No. 764,798. PATENTED JULY 12, 1904.

E. DIEBITSCH.

APPARATUS FOR BUILDING TUNNELS OR THE LIKE.

APPLICATION FILED OCT. 17, 1903.

NO MODEL. 5 SHEETS—SHEET 1.

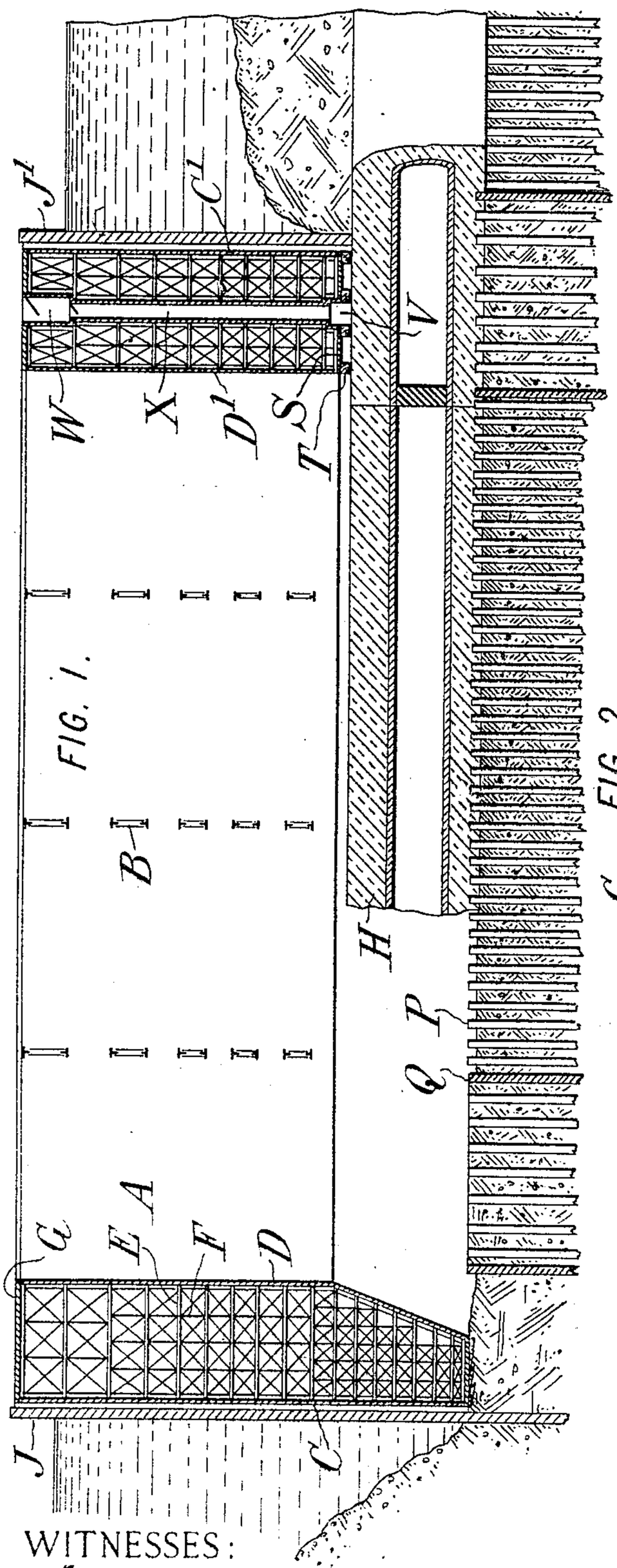

FIG. 1.

