

July 28, 1936.

L. RANNEY

2,048,710

PROCESS FOR BUILDING UNDERGROUND STRUCTURES AND APPARATUS THEREFOR

Filed Nov. 25, 1932

8 Sheets-Sheet 1

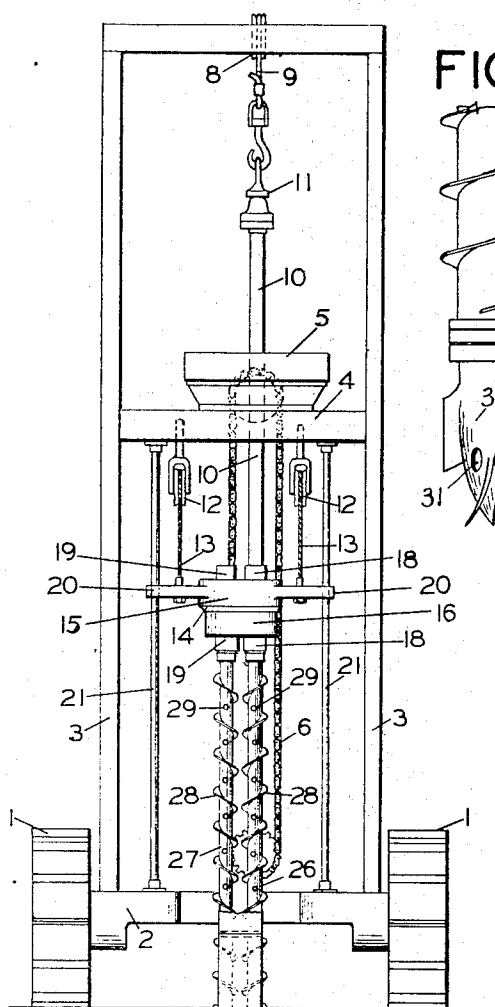


FIG-1.

FIG-28.

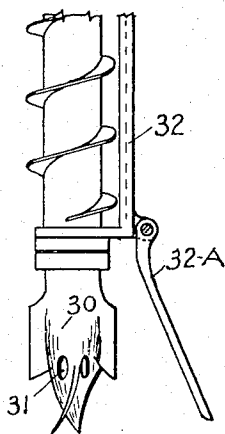
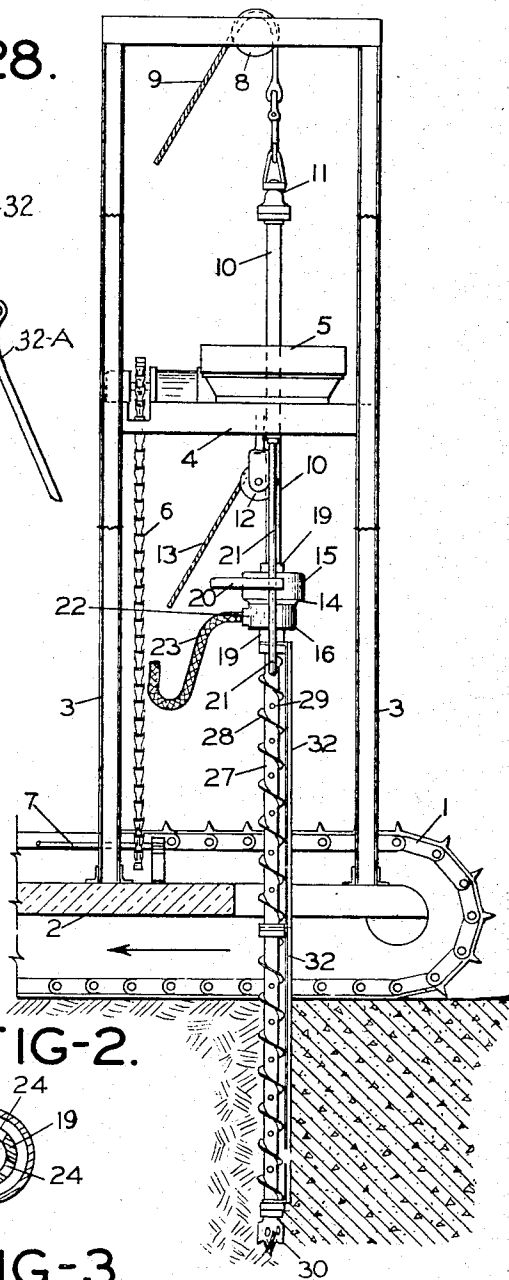


FIG-2.

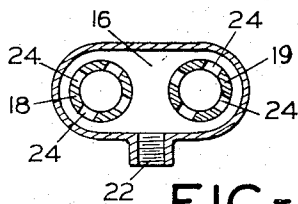


FIG-3.

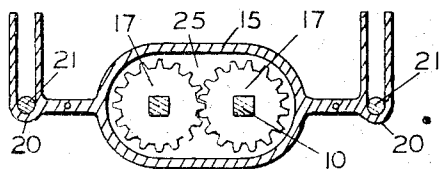


FIG-4.

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FIG-5.

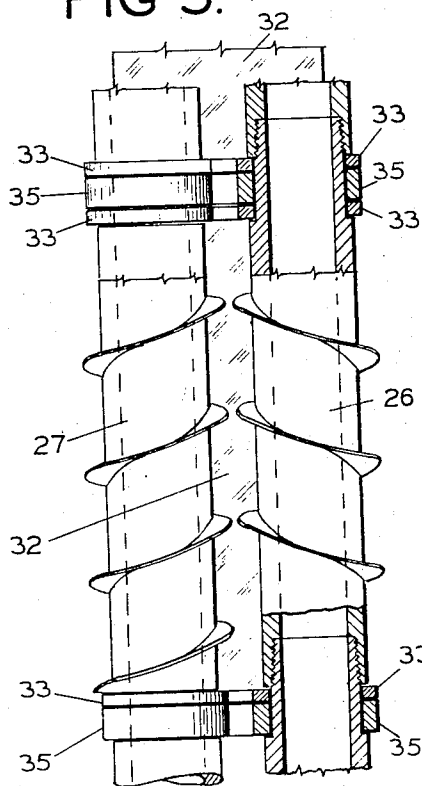


FIG-7.

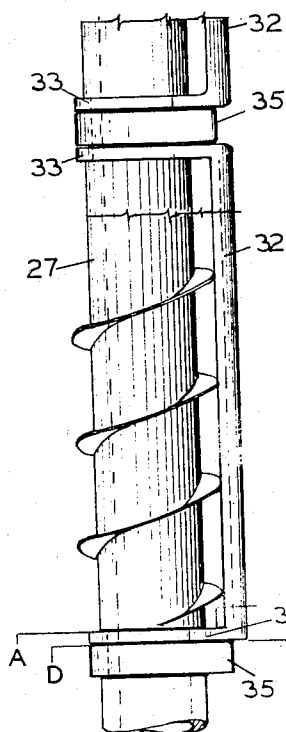


FIG-8.

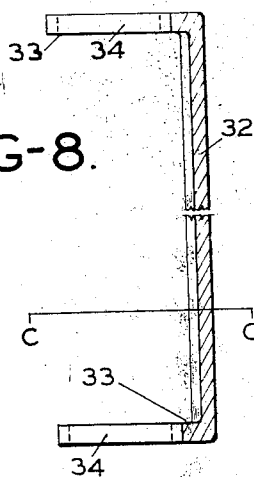


FIG-9.

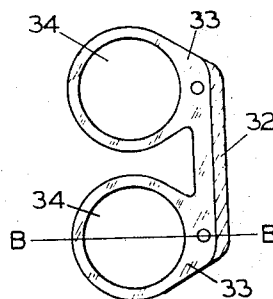
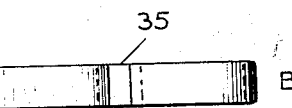


FIG-10.

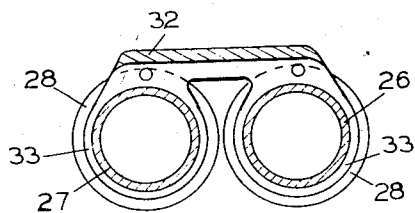


FIG-6.

