able to install underground ducts without digging trenches. For example, in city streets where heavy traffic conditions prevail, it is oftentimes desirable to install underground ducts extending from an accessible location such as one manhole, to another manhole, by some means which will avoid tearing up the pavement or obstructing traffic. Also removal of large quantities of earth in digging a trench may be time-consuming and excessively expensive, or may destroy expensively landscaped areas. This presents a problem which so far as I am aware has not been heretofore satisfactorily solved as regards installation of ducts of substantial size extending underground for any substantial distances, nor for ducts formed of concrete or the like and hence subject to breakage if an attempt is made to push the same into the earth. Also, if the concrete is to be in the form of a heavy multiple duct, the interior webs separating the cavities for each conduit or cable will make it difficult to obtain access to the head end of the duct in order to loosen or remove obstructing earth.

The present invention provides methods and means for overcoming these difficulties. According to a preferred form of the invention, a series of tubular metal sections adapted to have end-to-end interengagement, are first successively introduced into the ground as through an opening in the side wall of a concrete manhole, and pushed through the earth, for example by a hydraulic jack, until the head end of such series of sections reaches the side wall of another manhole or other accessible location, thus providing a continuous tubular cavity from one manhole to the next. Also according to the invention, if desired various mechanical or water-slucing means may be provided within this series of tubular sections for loosening the earth which obstructs the head end of the series, and for carrying such earth back through the sections to the first manhole. After this series of metal tubes is in place, the same are adapted to be withdrawn or pushed longitudinally, either in one direction or the other, from the cavity formed thereby in the earth, and during such withdrawal the metal sections are replaced step-by-step or gradually by the permanent concrete duct. Such duct may for example be of the precast multiple type and

in sections introduced successively with end-to-end interengagement, and so as to push out the metal sections, or if preferred, according to other phases of the invention the concrete duct may be cast in the ground during the process of withdrawing the temporary metallic members. Thus by these methods, a continuous cavity from one manhole to the next, may be first formed and the earth kept from settling therein, by the use of steel tubes which are capable of withstanding heavy pressures against the earth without being deformed or broken even when engaging serious obstructions. And once the cavity is thus formed, the steel tubing may be readily replaced by the concrete duct without danger of breakage or cracking of the concrete.

Various further and more specific objects, features and advantages will clearly appear from the detailed description given below taken in connection with the accompanying drawings forming a part of this specification and illustrating by way of example various forms of apparatus which may be used in carrying out the invention. The invention consists in such novel features, arrangements, combinations of parts and methods, as may be shown and described in connection with the apparatus herein disclosed.

In the drawings,

Fig. 1 illustrates a method and apparatus for pushing a series of the tubular metal sections into the ground so as to extend from one manhole to another, this form of the apparatus including means and equipment for water-slucing obstructing earth from the head end of the tubular sections back into the first manhole;

Figs. 2, 3 and 4 respectively are sectional views taken substantially along the lines 2-2, 3-3 and 4-4 of Fig. 1; and

Fig. 5 is a longitudinal sectional view of a construction such as of Fig. 4.

Fig. 6 is a schematic view illustrating an alternative arrangement of water connections for the slucing means of Fig. 1;

Fig. 7 is a view similar to Fig. 1, but illustrating a further stage in one example of the method, and at a time when the tubular metal sections are being pushed from the cavity in the earth and replaced by sections of concrete duct;

Figs. 8 and 9 are side and end views respectively of a typical tubular metal section which may be used according to the invention;

Figs. 10 and 11 are side and end views respectively of a somewhat modified or head end tubular metal section;

Fig. 12 is a side view partly in section of a

suitable multiple duct concrete section which may be installed and used in connection with this invention, and Fig. 13 is an end view of the same;

Fig. 14 is a side view of a suitable concrete adaptor member which may be used for joining concrete sections as of Fig. 12 to other forms of ducts, or which may be used at the end of a series of such ducts, opening into a manhole;

Fig. 15 is a view similar to Fig. 1, but illustrating an alternative method for loosening and removing earth by mechanical means during the pushing of the tubular metal sections through the ground;

Fig. 16 is an enlarged sectional view of the head end of the arrangement shown in Fig. 15;

Fig. 17 illustrates certain details of the apparatus which may be used within the tubular sections of Fig. 15;