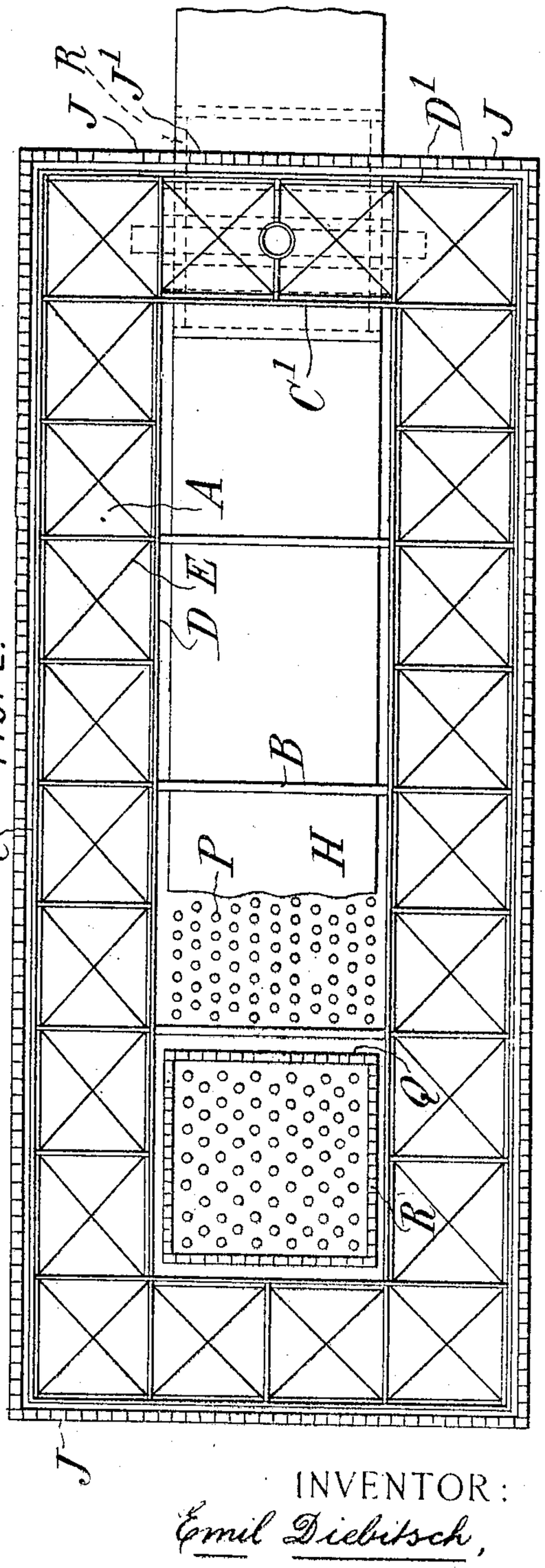

FIG. 2.

WITNESSES:
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René Bruine

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NO MODEL. 5 SHEETS—SHEET 3.

FIG. 3.