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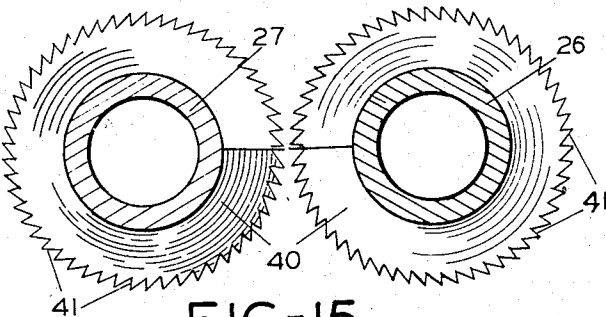


FIG-15.

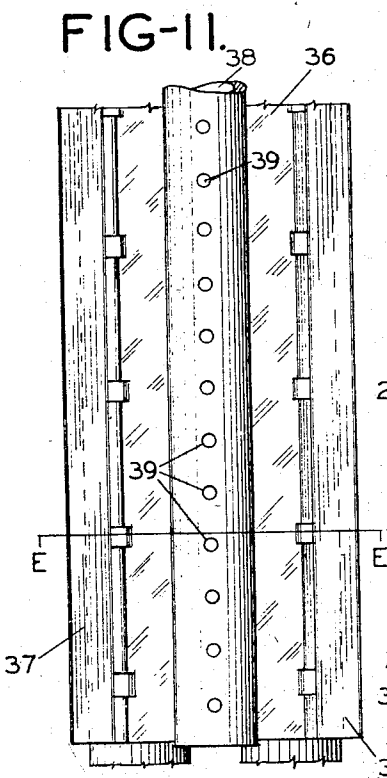


FIG-11.

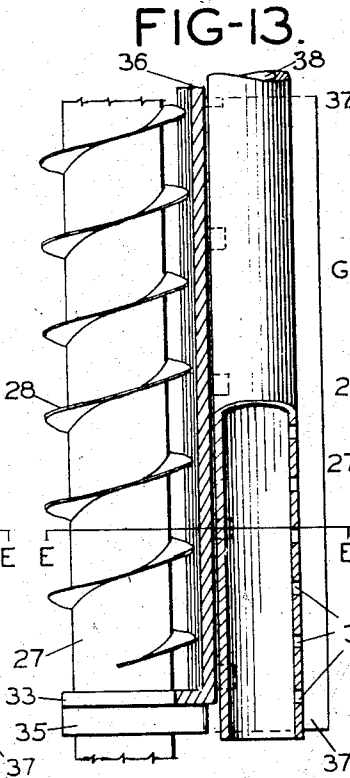


FIG-13.

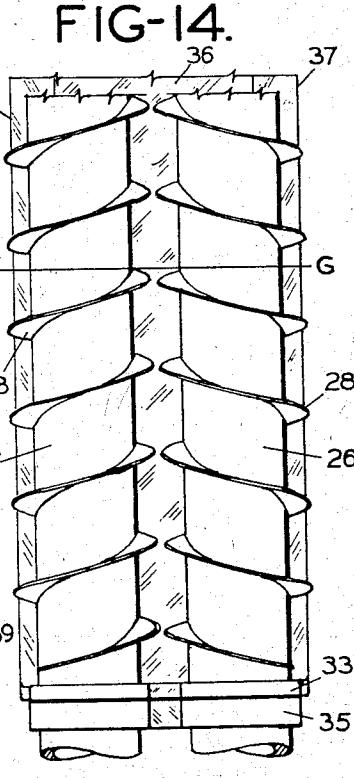


FIG-14.

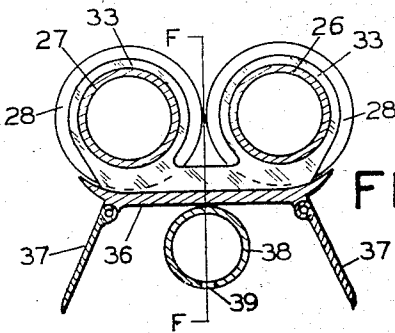


FIG-12.

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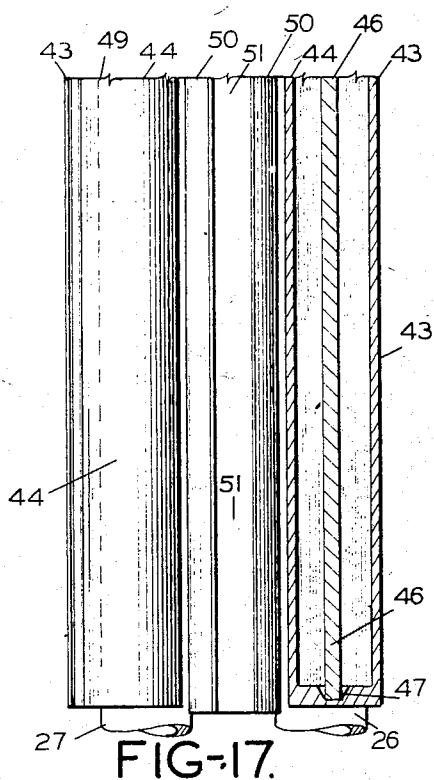
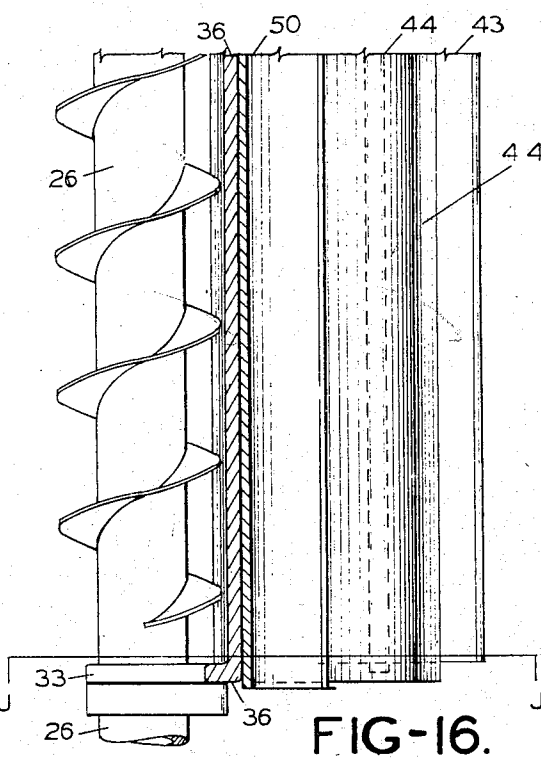
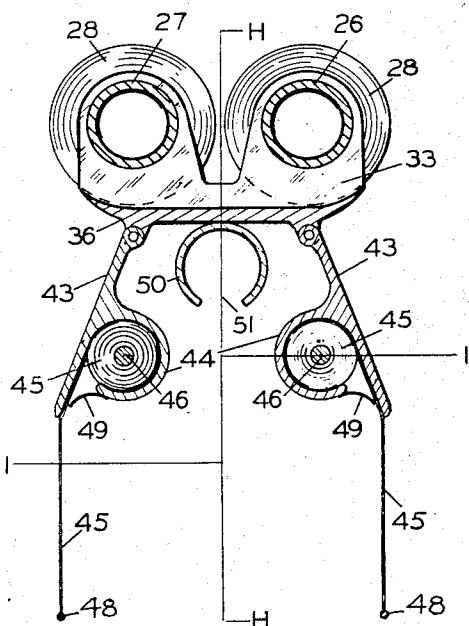
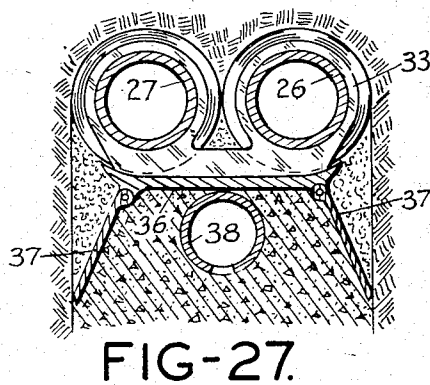
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8 Sheets-Sheet 4



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8 Sheets-Sheet 5

FIG-20.