Fig. 18 is a plan view of a mechanically operated scoop or shovel which may be used within the tubular sections of Fig. 15;

Figs. 19 and 20 respectively comprise sectional views taken substantially along the line 19—19 of Fig. 17 and line 20—20 of Fig. 16;

Fig. 21 is a view showing an alternative arrangement of the apparatus for casting the concrete duct in situ, as the tubular metal sections are being withdrawn;

Fig. 22 is a sectional view taken substantially along line 22—22 of Fig. 21;

Fig. 23 is a view illustrating the apparatus as of a subsequent stage in the operations according to the method of Fig. 21; and

Fig. 24 is a sectional view taken substantially along the line 24—24 of Fig. 21.

Referring now to Fig. 1, a concrete underground manhole is indicated at 25 which may be constructed in a suitable known manner. This manhole may be located at a substantial distance from another similar manhole as at 26 and to which it is desired to extend an underground concrete duct. To this end, the first step may comprise cutting a hole as at 27 through the concrete of a side wall of the manhole 25, and through this hole a series of tubular metal sections as at 28 may be successively introduced and pushed through the ground in the direction of the other manhole 26, as by means of a hydraulic jack 29 operating on a notched rail assembly as at 30. This hydraulic jack may be operated manually or by a suitable motor driven oil pump as at 31 connected thereto by pipe 32.

The hydraulic jack 29 and the notched rail 30 on which the same operates, may be of a suitable known type, supported as by jack screws 33 extending to the bottom of the manhole. Pieces of steel of substantial area as at 34 may be applied respectively to opposite side walls of the manhole to distribute the pressures due to the duct pushing operations. That is, the notched rail assembly 30 may be clamped or wedged in place at the proper elevation and in the proper alignment along the direction of the desired travel of the duct, as by the use of a jack screw 35 or equivalent means, so that the rail assembly 30, at its respective ends, presses against the plates 34. The head 36 of the hydraulic jack may engage a suitable metal plate as at 37, which in turn engages and partially covers the rear end of the tubular section or series of tubular sections which are to be pushed into the ground.

As shown in further detail in Figs. 8 and 9, each of the tubular sections 28 may comprise for example a cylindrical steel tube having an

outside diameter slightly greater than that of the concrete duct which is to ultimately replace the steel tube. One end of each of the members 28 may have welded thereto a plurality of cleats as at 38 at spaced points around its periphery for holding the section in alignment with the next succeeding section. If the series of tubular sections is to be used according to a method in which they are to be withdrawn by pulling, rather than pushing the same out of the earth, then each of the portions 38 may be formed with recessed or cut-out areas such as holes 39, for engaging suitable protuberances or studs as at 40 on the next section. The cleats 38 may be sufficiently flexible outwardly, to yield and snap into place in interengagement with the studs as at 40 when the next section is applied.

The first or head end section of the steel tubing which is to be pushed into the earth, may preferably be of a somewhat more rigid construction such as shown at 28' in Fig. 10. That is, this member may have thicker walls to better withstand the engagement with obstructions, and if desired, the advancing edge of this member may be suitably beveled as at 42 for effectively cutting into the earth. The member 28' at its rear edge may be formed with suitably apertured lugs as at 43 for the same purpose as the cleats 38, on the member 28.

In some cases where the distance through which the series of tubular members are to be pushed, is relatively short, the earth accumulating within the series of tubes may be removed to the extent necessary manually, as with long handled shovels, by a workman standing in the manhole as at 25. In other cases, as where the earth is relatively soft or sandy, it may be unnecessary to take any special steps to remove the earth from within the tubes as the same are advanced. In many cases, however, in order to prevent building up of excessive pressures on the tubular casing as it is being pushed, it will be preferable to provide means for softening the earth at the head end, and to also carry the dislodged earth back to the first manhole. In Fig. 1, a water-slucing arrangement is shown for this purpose and which may comprise an annular hollow ring as at 44 firmly fitted within the head end tubular section near its advancing edges. This ring may be supplied with water under relatively high pressure as from a pump 45, or other suitable source, connected through sections of hose or piping as at 46, 47 coupled to an intake opening as at 48 in the ring 44 (Fig. 4). As shown in Figs. 3 and 5, the ring 44 may have an inwardly directed annular and conical surface 49 positioned at an oblique angle in respect to the head end of the steel tubing and formed with a series of water jet outlets as at 50 at spaced points around the ring and so as to project streams of water into the earth for softening and loosening the same and thus minimizing the obstruction of the steel tubular sections as they are advanced. With the jet openings 50 as shown, the action of the water is substantially limited to the confines of the casing, or its path through the earth, so that earth outside the path of the casing is not materially disturbed. The inside of the ring 44 may be also formed with a rearwardly directed annular conical surface as at 51, also having at spaced points a series of water jet outlets as at 52 for further softening the dislodged earth to permit the same to readily pass back through the open central area within the ring 44 (Figs.