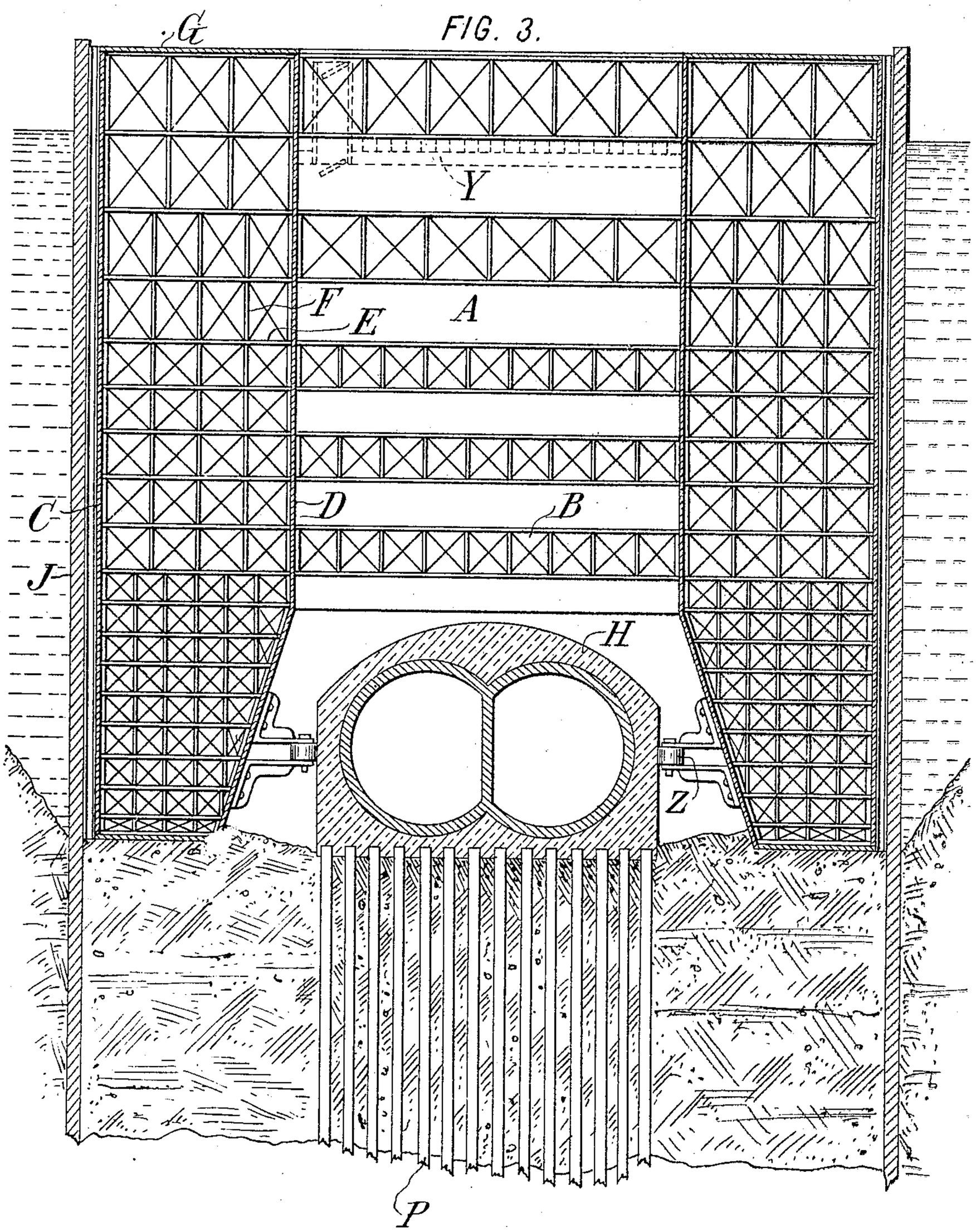

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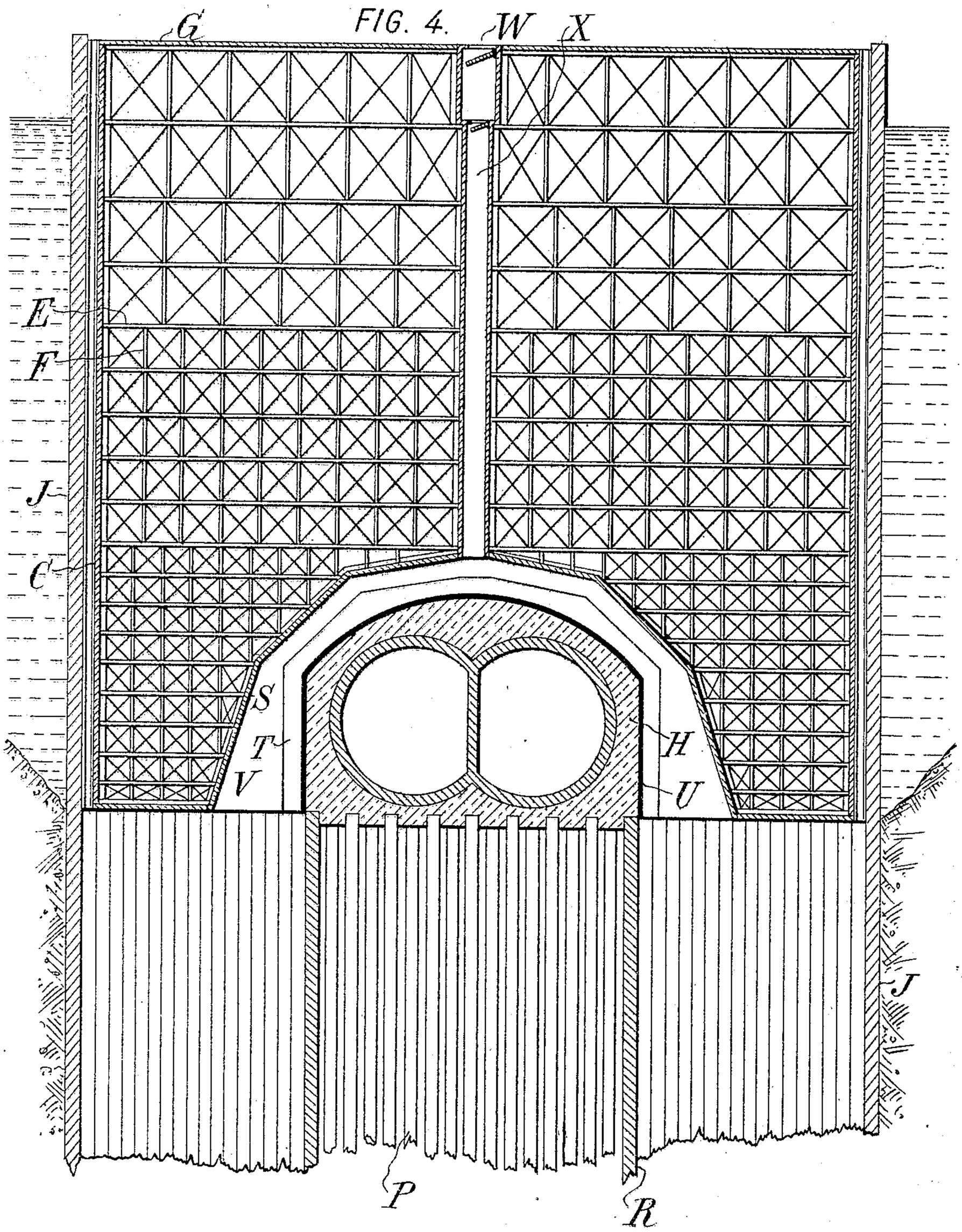
FIG. 4.



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NO MODEL. 5 SHEETS—SHEET 4.

FIG. 5.

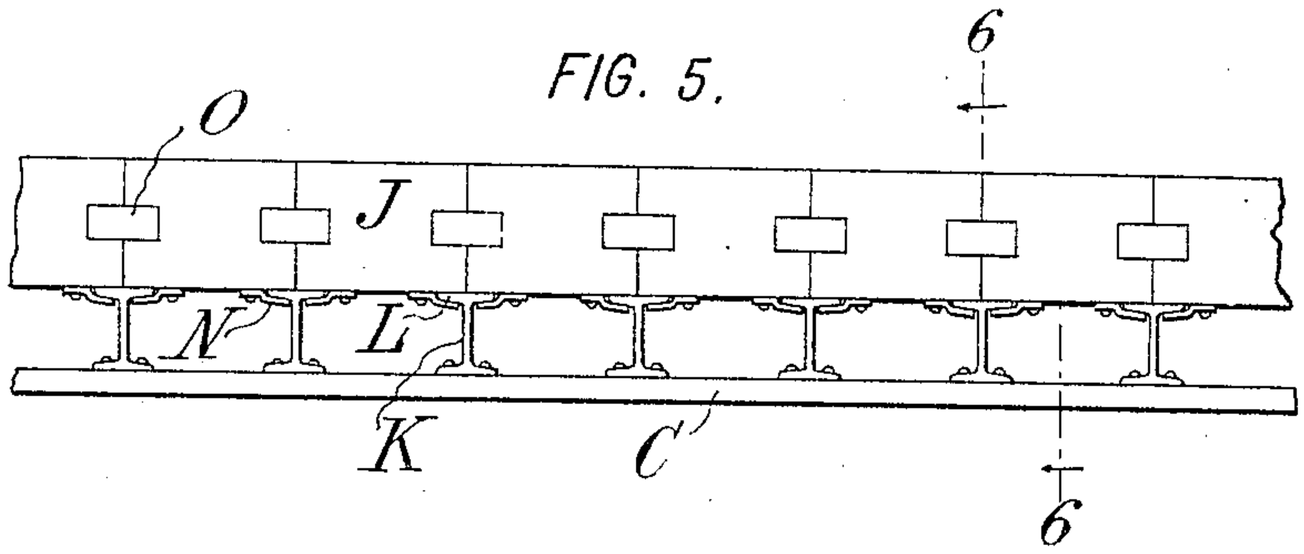


FIG. 6.