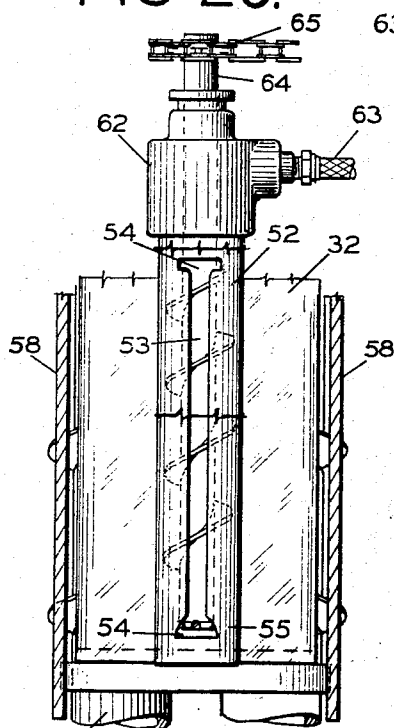
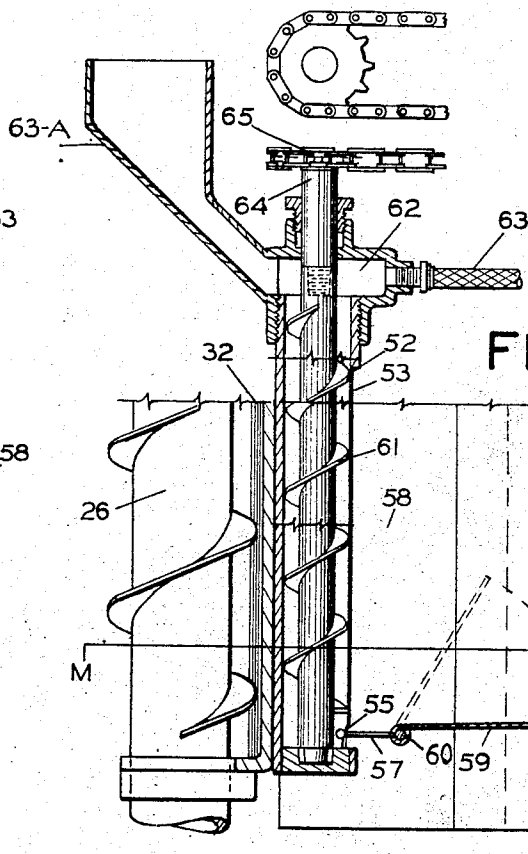


FIG-19.

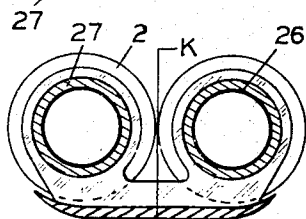
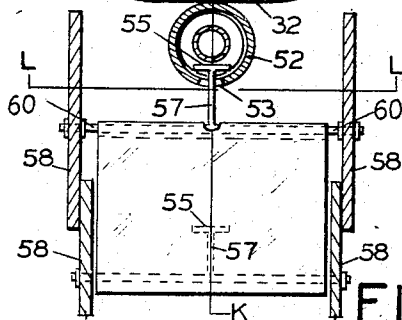


FIG-21.

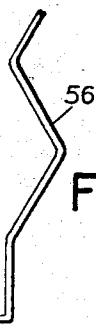


FIG-22.

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8 Sheets-Sheet 6

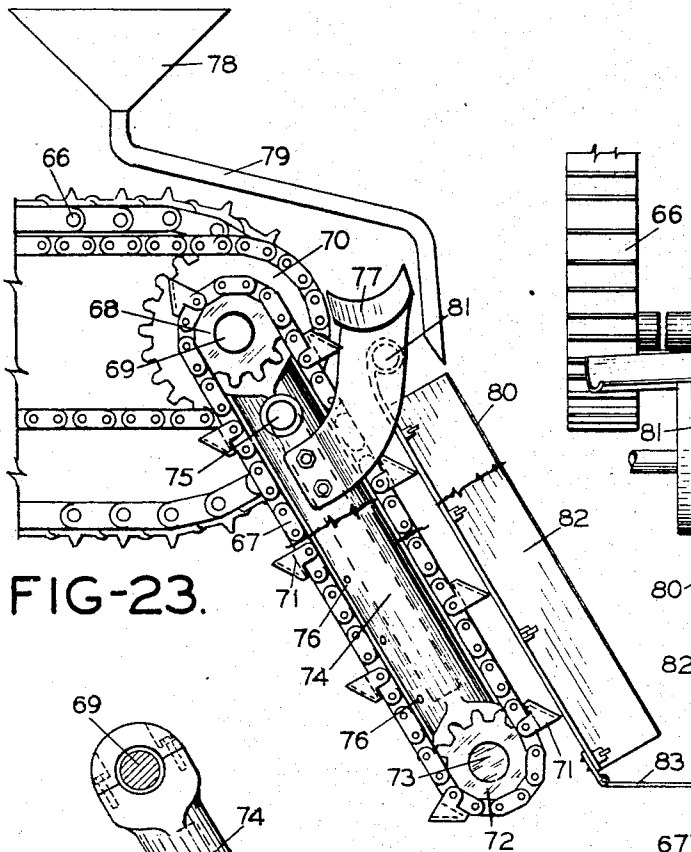


FIG-23.

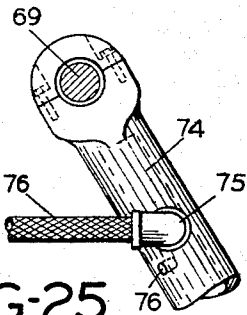


FIG-25.

FIG-24.

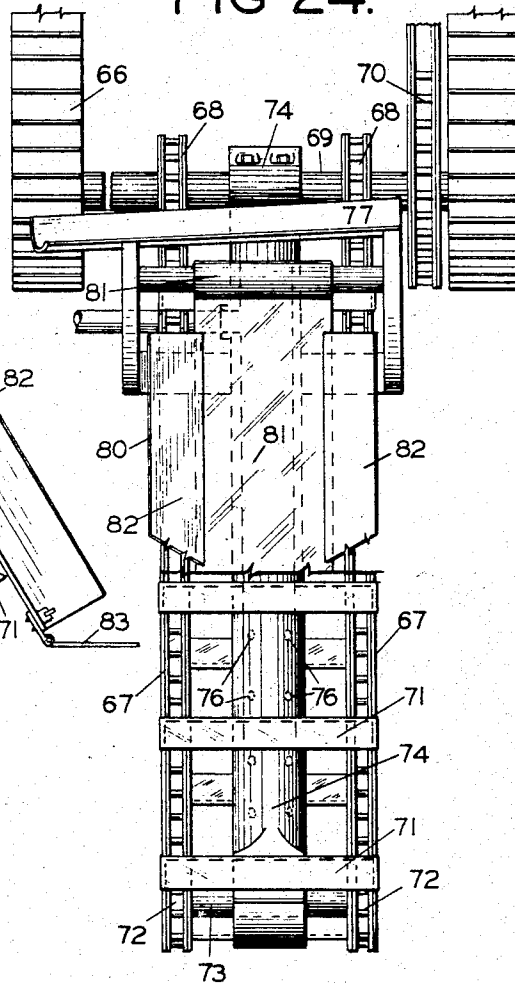
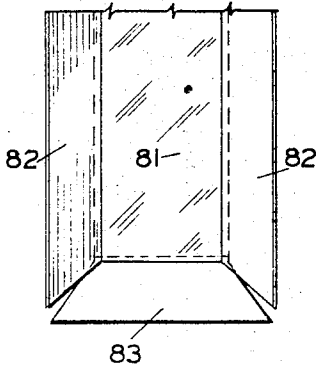


FIG-26.