4 and 5). A rear vertical surface as at 53 may also be provided on the ring 44 with jet openings as at 54 pointing directly back toward the manhole 25 for sluicing back the dislodged earth.

Where the series of tubular sections is of substantial length, it is desirable to sluice back the dislodged earth at several successive stages. For this purpose one or more additional sluicing rings as at 55 (Fig. 2) may be provided at suitably spaced points. The rings as at 55 may be provided with couplings as at 56 for connection to the source of high pressure water supply and a similar coupling on the reverse side may be provided for carrying part of the water supply on through pipes as at 47 to the succeeding ring or rings. The rings 55 may be generally similar to the ring 44, but need only be provided with jet openings as at 54' directed rearwardly for sluicing the earth back to the next ring or to the manhole 25.

In some cases it may be desirable to provide each of the sluicing rings with a separate source of water supply which may be remotely controlled as desired, as from the manhole 25. Such an arrangement is indicated in Fig. 6, wherein pipe 46' running from the pump is shown connected through pipes 57 and 58 respectively to the rings 55 and 44, each through suitable valves so that more or less water pressure as desired may be applied to each ring to insure removal of any excess accumulations of dirt or rubble at either ring.

The pushing of the casing, and the admission of the water to the sluicing rings may be carried on simultaneously, or alternately, as conditions may warrant. The water may also be supplemented by the use of compressed air therein to increase its velocity if desired.

The earth and water as sluiced out of the series of tubes may as indicated in Fig. 1, fall to the bottom of the concrete manhole 25 and if desired, as shown, this manhole may be used as a settling chamber. The water from which the rubble or mud has settled, may be withdrawn as through a strainer 60 and pipe 61 to the intake side of the pump 45, whereby a substantial part of the water used for the sluicing operations may be recirculated with a considerable saving of expense in some cases. The earth which settles to the bottom of the manhole may be removed mechanically or by other approved methods after the tubular casing is in place.

In carrying out the method of Fig. 1, it will be apparent that the first tubular section as at 28' with the sluicing ring 44 and water connection therefor, may first be introduced through the opening 27 in the wall of manhole 25. Then with the hydraulic jack 29 at a suitable position along its notched rail, this first section may be pushed into the ground until its rear edge is almost flush with the inside wall of the manhole. Then the hydraulic jack may be moved back on its notched rail to the left as viewed in Fig. 1, to permit insertion of the next section of steel tubing in engagement with the rear edge of the first section. This second section if necessary or desired may have a sluicing ring as at 55 installed therein. Then the hydraulic jack is used to push the two sections of the tubing further into the ground until the rear edge of the second tube section is nearly flush with the inside wall of the manhole. Thereafter succeeding sections of the tubing may be similarly inserted in turn, and the series of tubes pushed further until the head end thereof reaches the

manhole 26. An opening as at 27' should be cut through the side wall of the manhole 26 at the proper place to permit the head end of the series of tubes to enter this manhole. When the series of tubes thus extends continuously from one manhole or accessible location to another, the water supply may be disconnected and steps may be taken according to Fig. 7 to gradually push the metal tubular sections out of the cavity formed thereby, and to replace the same, section by section with a concrete duct.