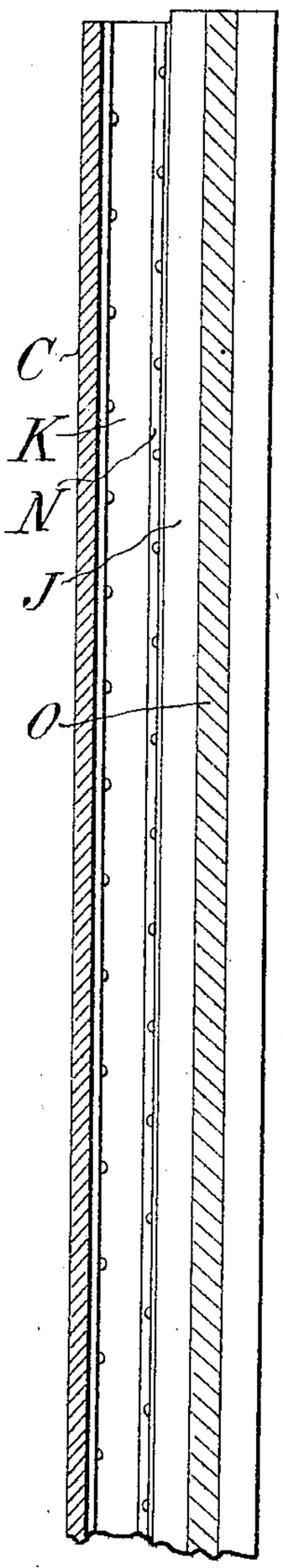
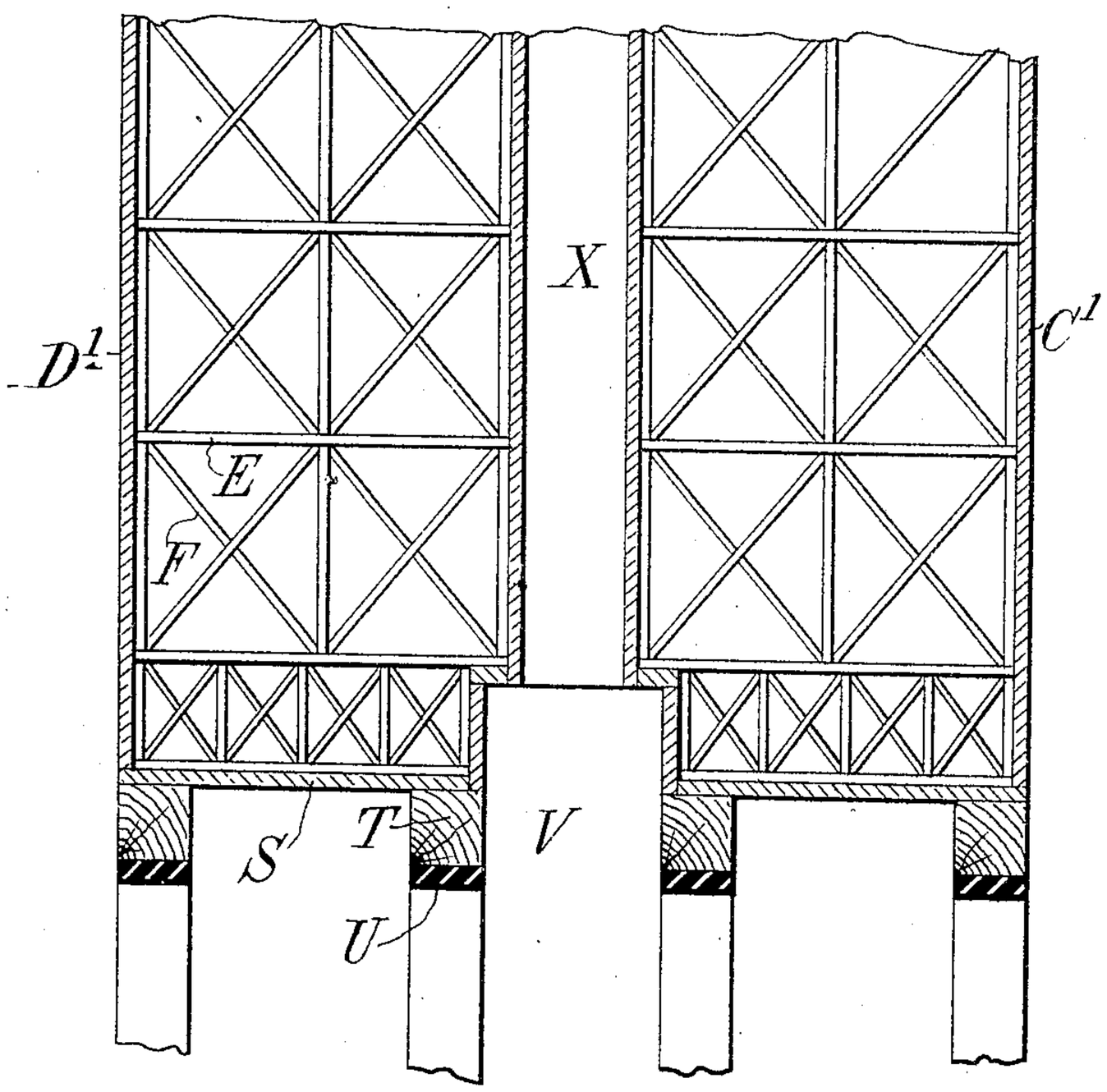


FIG. 7.