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8 Sheets-Sheet 7

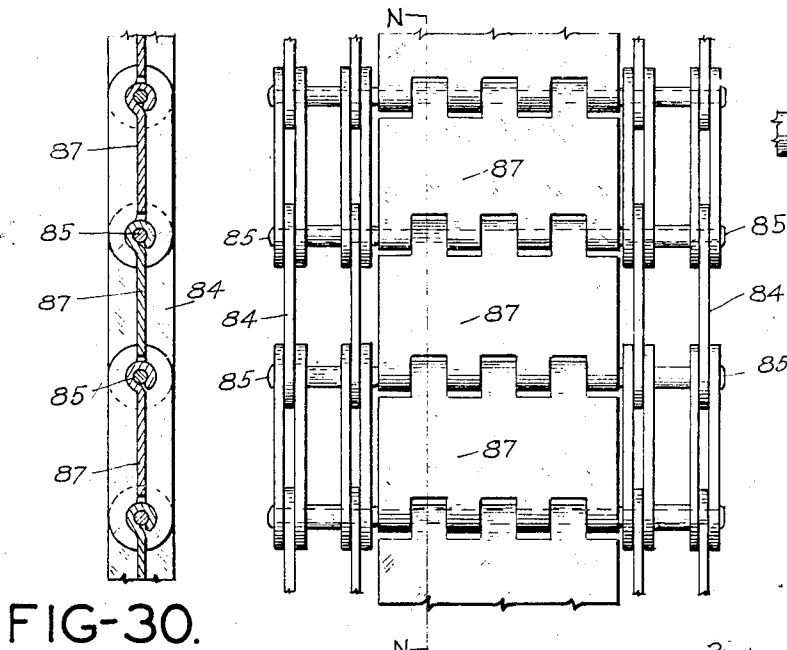
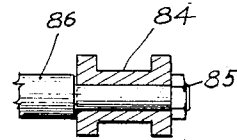


FIG-36.

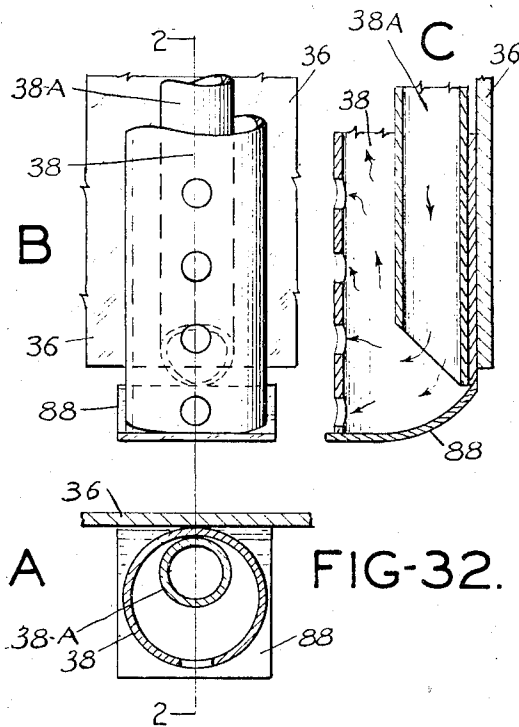


FIG-32.

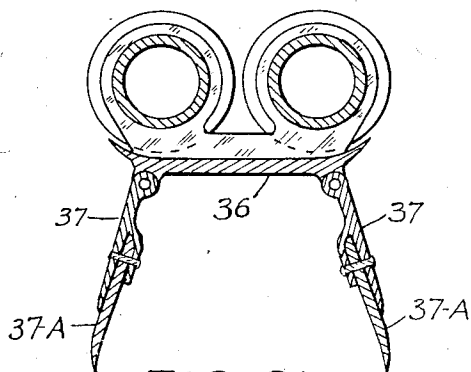


FIG-31.

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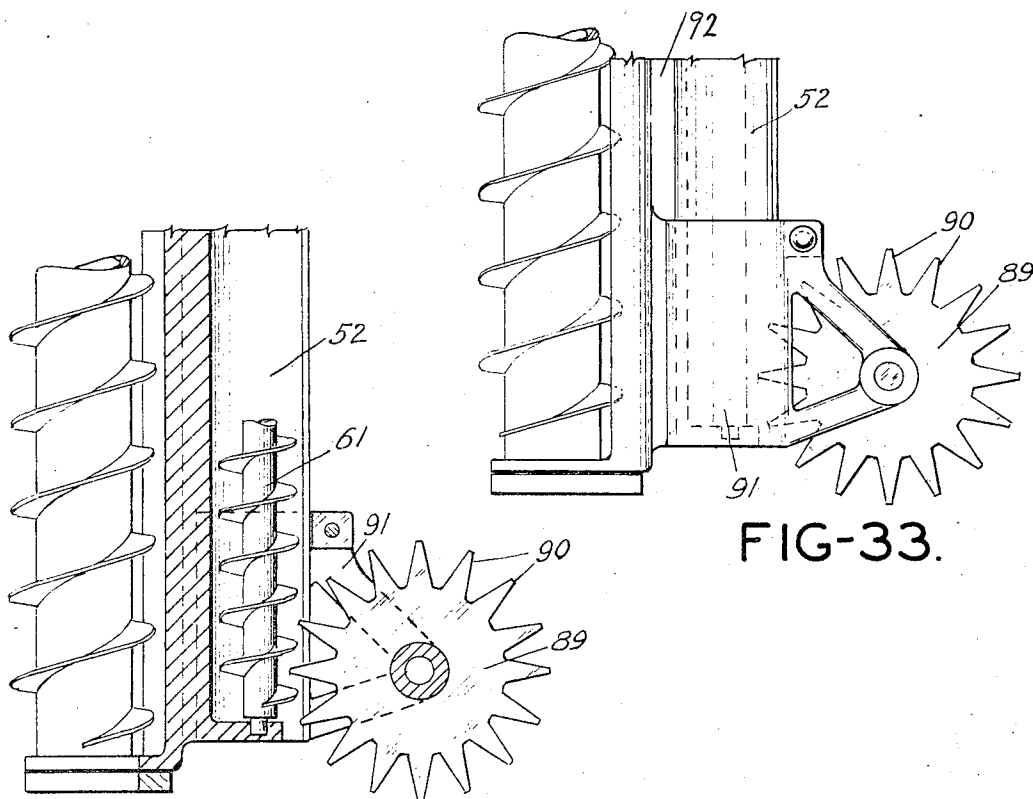


FIG-34.

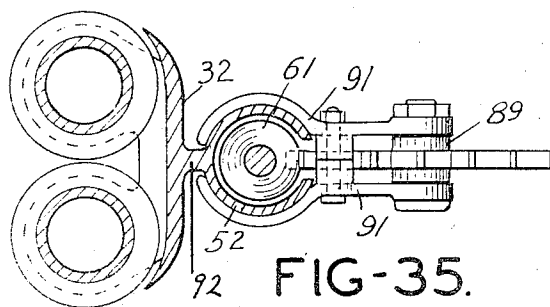


FIG-35.

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UNITED STATES PATENT OFFICE

2,048,710

PROCESS FOR BUILDING UNDERGROUND
STRUCTURES AND APPARATUS THERE-
FOR

Leo Ranney, Tulsa, Okla.

Application November 25, 1932, Serial No. 644,167

62 Claims. (Cl. 61-63)

My invention relates to new and useful processes of building underground walls, foundations, supports or walled ditches, and like structures, and has for its object to materially lessen the time and cost of constructing the same. My processes also make it possible to use a plastic material such as clay, for building a wall for the purpose of holding water, oil or gas or retarding its percolation in the ground, or to use a liquid asphalt or oil or a cheap mixture of low cement content in building such a wall, or a supersaturated solution of calcium carbonate or water glass solution or other minerals or salts as a cementing medium or any other medium which can be introduced and mixed in a fluid or powdered form with other material such as earth material and which will then harden, coagulate or congeal by cooling or setting or being subjected to a chemical reagent to solidify or bind the mass of the admixture. One of the chief features of the processes is the simultaneous excavating of the earth and the building of the wall or other structure in one continuous operation. The provision of suitable apparatus for the practicing of my processes is also of my invention, and I have herein disclosed my preferred form thereof, covering various types of apparatus each particularly adapted to more efficiently work in various certain earth deposits such as hard earth, clay, soil, sand, gravel, quicksand, soft mud and the like.

With the above and other objects in view which will appear as the description proceeds, my invention consists in the novel features hereinafter set forth in detail, illustrated in the accompanying drawings and more particularly pointed out in the appended claims.

Referring to the drawings in which numerals or like character designate similar parts throughout the several views; there are two groups of drawings, one group, comprising Figures 1 to 22 inclusive and Figures 27 and 28 and Figures 31 to 35 inclusive relating to my rotary drill, cutting tool and conveyer type of apparatus, and the other group comprising Figures 23 to 27 inclusive and Figures 29 and 30, concerning my belt form of cutting tool and conveyer type of apparatus which is more generally adapted to use in building walls in hard earth material than is my rotary form of equipment.