One example of the multi-duct concrete sections which may be used in connection with this invention, is illustrated in Figs. 12 and 13. These sections may for example be about four feet in length and with an outside diameter of 15 or 16 inches. The particular form here shown has six longitudinally extending cavities or 4 inch ducts, as at 62 arranged in spaced positions annularly around a seventh or center 3 inch duct as at 63. The ends of these concrete sections, in the example here shown, are so shaped as to hold the successive sections in alignment and in interengagement, and at the same time the joints for each cavity are displaced somewhat in respect to the joints for all adjacent cavities, whereby there will not be any direct passage between any two cavities such as would permit arcing between electrical conductors in adjacent cavities, should breakdown of the insulation occur. That is, the joint areas for alternate outer cavities such as 62, 62a and 62b, may extend out further than the joint areas for the intervening cavities as at 62c, 62d and 62e. It will be apparent that this arrangement will prevent any straight line free path between alternate cavities of the six annularly arranged outer cavities. To avoid any straight line path between the central cavity 63 to any of the outer cavities, the joints for the central cavity may comprise a male portion as at 64 at one end of the section for engaging a female portion as at 65 at the adjacent end of the next section. That is, the portion 64 may extend out beyond the surrounding joint areas and the portion 65 may be recessed further inwardly than any of the surrounding joint areas.

The end section of the concrete duct where it opens into a manhole or joins duct of other forms, may be provided with a concrete adaptor for example, as shown in Fig. 14, having one end as at 66 suitably formed to fit an end of one of the concrete duct sections and having its other end flared outwardly as at 67. It will be understood that suitable cavities as shown may be provided within the end 66 to coincide with the cavities in the section such as shown in Fig. 12. These cavities may open into a single large cavity within the flared end 67 as shown.

As shown in Fig. 7, the sections of concrete duct as at 68, 68', may be introduced successively into the cavity formed by the series of steel tubes and pushed into place by the hydraulic jack 29 so that at the same time the series of steel tubes is pushed out of the cavity into the manhole 26. The hydraulic jack may be used in pushing the concrete sections into place in a manner similar to the steps followed in successively applying and pushing the steel tube sections into place, except that only comparatively small pressures will be necessary against the concrete sections, since the steel sections have previously cleared a cavity through the obstructing earth. As the steel sections reach the manhole 26, they may be removed one by one, at the

same time that additional sections of the concrete duct are being applied in the manhole 25.

At the point where the last tubular steel section engages the first concrete section, a suitable adaptor member as at 69 should be inserted. This member may be made of wood for example and have one face shaped to engage the rear edges of the steel section and its other face shaped to engage the forward end surfaces of the first concrete section. Thus this adaptor member will serve to protect the irregularly shaped forward end surfaces of the concrete section against being cracked or broken by the edges and cleats on the steel section. The head 36 of the hydraulic jack may also be equipped with a suitable face plate 70 shaped to engage the rear end surfaces of the concrete sections.

Instead of using the water sluicing arrangements as of Fig. 1, while the steel tubular sections are being pushed into place, suitable mechanical means may be provided as shown in Figs. 15-20 inclusive, for loosening the earth and carrying the same back to the first manhole. This arrangement may include a rotatable cutter member as at 71 mounted on a shaft as at 72 having a threaded portion as at 73 for engaging the threaded interior of a sleeve 74. The sleeve 74 may be supported in a central location within the tube 28', as by a plurality of web plates 75, 76, 77 extending to the inside walls of the tube 28'.

The shaft 72 may have a number of sectional extensions as at 72', which may be attached as necessary by the use of couplings as at 78, to have the shaft extend back into the manhole 25. As more sections of the shaft are added, and as the sections of steel casing are pushed into the ground, it may also be desirable to insert at spaced points within the casing, a plurality of spider-like shaft supporting members as at 79. Further details as to the construction of these members will be explained hereinafter in connection with Figs. 17 and 19. The shaft 72 is adapted to be rotated either by motor or by manual means, which may be applied either to the shaft 72 or one of its extensions 72' within the manhole 25. As shown in Fig. 15, the shaft is rotated manually as by means 80, which may be in the form of a wrench applied to the end of the outermost shaft section 72'. Rotation of the shaft 72 in one direction will cause the threaded portion 73 to advance in the threaded sleeve 74, thus advancing the cutter member 71 in respect to the steel tubing as the cutter member rotates in the earth. After the cutter member has been thus advanced for some distance, it may be retracted by rotating the shaft 72 in the opposite direction. Thereupon the hydraulic jack may be applied to push the series of tubing into the earth for some distance further, and then the cutter may again be advanced to dislodge and loosen further earth.