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APPLICATION FILED OCT. 17, 1903.

NO MODEL. 5 SHEETS—SHEET 5.

FIG. 8.

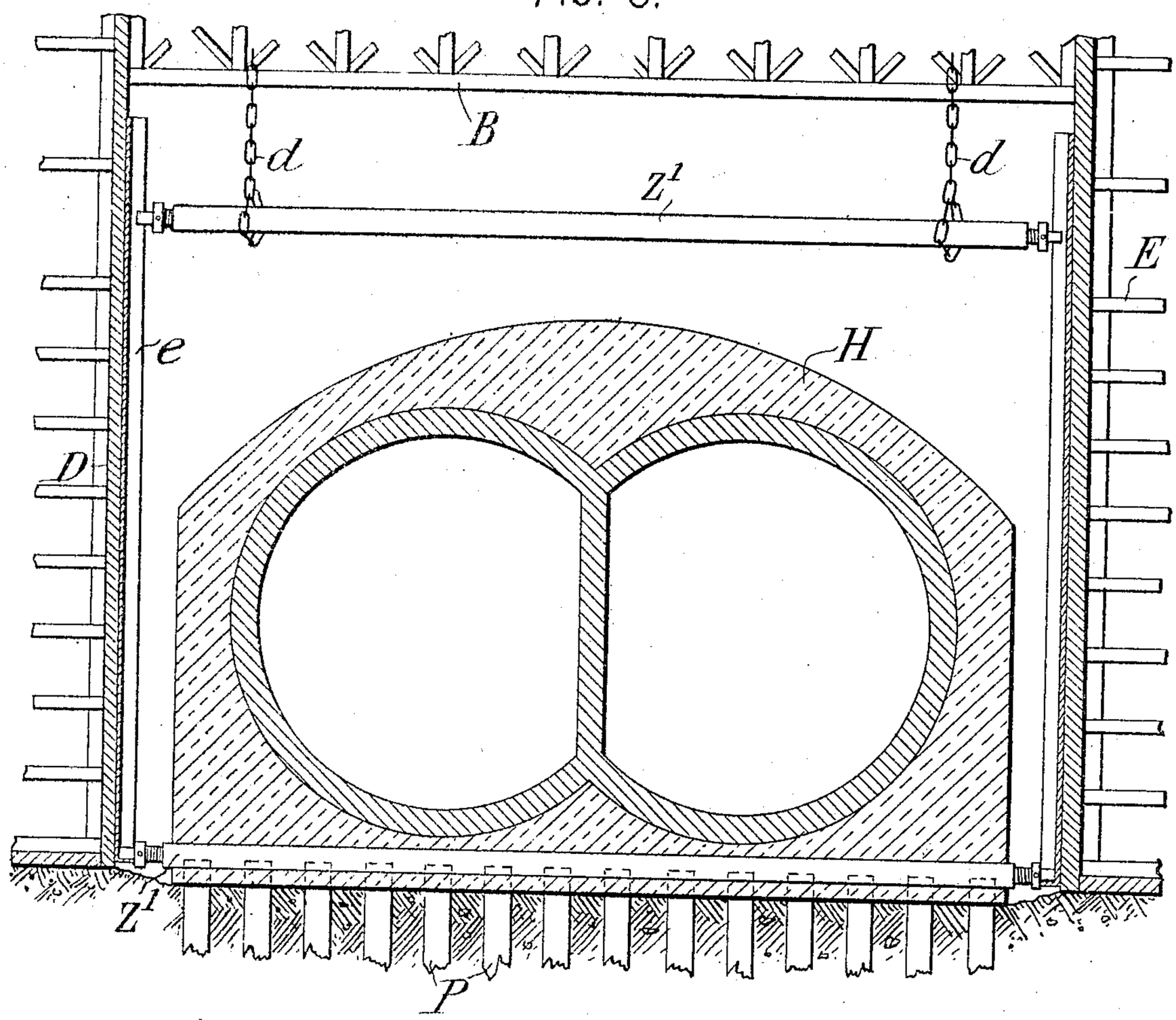
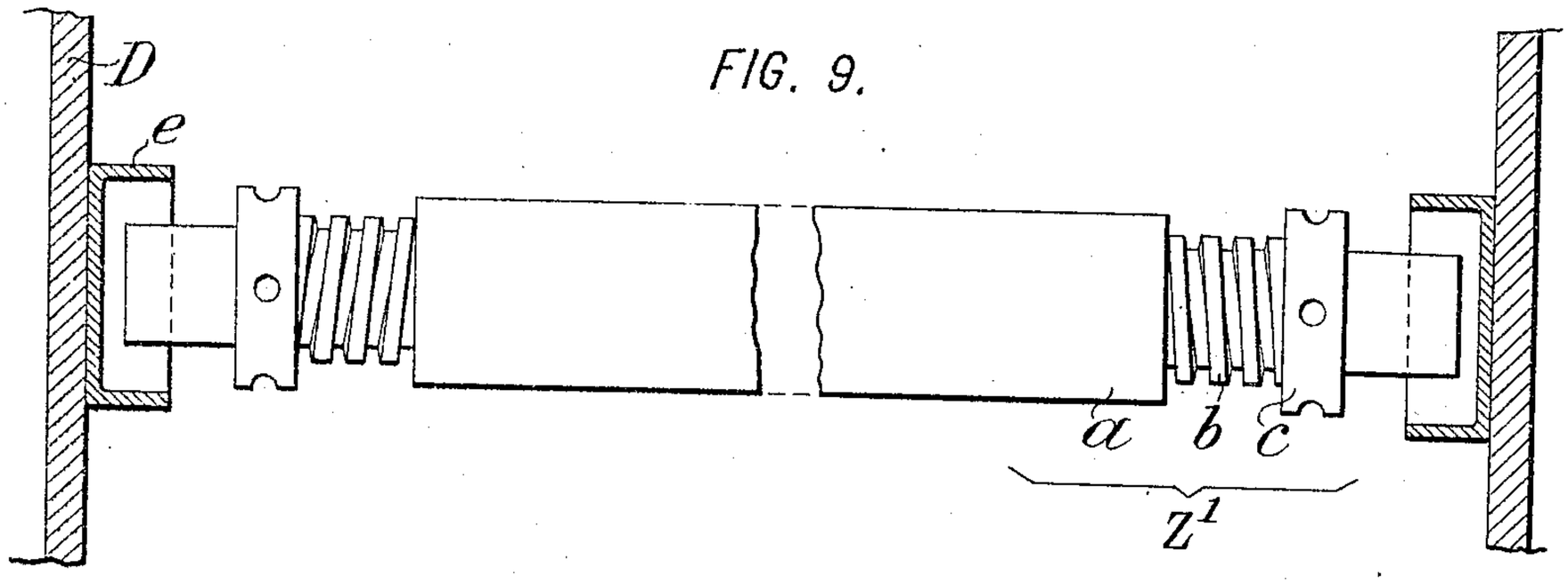