Dealing with the first group:—

Fig. 1 is a view in front elevation of my rotary apparatus above mentioned, indicated as being mounted on a heavy tractor or other movable

structure, said apparatus consisting of two co-acting rotary drill, cutting and conveyer screws, with drill bits thereon, which will hereinafter be referred to generally as rotary pipes whether the same is operated for boring, cutting laterally, or for conveying, and which said rotary pipes are suspended from a gear case which in turn is hung from blocks on a derrick, with a rotary table superimposed on said structure and having therein a drill stem which itself is suspended by a swivel socket from a block held on a superstructure above the rotary table, and showing a chain drive to said rotary table, a fluid hose connection into the rotary pipes and cables with which to raise or lower the drill stem and gear case. The apparatus permits of the use of only one rotary pipe when desired.

Fig. 2 is a view in side elevation of the same.

Fig. 3 is a view in transverse cross section of the rotary pipe head into which the fluid may be injected to be transmitted to the rotary pipes.

Fig. 4 is a view in transverse cross section of the gear case and gears therein and the anti-rotary locking member for said case and rotary pipes.

Fig. 5 is a view partially in elevation and partly in longitudinal cross section, of a pair of joints of the rotary pipe, showing the yoke holding the pair together.

Fig. 6 is a view of the same on line A—A of Fig. 7.

Fig. 7 is a view in side elevation of the same but also disclosing a shield, or partition plate or semi-partition plate, or guard plate, or one of the mixing means or one of the elevating means, said member having a number of different uses, and which said member, for the sake of brevity will hereafter be referred to generally as a shield, with said shield located to the rear of said rotary pipes.

Fig. 8 is a view in cross section of one of the sections of said shield on line B—B of Fig. 9.

Fig. 9 is a view thereof in cross section on line C—C of Fig. 8.

Fig. 10 discloses the aforesaid yoke with A a top plan view thereof on line D—D of Fig. 7, and B a view in side elevation of the same.

Fig. 11 is a view in rear elevation of said rotary pipe, with shield thereon as in Fig. 7, but with said shield adapted to bear and bearing hinged side wings to follow in the wake of said shield as the whole structure is advanced in operation, and showing a wall material conductor attached to the rear of the shield.

Fig. 12 is a view of the same in cross section on line E—E of Figs. 11 and 13.

Fig. 13 is a view of the same partly in side elevation and partly in cross section on line F—F of Fig. 12.

Fig. 14 is a view of the same in front elevation.

Fig. 15 is a top plan view of a saw toothed worm or spiral flight as if on line G—G of Fig. 14.

Fig. 16 is a view of a lining attachment to a section of rotary pipe and shield form of apparatus shown in Fig. 11, wherein the side wings on the shield provide housings for rolls of suitable lining material, such as cloth, fabric or paper treated as may be desired, with which to line the walls of the ditch being dug, preparatory to filling the ditch with the desired wall material, which lining acts as a separator or divider between the earth material and the wall material after the latter has been placed in the ditch, said view being partly in side elevation and partly in cross section on line H—H of Fig. 18.

Fig. 17 is a view of the same partly in rear elevation and partly in cross section on line I—I of Fig. 18.

Fig. 18 is a view of the same in cross section on line J—J of Fig. 16 showing also a roll of lining material in place in each of the housings in said wings and with part of the lining material indicated as already being in place.

Fig. 19 is a view partly in side elevation and partly in cross section on line K—K of Fig. 21, of a modified form of apparatus attached to the rotary pipes aforesaid whereby reinforcing rods may be run to the bottom of the wall, and also whereby solid plate forms, such as steel or wood forms, may be run down to the bottom of the ditch to line it preparatory to placing the wall material therein.

Fig. 20 is a view of the same in rear elevation on line L—L of Fig. 21.

Fig. 21 is a view of the same in cross section on line M—M of Fig. 19.

Fig. 22 is a view in perspective, of a form of reinforcing rod adapted to use with said apparatus.

Fig. 27 is a view in cross section of the apparatus shown in Fig. 12, but also showing the undisturbed earth in front of the rotary pipes and at the side thereof and along the ditch in the wake of the pipes, and showing the wall material in the ditch and to the rear of the shield and its side wings, and also showing between the two rotary pipes, and between said pipes and said shield and side wings thereof, the earth material, which has been cut away by the rotary pipes, being either dry or in a liquid form as mud, the presence of which prevents the side from caving or flowing into the ditch.

Fig. 28 is a view in side perspective of a part section of the rotary pipes with drill bits attached to the bottom end of the strings of pipe and with a shield to the rear of said pipes and with a tail board hinged from said shield to drag on the bottom of the ditch in the wake of the bits.

Fig. 31 is a view in cross section of a modified form of shield wings such as shown in cross section in Fig. 12, wherein the wing tips or edges are of resilient material.

Fig. 32 discloses an inner pipe arrangement for a conveyer pipe such as pipe 38 shown in Fig. 12, in which said pipe 38 is closed at the bottom end, and an inner string of pipe run therein, with A a view in transverse cross section, B a view in side elevation, and C a view in longitudinal cross section, of the end construction of said pipes.

Fig. 33 is a view in side elevation of a pusher device shown as attached to a pipe such as pipe

52 in Fig. 20, at the bottom thereof, with a worm in said pipe with which to drive the pusher wheel.

Fig. 34 is a view of the same in side elevation with pipe portion thereof shown in cross section.

Fig. 35 is a view of the same in transverse cross section except the pusher wheel portion which is shown in a top plan view.

Turning now to the second group of drawings:—

Fig. 23 is a view of my belt form of apparatus as aforesaid, in side elevation.

Fig. 24 is a view thereof in rear elevation with part of the apparatus broken away.

Fig. 25 is a view in side elevation of the drive shaft head of the belt supporting member which also serves as a coupling between the driving shaft and the shaft whereon the idler sprockets are held, said coupling being in the form of a pipe adapted to convey liquid therethrough.

Fig. 26 is a top plan view of the end of the shield for the belt, with wide wings and tail board attached thereto.

Fig. 29 is a top plan view of a preferred form of chain belt conveyer wherein plates, hinged on the same pins which provide the pivots for the links, are placed on or between each pair of links.

Fig. 30 is a view of the same in cross section on line N—N of Fig. 29.

1 indicates generally a heavy tractor with bed 2 whereon my structure is placed. 3 represents generally a derrick mounted on bed 2, with 4 a platform thereon holding rotary table 5 driven by chain drive 6 through power shaft 7 connected with a source of power which is not shown.

At the top of derrick 3 is mounted block 8, the same being a sheave through which cable 9 supports rotary drill stem 10 connected with it by swivel connection 11. No details of the various parts above mentioned are shown as the same are well known although the arrangement thereof is novel.

Suspended from platform 4 by means of blocks 12 and cables 13, is a combined gear case and rotary pipe head 14 through which drill stem 10 is operatively connected to the rotary pipes, with 15 representing the gear case and 16 the drill pipe head. In the gear case two cog wheels 17 of equal pitch diameter are meshed with one wheel adapted to be connected with drill stem 10 and having a sleeve 18 thereon adapted to permit of its connection with one of the rotary pipes, and the other wheel having a sleeve 19 thereon adapted to permit of its connection with the other of said rotary pipes, the connection between the sleeves and the pipe being by the conventional tool joint. The sleeves mentioned are mounted on thrust bearings which are not shown but which are of the usual type and are adapted to sustain the weight of the rotary pipes.

On the combined gear case and pipe head 14 are projections having bifurcated arms 20 thereon which slip over guide bars or anti-gyratory members 21 attached to the derrick 3 and which prevent the whole rotary pipe structure from swinging bodily about on the projected axis of the drill stem 10.

The rotary pipe head 16 is provided with hose connection 22 and hose 23 through which fluid such as water or neat cement or other liquid mixture may be forced into the rotary pipes through apertures 24 in said sleeves 18 and 19. Stuffing boxes of conventional arrangement and which are not shown, pack off said sleeves from the partition 25 which divides the gear case

from the rotary pipe head, which partition also serves as a support for the sleeve bearings aforesaid.