The loose earth which accumulates in the end of the steel casing may be carried back to the manhole 25 as by the use of a dirt pan 81, preferably shaped with an arcuate cross section to fit the inside bottom walls of the steel tube 28'. This dirt pan may be drawn forward as by a wire rope 82 passing over a pulley as at 83 mounted upon the sleeve 74, and thence back through the series of casing tubes to the manhole 25. The pan may be withdrawn back to the manhole 25 as by a cable 84.

As shown in Figs. 16 and 20, means are preferably provided as for example on one of the web members 77 for releasably clamping the parts

supporting the cutter member at a desired position within the head end of the tubular casing. This means may comprise a clamping shoe as at 85 pivotally supported on a pair of cam members 86, the middle portions of which cam members may be pivotally supported as shown on each side of the web 77. The inner ends of these cam members as shown may be attached to operating cords or cables as at 87 and 88, the latter passing over a pulley 89, and thence back to the manhole 25 together with the cable 87. By pulling the cable 87 toward the left as viewed in Fig. 16, it will be apparent that the clamping shoe 85 will be brought into clamping engagement with the top inside wall surface of the casing and thus hold in position the parts for supporting the cutter. The clamping shoe 85 may be released by pulling on the cable 88.

The spider member 79 for supporting the sections 72' of the shaft, may similarly be provided with releasable clamping means as shown in Figs. 17 and 19, and including clamping shoes as at 90, cam members as at 91, and a cam-locking member as at 92. If desired, cables or ropes may be attached to the members 91 and 92 for manipulation of the same from within the manhole 25.

If the tubular casing as it is being advanced into the ground should meet with serious obstructions, such as large masses of rock, the dirt removal equipment such as shown in Figs. 15 to 20 inclusive, may be removed and then suitable known forms of compressed air rock drills with rotating cutting heads actuated by compressed air motors may be introduced into the tubular casing. For instance, such devices may be mounted on rollers or wheels and pushed, as by the use of a long sectional handle, into operating position at the head end of the casing.

Apparatus and methods will now be described in connection with Figs. 21-24 inclusive for withdrawing the tubular casing sections and simultaneously casting in situ a concrete duct extending continuously from one manhole to the other. Assuming that the series of tubular casing sections have been pushed through the ground so that the head section 28' protrudes into the manhole 26, then a head piece as at 100 is applied thereto. This head piece may be accompanied by a mixing chamber as at 101 connected by a water pipe 102 to a water pump or other source of water supply, as at 103. A pipe or hose 104 is also connected into the mixing chamber 101 and may extend to a suitable device as at 105 for supplying a mixture of compressed air, dry sand and cement, so that when this mixture arrives in the mixing chamber 101 and is mixed with water, concrete is formed which may be forced through an opening as at 106 through the head piece 100. The pipes 102 and 104 may be in the form of hose or pipe sections as desired, and each may be provided with suitable valves as at 102' and 104' for adjusting the water, sand and cement mixture.

Before the ingredients of the concrete mixture are admitted to the mixing chamber 101, a sectional rotatable shaft as at 107 may be installed so as to extend all the way from manhole 25 to and through the head piece 100. A suitable coupling member as at 108 may then be fixed to the head end of the shaft for carrying the first of a series of rotatable mandrel sections as at 109. The sections of the shaft 107 as introduced, may be surrounded at spaced points by supporting members as at 110, which may have suitable central bearings as at 110 for the shaft, and also may be provided with apertures allowing passage

of the pipes 102 and 104 therethrough (see Fig. 22). With the apparatus assembled as above described, the hydraulic jack 29 may be turned around as compared with its position in Fig. 1 and provided with suitable hook means as at 111, for engaging the apertured cleats as at 38, so that when the jack is operated, the series of tubular casing sections will be withdrawn toward the manhole 25. In the first instance, the casing sections are withdrawn so that the head end is a short distance from the manhole 26, whereupon the opening in the wall of manhole 26 surrounding the mandrel 109 may be covered by a plate 112 to prevent the concrete mixture from being blown into the manhole 26. The supply of dry sand and cement mixture and also the water supply may now be connected for forming concrete in the mixing chamber 101. The concrete will be blown into the space surrounding the mandrel 109 as shown at 113. Meanwhile, the hydraulic jack may be operated to gradually withdraw the tubular casing sections further. At the same time, the shaft 107 may be rotated as by a motor in manhole 25 or manually as by a lever or wrench 114, so as to rotate the manhole 109 within the body of concrete 113. Vent holes as at 120 may be formed in the head piece 100, to permit the compressed air to escape from the area to be occupied by the concrete.