FIG. 9.



WITNESSES:
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No. 764,798. Patented July 12, 1904.

UNITED STATES PATENT OFFICE.

EMIL DIEBITSCH, OF NEW YORK, N. Y.

APPARATUS FOR BUILDING TUNNELS OR THE LIKE.

SPECIFICATION forming part of Letters Patent No. 764,798, dated July 12, 1904.

Application filed October 17, 1903. Serial No. 177,427. (No model.)

To all whom it may concern:

Be it known that I, EMIL DIEBITSCH, a citizen of the United States, residing in the borough of Manhattan, city, county, and State of New York, have invented certain new and useful Improvements in Apparatus for Building Tunnels or the Like, of which the following is a specification.

This invention relates to the construction of tunnels or other analogous submarine or subterranean structures, and especially to an apparatus designed for carrying out the process described in my application for patent Serial No. 175,904, filed October 5, 1903. In said application there is described a process for the building of a submarine tunnel with an artificial support of piles, though obviously the process there described and the present apparatus are applicable to the building of various other structures.

The present invention provides a caisson of special design and having various novel features specified hereinafter.

The accompanying drawings illustrate an embodiment of the invention.

Figures 1 and 2 are respectively a longitudinal section and a plan of a caisson and a tunnel, of which one section is completed and the work is progressing on the second section. Fig. 3 is a transverse section through said caisson, the scale being doubled. Fig. 4 is a transverse section through the rear end of the caisson, showing the pneumatic chamber, this scale being also double that of Fig. 1. The mud is omitted within the figure for the sake of clearness. Fig. 5 is an enlarged plan showing the edge of a caisson and the sheet-piling surrounding the same. Fig. 6 is a section on the line 6 6 of Fig. 5. Fig. 7 is a transverse section through the lower edge of the rear end of the caisson. Figs. 8 and 9 are respectively a transverse section and a plan illustrating another embodiment of the invention.

Referring to the specific embodiment illustrated in the drawings, A is a floating dam or caisson consisting, essentially, of a double-walled box preferably open at top and bottom and inclosing a working chamber. The caisson is of approximately the shape of the structure or section of structure to be built. In building a tunnel it may be of the elongated shape shown. In such case the side walls may be made of considerable length without danger by introducing internal transverse braces, such as the latticed girders or trusses B shown. The sheet-metal plates C and D, constituting, respectively, the outer and inner walls of the caisson, have suitable bracing between them. For large structures, such as that shown, the bracing may be provided in the form of horizontal latticed girders or trusses E, which take the principal strains, and vertical trusses or girders F between the horizontal trusses. A floor G (omitted in Fig. 2 for the sake of clearness) preferably covers the space between the inner and outer walls. Upon this floor or upon other suitable supports at the top of the walls may be mounted derricks, pile-drivers, &c., as well as a power plant consisting of boilers, engines, dynamos, pumps, &c., the details of which will of course vary with the character of the work. The dimensions of the caisson are such that when its lower edge is at the proper depth its top will be a convenient distance above high water and will serve as a pier for the discharge of all materials and also as a working platform. The walls of the caisson at the bottom may be tapered off on the inside, as shown in Fig. 3, to provide the needed working space; but the total thickness of the double walls is sufficient to provide the necessary resistance to the inward pressure, which, as is understood, increases with the depth below water-level. The braces B are omitted in the lower part of the caisson to leave a clear space for the tunnel H. The walls below the lowest brace B in such case may be designed as cantalivers, their lower ends being unsupported against the inward thrust. As shown in Figs. 1 and 2, the braces B are at comparatively widely separated intervals in plan, and therefore present almost no interference with the work.