Attached to each of the sleeves 18 and 19, are rotary pipes made up in sections adapted to be connected together by tool joints, and also adapted to be connected to said sleeves and with the bits in the same manner, one string of rotary pipe 26 being connected into sleeve 18 and the other string of rotary pipe 27 being connected into sleeve 19. It will be noted that with the arrangement provided the two strings will be rotated in opposite directions. On the sections of pipe comprising the strings are worms or spiral flights or vanes 28, which may also be a series of separate vanes, arranged in the desired pitch. Holes 29 in the rotary pipe permit water or cement or clay mud or other liquid mixture, to be forced into the hole being drilled or the trench being dug, and when the use of the holes is not desired they may be plugged or pipe without holes substituted therefor. Drill bits, such as the conventional fish tail bits 30, are attached to the bottom of the strings of rotary pipe and they are also provided with holes 31 communicating with the inside of the respective string of pipe into which they may be connected.

Presuming the mounted apparatus to be moving in the direction indicated by the arrow shown in Fig. 2, to the rear of said rotary pipes is attached a shield 32 which serves a number of uses as previously set forth, and which is made in sections corresponding to those of the rotary pipe and attachable thereto by means of a flange portion 33 thereof adapted to receive the end portion of the pipe which may be passed through holes 24 in said flange portions of the shield. Hinged to the bottom of shield 32 may be provided a tail board or hinged shield plate 32A which may follow in the wake of the drill bits 30. The two strings of rotary pipe 26 and 27, are held together in spaced relationship and parallel with each other, by yokes 35 placed in the string of pipe at each joint thereof as shown in Figs. 5 and 7.

Figs. 11, 12 and 13 disclose another shield arrangement wherein a shield proper 36, is provided with side wings 37 hinged thereto, and which after the excavation has been connected may be run into the trench prior to starting the placement of the wall therein. The tips of the side wings may be formed of a resilient material in the nature of a flap 37A as shown in Fig. 31. Attached to the shield and to the rear thereof is a pipe 38 with perforations 39 therein through which wall material may be inserted into the ditch as it is dug. An inner pipe 38A such as shown in Fig. 32 may be run in pipe 38 through which the wall material may be introduced into the pipe 38 at the bottom thereof when closed at the bottom as shown. The closure of pipe 38 may be made with a curved plate 88 which permits pipe 38 to drag on the bottom of the ditch.

Fig. 15 shows a modified form of spiral flight 40 for the rotary pipes, in which the edges of the spiral are provided with teeth 41 to aid in cutting away the earth material.

In Figs. 16, 17 and 18 is shown shield 36 with side wings 43 in modified form, said wings being provided with housing 44 for rolls of lining material 45 such as a fabric or paper, for lining the side walls of the trench preparatory to filling the same with wall material. The lining material is rolled on rod 46 and inserted into the housing on said rod and the rod seated in a thrust bearing

47 in the bottom of the housing. The lining material is shown in Fig. 18 as extending through the housing and held in place in the trench by bars 48 until the wall material has been placed in the trench against the lining material, whereupon the lining material is, of course, held in place by the wall material. Tension plates 49 loosely grip the lining material and prevent the wall material from passing into the housing.

In this group of figures is also shown a longitudinally slit pipe 50 with slot 51 running the length of the string of pipe and through which wall material may be conveyed into the trench.

In Figs. 19, 20 and 21 is shown a shield such as shield 32 with pipe 52 fastened to the rear thereof and slotted as by slot 53 with enlarged opening 54 at both ends of said slot and adapted to permit of the insertion of a cross-T 55 into the pipe through the enlarged opening at the top and to the ejection of the cross-T out of the pipe through the enlarged opening at the bottom of the pipe. The cross-T 55 may be either of a reinforcing bar such as bar 56, or of a connection 57 attached to a form such as a board or plate form comprising sides 58 and bottom 59 held together by bar 60 with which connection 57 is directly attached. In pipe 52 is a worm conveyor 61 with which the T 55 may be forced to the bottom of the pipe. The conveyer is also adapted to force cement or other liquid or powdered mixture through pipe 52 after it has been introduced into said pipe through head 62 into which a hose 63 or a hopper 63A is connected, or with both hose and hopper connected into the head as shown in Fig. 19. The worm 61 is driven by shaft 64 and chain and sprocket drive 65.

In Figs. 33 to 35 inclusive, a slotted pipe such as pipe 52, with worm such as worm conveyor 61 in said pipe appearing in Fig. 19, is shown. A wheel 89 having protruding spokes, teeth or cogs 90, is held in a yoke 91 on said pipe. The cogs of the wheel are meshed with the spiral of the conveyer and protrude into the pipe through the longitudinal slot therein. The yoke 91 grasps the pipe loosely, so that the wheel may be run to the bottom of the ditch on said pipe, and then rotated by turning the worm conveyor 61. The teeth of the wheel bite into the bottom surface of the ditch and as the wheel is rotated by the worm the entire structure is urged forward. This arrangement serves to assist the tractor at the surface of the ground to force the rotary pipes against the front wall of the ditch. Preferably, pipe 52 is attached to shield 32 by a web 92 so that there will be no obstructions on said pipe on which yoke 91 may impede in traveling to the bottom. The pusher wheel may be withdrawn by reversing the direction of rotation of the conveyer 61.

In the second group of drawings, consisting of Figs. 23 to 30 inclusive, a link belt conveyer type of apparatus is shown in which 66 represents generally a tractor or other movable structure bearing the apparatus which consists of a link belt conveyer wherein 67 is the chain and 68 the driving sprocket which receives its power through shaft 69 from chain and sprocket drive 70. The conveyer has conventional digging buckets 71 thereon, and the whole is pivotally suspended 70 from shaft 69. The idler sprockets 72 of the link belt conveyer are mounted on journal or axle 73 held by coupling member 74 which holds the driving sprockets with the idler sprockets. The coupling 74 is hollow as if of pipe construction be-

tween the two sprocket wheel shaft heads, and is provided with an inlet 75 and hose connection 76 thereto connected, wherewith liquid may be forced into the pipe part of the coupling member 74 and be conveyed to the outlets 76 in the pipe. The belt and the coupling may be of any desired length by substituting various lengths of coupling members and belt. A conventional lateral conveyer 77 receives the earth material from the buckets 71 and conveys the same to one side of the ditch, while a hopper 78 and pipe 79 conveys the wall material to a trough 80 hinged on the apparatus as at 81, the trough being made of a bottom plate 81, side plates 82 hinged thereon and a tail plate 83 also hinged thereon, the bottom plate and the side plates forming a winged shield interposed between the conveyer and the wall material when the same is placed in the ditch and the tail plate likewise acting as a shield for the extreme lower portion of the conveyer. The pressure of the wall material against the shield assists in forcing the conveyer buckets against the front face of the ditch being dug.

In Figs. 29 and 30 are shown my preferred form of link belt for the intended purpose, the same comprising sprocket chain with links 84 joined together by pins 85 with said pins having an enlarged central portion 86 thereof extending between the two links whereof it provides the pivot member of the links, and with plate members 87 hinged on the enlarged center portion of the pin, and with said plate members at intervals carrying a digging bucket or gouge or other bit wherewith to remove the earth material. With such a belt conveyer the loose earth material is held between the conveyer belt plates 87 and the front face of the ditch being dug and lessens the tendency of the loosened earth to pack and clog the apparatus. It is obvious that the plates 87 could be formed to extend over the links 84 if such an arrangement is desired.

In practicing my invention under various conditions and to accomplish a number of purposes and attain various results, it is obvious that the use of the equipment will also vary and that certain parts thereof may or may not be used, and if used may be used in combination with various other parts of my apparatus.

It is also evident that a variety of wall materials and cementing or binding substances may be used for various purposes under different circumstances to accomplish various objects.

To illustrate, presuming that it is desired to build a wall merely to stop or retard the underground flow of water down a valley, a clay mud would be sufficient as the wall would be supported on both sides and the clay would be impervious to the water and not subject to erosion except at the surface. This would also be true in building an underground reservoir wherein to store water, oil, gas and the like, whereas if it were desired to build a ditch wall or jetty or insert a core in an earthen dyke, or build a pier, a substantial wall, such as of cement, would be used. Moreover, in certain cases it would be desirable to use a mixture of the earth material itself with a little cement, or with oil or asphalt, molten sulphur, paraffin or other wall material, in which case only a part of the earth material would be removed and that part remaining would receive the cement or other binding agent. In such last mentioned case the cementing or binding or congealing or coagulating agent, or mixture thereof may be forced down through the rotary pipe 26 and 27, or either, to the bottom

and out the holes of the bits or through the holes in the rotary pipe itself, the holes being spaced as may be desired or plugged or pipe without holes used. However, where it is desired to build a firm or solid wall or foundation, the wall or foundation material may be inserted through the pipe 38 in back of the shield by hydraulic or air pressure or by a conveyer screw, leaving the pipe through the holes of the slot therein, and in some cases the fluid mix may be inserted through an inner pipe into the bottom of the pipe 38 from whence it may flow upwardly and out of the holes in pipe 38, or steam may be run through the inner pipe to keep the mix sufficiently hot to preserve its liquid state as in the case where molten sulphur or paraffin is used, or the hot mixture may be conveyed through one rotary pipe 27 while the other rotary pipe is used for conveying the heat, such as by steam or other hot vapors or gases, to the mass of the mix.