As the tubular casing sections are withdrawn into the manhole 25, it will be apparent that they may be removed one by one, by temporarily detaching the hydraulic jack which may then be suitably advanced along its notched rails and attached to the next casing section. Meanwhile if desired, sections of the hose or piping 102, 104 may be removed, as also may sections of the shaft 107 and the supporting means therefor from time to time. Fig. 23 illustrates the jack 29 in a position which it will assume just before one of the casing sections, with the sections of piping and shaft therein, are about to be removed.

Just before the mandrel section 109 is about to disappear into the surrounding concrete, an additional section as 109' may be secured thereto as by coupling means 109''. Further mandrel sections may be similarly applied as necessary during the further withdrawal of the casing sections. The number of sections of the mandrel which are to be added to the first section, will depend upon the speed of withdrawing the casing and the time required for the walls of the concrete duct to set or harden sufficiently to dispense with the support of the mandrel. The first one or more sections of the mandrel may be used without any provisions for heating the same, but in order to hasten the process or to minimize the number of cold sections of mandrel required, the last section of the mandrel may be equipped with suitable electrical heating elements for hastening the initial setting of the concrete. As shown in Fig. 23, two cold mandrel sections are in place, followed by a third section provided with heating elements as at 115. These elements may be connected for example through a suitable swivel plug connection 116 and wires 117 extending to a suitable source of power in the manhole 26 or outside to some other source. If desired, in some cases more than one of the mandrel sections may be similarly heated.

After all of the casing sections have been withdrawn into manhole 25, the mandrel sections

may also be withdrawn into this manhole, as will readily be understood. It will be apparent that the mandrel sections should have an external diameter substantially less than the diameter of the casing sections so as to provide a suitable annular space for the concrete between the mandrel and the walls of the cavity formed by the casing in the earth. The diameter of the mandrel sections will also of course be substantially the same as the desired internal diameter of the finished concrete duct.

While the invention has been described in detail with respect to particular preferred examples, it will be understood by those skilled in the art after understanding the invention that various changes and further modifications may be made without departing from the spirit and scope of the invention and it is intended therefore in the appended claims to cover all such changes and modifications.

What is claimed as new and desired to be secured by Letters Patent is:

1. Method of installing an underground concrete duct, which comprises pushing from one accessible location, into solidly compacted earth successively, a series of end-to-end hollow metal casing sections until such series extends from said location continuously to a second accessible location, meanwhile moving obstructing earth back through said series of sections to said first mentioned location, and thereby initially forming a continuous cavity lined by said sections between said locations, then successively introducing at one of said locations a series of end-to-end concrete duct sections, having a cross section approximating that of the casing sections, pushing said series of duct sections into the cavity formed by said casing and against an end of the series of casing sections, and thereby pushing the series of casing sections out of such cavity and successively to the other of said locations, whereby the casing sections are finally replaced by a continuous series of the duct sections.

2. Method of installing an underground concrete duct, which comprises pushing from one accessible location, into the earth successively, a series of end-to-end hollow metal casing sections until such series extends from said location continuously to a second accessible location, meanwhile moving obstructing earth back through said series of sections to said first mentioned location, and thereby forming a continuous cavity between said locations, and gradually pushing the concrete duct into the earth cavity occupied by the metal sections, and at the same time pushing the metal sections one by one out of such cavity by forcing the concrete duct against one end of the series of metal sections.

3. The method of installing a series of concrete duct sections, which comprises first pushing through the ground from one manhole or the like to another, a complete series of interengaging metal tube sections while projecting streams of water forwardly into the earth at the head end of said series and sluicing with water the obstructing earth back through such series of tube sections, then pushing a complete series of the concrete duct sections formed for end-to-end interengagement, into the earth cavity occupied by the metal sections, and pushing the metal sections out of such cavity with said concrete duct sections.

ERNEST WILLIAMS.