An important feature of improvement lies in the means for cutting off water from flowing around the lower edge of the caisson into the working chamber. I propose to use for this purpose one or more lines of sheet-piling

extending continuously around the site of the work and below the edge of the caisson. The row of piles J, for example, may be on the outside wall of the caisson or on the inside wall, or on both walls. The depth to which this piling will have to be driven below the lower edge of the caisson in order to keep the working chamber dry may sometimes be very great, and it should be very securely guided, so that its lower ends shall be held against lateral movement and the entire line of piling shall be practically water-tight. A suitable means for insuring such a result is illustrated in detail in Figs. 5 and 6. On the wall C of the caisson are provided vertical guides, such as the I-beams K, having at their outer ends flanges L. The piles J are held in engagement with the flanges L, as by means of strips N, fastened to the faces of the piles. A tight joint between the edges of the piles may be effected by the well-known tongue-and-groove construction or by means of separate tongues O engaging grooves in the adjacent edges of each two piles.

It may be explained at this point that the caisson is built in a sheltered locality and when completed is ballasted to float at a stable depth and is towed into place above the site of the work and secured by moorings or otherwise in such position and then sunk by the addition of ballast either in the form of water or otherwise. Preferably the site has been previously dredged to about the subgrade of the tunnel or other work, so that the caisson may be sunk at once to its working position, or the caisson may rest first upon the river-bottom and may then be sunk by dredging from within. The sheet-piling cut-off is then driven below the lower edge of the caisson, and the latter is pumped substantially dry. The foundation or artificial support, comprising the piles P, is then constructed and the tunnel H built thereon as conveniently as it could be done in an open cut on land. Preferably, also, before the tunnel-section is completed there is driven at the forward end of the working chamber a sheet-pile cut-off comprising, for example, a pair of transverse rows Q, connected by a pair of longitudinal rows R, of piling. The use of these will be described hereinafter. The bearing-piles P, the sheet-pile cut-off Q R, and the tunnel-section H being completed throughout the length of the working chamber and the finished section being stopped at the end by a bulkhead, the caisson will be moved to the position for building the next section. Generally both ends of the completed section of the tunnel will be closed with bulkheads, the working chamber will be filled with water, and the sheet-piling will be drawn out or cut off at the level of the bottom of the caisson, after which the latter will be raised by removing a part of the ballast and then drawn into its new position. It may also be necessary to fill the completed section of the tunnel with water, depending on whether or not its weight is sufficient to keep it from floating when empty and whether or not its design provides for anchors to hold the tunnel down.

The new position of the caisson is such that when sunk it will overlap the advance end of the completed section sufficiently to enable the latter to project into the working chamber. Special means may be provided, therefore, for making a tight fit at this point. The sheet-pile cut-off Q R prevents the water flowing into the chamber by way of the under side of the tunnel. The longitudinal rows R are longer than the thickness of the end of the caisson, and therefore extend beyond the inner and outer end walls C′ D′ and permit the sheet-piling J to be driven close up against them, so as to insure a tight continuous line of sheeting all around. To prevent water entering the chamber by following the sides or top of the finished tunnel-section, the end wall C′ D′ of the caisson is cut out at its lower edge to fit closely over the tunnel-section. This construction is shown in Figs. 4 and 7. The bottom plate S of the caisson-wall is hollowed out at the central portion to provide a space considerably larger than the outside of the tunnel, as shown in Fig. 4, and is lined with ribs T, shaped to fit the outside of the tunnel closely and preferably provided with gaskets U, of rubber or similar material, which shall form a tight joint. Also at any suitable point between the inner and outer walls D′ and C′ there is provided a chamber V, preferably larger than the ribs T, and which chamber is connected with an air-lock W, preferably through an interposed shaft X, carrying the air-lock to the top of the wall. The chamber V thus constitutes a subsidiary caisson which can be cleared of water independently of the working chamber of the main caisson by introducing sufficient air-pressure into the chamber V. This permits a workman to go down and examine the joint between the finished section of the tunnel and the rear wall of the caisson and to tighten the joint all around the outside of the tunnel by calking or otherwise, if necessary. The main caisson can then be pumped dry and the work proceeded with as before. Preferably the sheet-piling around the outside of the main caisson is continued above the completed tunnel-section, as at J′, the lower end of each of these piles being shaped to fit approximately the outline of the tunnel-section and a bank of clay and gravel or similar material being placed around the toes of the piles.

In some cases I prefer to make the main caisson also pneumatic by providing a roof and one or more air-locks, as indicated in dotted lines at Y, Fig. 3, and this roof may be either permanent or removable. The latter

construction would be advantageous where it is desirable to build the artificial support for a tunnel without first pumping the caisson dry and to subsequently expel the water, so as to permit the building of the tunnel-section.

It may be possible in some cases to dispense with the surrounding sheet-piling and to advance the caisson directly along without lifting it above the subgrade of the tunnel. In this case of course it will not be necessary to complete an entire section of the tunnel throughout the length of the caisson before moving the latter. In some cases also I may utilize the finished section of the tunnel as a guide, the caisson being provided with bearings, such as the rollers Z, engaging the sides of the finished section of the tunnel, and thus guiding the caisson in the direction of the tunnel.