Moreover, in cases where a very substantial wall or foundation is desired, instead of mixing concrete on the surface and injecting it into the ditch in liquid form, a dry mix may be delivered from a hopper into the pipe 28, and forced into the ditch with a worm conveyer, the necessary water being delivered into the ditch through one of the rotary pipes 26, or, if the belt conveyer type of apparatus is used, the mix may be delivered from the hopper into the shield trough while water is conveyed through the coupling. Furthermore, in certain instances no water for the mix need be delivered, in as much as it may be present in the earth in sufficient quantity to supply the necessary amount to the mixture.

The apparatus shown in its various forms and parts, readily lends itself to the practice of the various processes, and in examining the equipment it is readily apparent that, in addition to the matters above disclosed, the equipment has other functions as well. In the rotary form of apparatus the shield acts to separate earth material from wall material; also to assist the worms of the rotary pipe to lift the earth material, and, when desired to do so, to assist in mixing the cement or binder with the earth material; also to prevent the larger stones from being conveyed into and lodging between the worms of the rotary pipe; and also as a wall against which the weight of the liquid wall material may lay to press the rotary pipe cutters against the front face of the ditch which is being cut. The tail board may be used when desired to make the separation more complete. The wings on the shield also assist in further separating earth material from wall material. They also assist in creating further pressure of the wall material on the rotary pipe cutters as aforesaid. The resilient wing edges, tips or flaps further assist in this respect as they follow closely the contour of the side walls. The teeth in the edge of the spiral flights make it possible to cut into fairly hard earth material and to pulverize it when desired to make it very fine for use as wall material as previously mentioned. The fabric or paper lining attachment, makes it possible to stretch the lining along the side walls of the ditch to create a partial or total separation between wall material and earth material for the purpose of preventing dilution of the wall material by earth waters or preventing loss of any part of the wall material; or, as in the case of a porous fabric, to act as a strainer through which excess liquid of the wall mix may pass into and be absorbed by the earth material; or, as in the case of a material treated to make it impervious to

water, to retain the entire wall mix intact in the ditch until it has congealed or set. Moreover, the fabric itself may be treated to render it impervious to the ground water and in itself constitute the wall or a substantial part thereof. The plate form of lining and the apparatus for placing it in the ditch makes it possible to even more completely line the ditch for the aforesaid purposes, or to set forms when desired, the equipment being adapted to place the forms even after the mix has been introduced into the ditch and while the same is still in liquid state; and bottom plates may likewise be introduced as will readily appear from the drawings. Reinforcing rods may also be run down when the wall material is already in place in the ditch.

In the operation of the rotary type of equipment aforesaid, it will be readily apparent that various practices are possible. The drill bits may or may not be, but generally would be, used, and presuming their use, a hole is first drilled to the desired depth, and if the earth material in which the operations are being performed is hard, water is introduced to sufficiently soften the earth about the hole so that the rotary pipe with its shield and wings thereto attached, if their use is desired, may be sunk in the earth. Presuming that the depth desired is to bed rock, the bits stop thereon and the structure then slowly advanced as the worms of the rotary pipe cut away and carry out a portion or all, whichever may be desired, of the earth material. The wall material is injected, as previously explained, simultaneously with the digging of the ditch. The bits will drag on the bed rock and clean the same so that the wall or foundation will be made to rest thereon, the strings of rotary pipe raising and falling with the undulations of the surface of the rock formation with arcuate movement from the point of suspension of the rotary pipe, or the whole pipe may be bodily raised or lowered through the cables provided for that purpose. Pipe joints and shield joints may be removed or added to the string to shorten or lengthen it.

This form of apparatus also lends itself to building cores or small structures as it is adapted to turn on an extremely short radius.

Considering now the belt conveyer type of apparatus, the same is more adapted to digging comparatively straight ditches than to placing piers or short walls with angles to them, and its operation is readily apparent from the drawings and from what has previously been said. It too, is adapted to simultaneously excavate for and place underground walls or similar structures. It is particularly adapted to building very narrow walls such as walls less than a foot thick, the width depending, of course, on the width of the link belt, cutters and conveyors which may be made very narrow. Water may be jetted through the coupling to soften the earth material which is being removed, or for providing the water to dry mix for the wall.

I claim:

1. A replacement method of building an underground wall comprising removing earth material in relatively small quantities and replacing the same by wall material at the same time and while maintaining a fluid pressure on the sides of the wall trench between the newly laid wall and the undisturbed earth material in the path of the wall.

2. A method of building an underground wall, comprising removing part of the earth material from the space to be occupied by said wall ma-

terial and mixing the remainder of said earth material in said space with wall material disposed between the particles of said earth material.

3. A method of building an underground wall in which earth material is removed gradually and the place formerly occupied by the removed earth material is filled with wall material simultaneously with the removal of earth material, meanwhile supporting by fluid pressure the sides of the excavation ahead of the newly built wall, all in one operation, continuously and progressively.

4. A machine for building an underground wall, comprising means to elevate earth material upwardly from the path of said wall, means for supporting the unwallled trench by fluid pressure, means for keeping the desired separation of wall material from earth material, means for delivering wall material to replace all or part of the earth material removed, and means for operating said machine.

5. A method of building an underground wall, comprising removing earth material from the path of said wall, meanwhile supporting the adjacent undisturbed earth by fluid pressure, replacing said fluid by wall material and reinforcing said wall material while it is still plastic.

6. A method of trench excavation comprising removing earth material from the path of the trench, holding the sides of the trench by the pressure of a supporting fluid, and causing the sides of the trench to stand up by the action of said fluid.

7. A method of trench excavation as claimed in claim 6, and in which a heavy mud fluid is used.

8. A method of trench excavation as claimed in claim 6, and in which a part of the fluid is forced into the pores of the undisturbed earth adjacent to the trench.

9. A method of building an underground wall comprising removing earth material from the path of the wall, simultaneously replacing the removed earth material with a heavy mud mixture and causing the water to issue therefrom to make the mixture substantially impervious to the passage of ground water therethru.

10. A method of building an underground wall comprising simultaneously removing earth material from the path of the wall, filling the disturbed space ahead of the wall with a heavy mud mixture, and forming the wall within the mud-filled space.

11. A method as claimed in claim 10 and in which porous strata are mudded off to prevent caving.

12. A method of building an underground wall comprising removing earth material from the path of said wall and simultaneously placing wall material in the path of the disturbed earth material in such a way as to create the desired mixture of earth material and wall material and leave said mixture in place for said wall, and simultaneously holding the side walls of the space between the undisturbed earth material in the path of the wall and the wall material by fluid pressure.

13. A method of building an underground wall comprising simultaneously removing earth material from the path of said wall, and placing wall material among the particles of remaining disturbed earth material in such a way as to create the desired mixture with earth material

and wall material and leave said mixture in place for said wall.

14. A method of building an underground wall as claimed in claim 13, and in which the wall material becomes substantially impervious after its introduction.

15. A method of building an underground wall as claimed in claim 13, and in which a coagulating agent is used as a binder for said wall.

16. A method of building an underground wall as claimed in claim 13, and in which a coagulating material is used as a binder for said wall.

17. A method of building an underground wall as claimed in claim 13, and in which a chemical reagent is used to bind the particles of wall material together.

18. A method of building an underground wall as claimed in claim 13, and in which the wall so built is narrower than the path of the earth material disturbed in building the wall.

19. A method of building an underground wall as claimed in claim 13, and in which a sheet of lining is applied to the sides of the wall as built.