The invention provides a most safe and reliable means of building a tunnel structure, which has up to the present been thought to involve great dangers and uncertainties. The apparatus is simple and strong. The work can be done rapidly and well, because the workmen are in the open air with no extra pressure. There is abundant room permitting the utilization of a great many workmen at once and of numerous and powerful machines, and these machines are always at hand and mounted upon stable supports. There are no complicating circumstances attending the building of the tunnel.

Instead of building the entire caisson in a dock or other locality remote from the work, which would introduce difficulties in towing it to the tunnel site, especially where it is of great depth, a lower portion may be built and towed to or near to the site, after which the upper portion may be built thereon.

The chamber V may be supplied continuously with air under pressure sufficient to exclude water, and thus, in effect, forms a pneumatic packing-ring and keeps tight a most difficult portion of the work. In fact, it is not essential that the chamber V be of the size or arrangement shown or that the air-lock be provided, as any space between the tunnel and the caisson (and within the edges of the caisson-wall) with means for permitting the introduction of air under pressure thereinto would serve the same purpose.

A construction is illustrated in Figs. 8 and 9 which, while applicable at all depths, will be found especially useful at very great depths, where the inward pressure at the lower edge of the sides of the caisson is extreme. In this case I prefer to make the inner wall D of the caisson vertical throughout its height and to provide a removable brace Z′ at or adjacent to the lower edge. This brace may, however, be used in connection with the flaring sides shown in Fig. 3. This brace, for example, may be of the type shown, comprising a strong tubular central portion *a*, into the ends of which extend screw-threaded rods *b*, arranged to be rotated by any suitable means, as the ring *c*, provided with capstan-holes. These braces are located before the water is pumped out from the caisson, the screw-threaded end portions being turned to jam the ends against the walls of the caisson. Then when the water is pumped out these braces resist the inward pressure most effectively. Any number of them may be arranged at suitable intervals throughout the length of the caisson. The work is proceeded with, the concrete being built around these braces, and after the work is completed and the caisson refilled with water the braces may be shortened by a diver, so that the caisson is clear of their ends. The caisson is then lifted, leaving the braces in place. I prefer to replace these braces as they are left in the work by new braces Z′, which at any time before the caisson is refilled with water are suspended above the finished tunnel, as by means of chains *d*, and which as the caisson is raised are lowered and jammed into place, as already described. Preferably in a caisson in which the inner wall D is vertical all the way to the bottom it is provided with guides, such as the channels *e*, which engage the ends of the braces Z′ and accurately determine their lateral position. Preferably, also, these channels *e* are closed at the bottom, so that the diver or other person who sets them in place has only to screw out the ends, the vertical and horizontal position being automatically determined.

Though I have described with great particularity of detail a specific embodiment of the invention, yet it is to be understood that the invention is not limited to the specific embodiment disclosed. Various modifications thereof in detail and in the arrangement and combination of the parts may be made by those skilled in the art without departure from the invention.

What I claim is—

1. In combination, a movable caisson for submarine work, and means for extending a substantially water-tight cut-off below the bottom of said caisson and cutting off the passage of water around such bottom.

2. In combination, a movable caisson and sheet-piling carried thereby and adapted to be driven close together below the bottom of the caisson so as to form a substantially water-tight cut-off surrounding the working space within and cutting off the passage of water around the bottom of the caisson.

3. In combination, a caisson having vertical guides attached to a wall thereof, and sheet-piles having means on their faces for engaging said guides, leaving the edges free for forming a substantially water-tight connection between adjacent piles.

4. In combination, a caisson having flanged

vertical guides, and sheet-piles engaging the flanges of said guides.

5. An elongated movable caisson for building submarine tunnels or the like, having transverse internal braces.

6. An elongated movable caisson for building submarine tunnels or the like, having transverse internal braces and having at the bottom a working space without internal bracing.

7. Means for maintaining a tight joint under water, comprising the two adjacent structures with an air-space between the edges and a connection to said air-space permitting the maintenance of a pressure of air therein.

8. In combination, an open caisson adapted to overlie a structure, and means permitting the maintenance of a pressure of air between said structure and the adjacent portion of the caisson to form in effect a pneumatic packing.

9. A caisson having at one end a subsidiary pneumatic chamber permitting access to the bottom of said end regardless of the conditions in the working chamber of the main caisson.

10. A caisson for building tunnels or the like and having the lower edge of one end cut out and provided with ribs fitting over a completed section of the work, the space between said ribs being connected through an air-lock with the atmosphere to form a subsidiary pneumatic caisson giving access to said space.

11. A caisson for building tunnels or the like, having bearings to engage the sides of a finished section of tunnel so as to guide the caisson in the direction of the tunnel.

12. A double-walled movable caisson for submarine work, having a wide bottom edge and having its inner walls flaring downwardly to provide a convenient working space.

13. A caisson having in its lower portion a removable transverse brace of adjustable length to permit its being jammed between the sides of the caisson or released from said sides.

14. A caisson having channels *e* and a vertically-movable transverse brace Z′ of adjustable length to permit its being jammed between the sides of the caisson or released from said sides.

In witness whereof I have hereunto signed my name in the presence of two subscribing witnesses.

EMIL DIEBITSCH.

Witnesses:
P. A. Gage,
C. B. Paine.