20. A method of operating a machine for the building of an underground wall wherein the wall material injected into the excavation formed forces the machine against the material to be excavated.

21. A method of operating a machine for the building of an underground wall in which the machine is held in continuous contact with the material to be replaced by said wall from top to bottom, by the combined forces of gravitational pull on the suspended part of said machine and the hydraulic pressure of the fluid wall material injected behind said machine.

22. A method of building an underground structure comprising, loosening the earth material in the path of said structure, removing a part of said earth material, leaving earth water in the earth material below ground level, maintaining the material in the path of said structure in such a condition that structural material may be introduced therein, introducing structural material into the loosened earth material, placing said structure in a predetermined position, and building the structure progressively.

23. A method of trench excavation comprising a mechanical conveyance of earth material upward at the forward end of the trench, and in which an upward current of fluid is combined with said mechanical conveyance of said earth material, the entire operation being done in a fluid bath and the wall of said trench being supported by fluid pressure.

24. A method of building an underground wall comprising removing earth material from the path of said wall and simultaneously replacing earth material removed by wall material under artificial pressure.

25. A machine for building an underground structure comprising, means to loosen and agitate the earth material in a fluid bath in the path of said structure to a degree which permits the introduction of the structural material therein, means to support the earth material adjacent to said structure, means for carrying structural material downward into position, means for placing separate members of desired shape and to desired depth within said structural material after said structural material is in place, and means for operating and advancing said machine.

26. A method of building an underground wall, comprising removing earth material from the

path of said wall, meanwhile supporting the adjacent earth by fluid pressure, simultaneously placing the wall material and reinforcing the same while it is being laid, the reinforcing material being pressed into position before the wall material has solidified.

27. A method of building an underground wall, comprising removing earth material from the path of said wall, meanwhile supporting the adjacent earth by fluid pressure, simultaneously laying said wall and continuously and progressively setting permanent forms, under fluid pressure, to confine the wall to the shape and dimensions desired.

28. A method of building an underground wall, comprising removing earth material from the path of said wall, meanwhile supporting the adjacent earth by fluid pressure, and simultaneously, continuously and progressively, in a fluid or plastic bath, laying said wall and surrounding it with material other than wall material.

29. A method of laying an underground wall in which the excavation is dug, the adjacent earth supported by fluid pressure, the wall material placed in position, all in a fluid or plastic bath, simultaneously, and in which the rate at which the wall is built, continuously and progressively, is subject to positive control.

30. A method of building an underground wall, continuously and progressively, comprising removing earth material from the path of the wall and replacing the earth material removed with wall material, meanwhile keeping the trench ahead of the wall filled with a fluid or plastic filler, while the substitution of material is being made.

31. A method of building an underground wall, comprising removing earth material to be replaced by said wall, supporting the adjacent undisturbed earth by fluid pressure while said substitution is being made, from the bottom of the excavation upwardly, and simultaneously therewith injecting wall material and building said wall from the bottom upwardly.

32. A method of building an underground wall with the use of wall forms in which after the wall material is in place the wall forms are simultaneously and progressively placed with the building of that portion of the wall with which the particular form placed may contact.

33. A method of building an underground wall, comprising removing earth material from the path of the wall, filling the space so created by a supporting fluid, stiffening the adjacent undisturbed earth by the action of said fluid thereon, and replacing said fluid by wall material.

34. In a machine for excavating a trench, a series of buckets on an endless chain designed to remove earth material from the path of the trench, and one or more jets behind the buckets, designed to force streams of fluid between the buckets to contact the material to be elevated by the buckets.

35. In a machine for building an underground wall, a pair of rotary spiral cutters and conveyors held in parallel spaced relationship one to the other, means for rotating said rotary members in opposite directions, means of advancing the same in a direction transverse to their longitude, and a detachable shield secured to and positioned at the rear of said rotary members.

36. A machine for building an underground wall, comprising cutters and upward conveyors, a shield immediately back of the conveyors and

substantially parallel thereto, shield and conveyor assembly being mounted to swing together, means for delivering wall material into the trench at the desired level, and means of advancing the cutter, conveyor, shield and wall material-delivery assembly as a unit without substantially altering their relative positions.

37. A machine as claimed in claim 36, and side wings for said shield.

38. A machine as claimed in claim 36, side wings for said shield and resilient flaps on the edges of said wings.

39. A machine as claimed in claim 36, and in which the wall-material delivery means is a tube with desired openings.

40. A machine as claimed in claim 36, and in which the wall-material delivery means comprises a tube within a tube with desired openings in each of said tubes.

41. A machine as claimed in claim 36, and in which the wall-material delivery means comprises one or more tubes with openings, and means for forcing wall material therethru.

42. A machine as claimed in claim 36, and means of holding and unrolling a flexible cover for the sides of the wall.

43. A machine as claimed in claim 36, and means of inserting reinforcing rods into said wall material after the same is in place.

44. A machine as claimed in claim 36, and means of placing a stiff cover on the sides of said wall after the wall material is in place, so as to prevent the deforming of said wall in soft earth formations.

45. In a machine for building an underground wall, a pair of rotary pipe spiral cutters and conveyors held in parallel spaced relationship one to the other, means of rotating said rotary pipes in opposite directions, means of advancing the same in a direction transverse of their longitude, a plurality of holes in one of said rotary pipes, a rotary pipe head to said rotary pipe, and means of injecting fluid into said rotary pipe thru said pipe head.

46. A machine for building an underground wall comprising a spiral conveyor and a jet designed to operate on the full face of the earth material in the path of said wall, means of actuating the same simultaneously, and means of holding the same in proper relation with the material in the path of said wall.

47. A method of building an underground wall comprising simultaneously removing earth material from the path of the wall, replacing removed earth material with a heavy mud mixture and replacing the mud mixture with wall mixture.

48. In a machine for building an underground wall, a pair of rotary pipe spiral cutters and conveyors held in parallel spaced relationship one to the other, means of rotating said rotary pipes in opposite directions, means of advancing the same in a direction transverse of their longitude, and a segmentally detachable shield secured to and positioned at the rear of said rotary pipes.

49. In a machine as claimed in claim 48, and side wings for said shield.

50. In a machine as claimed in claim 48, side

wings for said shield, and resilient flaps on the edges of said wings.

51. In a machine as claimed in claim 48, and a wall material delivery pipe at the rear of said shield.

52. In a machine as claimed in claim 48, side wings on said shield, and a wall material delivery pipe at the rear of said shield.

53. In a machine as claimed in claim 48, a shield secured to and positioned at the rear of said rotary pipes, side wings on said shield, and a housing in each of said wings each adapted to hold a roll of ditch lining material therein, and a slot in each of said housings thru which said lining material may be unrolled out of the respective housing wherein it may be placed.

54. In a side wing of a shield of the character described herein, a housing adapted to hold a roll of ditch lining material, a slot in said housing thru which said lining material may be unrolled out of said housing, and a flap covering for said slot.

55. In a wall material delivery pipe adapted to use to the rear of a shield as herein described, a longitudinally extending slot in said material delivery pipe, a worm in said pipe and means of rotating the same.

56. In a wall material delivery pipe as claimed in claim 55, and with both ends of said slot terminating in an enlarged opening.

57. A reinforcing bar for an underground wall, and an enlarged end portion thereof adapted to be inserted into a slotted pipe having a worm therein and to be conveyed into said wall by said worm.

58. A plate lining for use in making an underground wall, a connecting bar attached thereto, and an enlarged portion on the end of said connecting bar.

59. In an underground wall building machine wherein are suspended rotary pipes employed to cut and to raise earth material, means of advancing the bottom of said rotary pipes independently of the advancement of the top thereof.

60. In an underground wall building machine, a wall material delivery pipe therein with its bottom end closed, a sled portion on the bottom thereof, and an inner pipe in said first mentioned pipe with opening near the lower end of said material delivery pipe first mentioned.

61. A machine for building an underground wall comprising in combination, an upward conveyor and jets designed to operate up and down the face of the material in the path of the wall to loosen said material, means for operating the same, and means of keeping said jets in proper position with respect to the material in the path of said wall to remove all or a portion of said material.

62. A method of building an underground wall, continuously and in one operation, comprising removing earth material from the path of said wall, meanwhile supporting the adjacent earth by fluid pressure, and simultaneously laying said wall and confining it to the shape and dimensions desired.

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