No. 793,696. PATENTED JULY 4, 1905.

G. T. VOORHEES.

REFRIGERATING APPARATUS.

APPLICATION FILED JAN. 28, 1901.

2 SHEETS—SHEET 1.

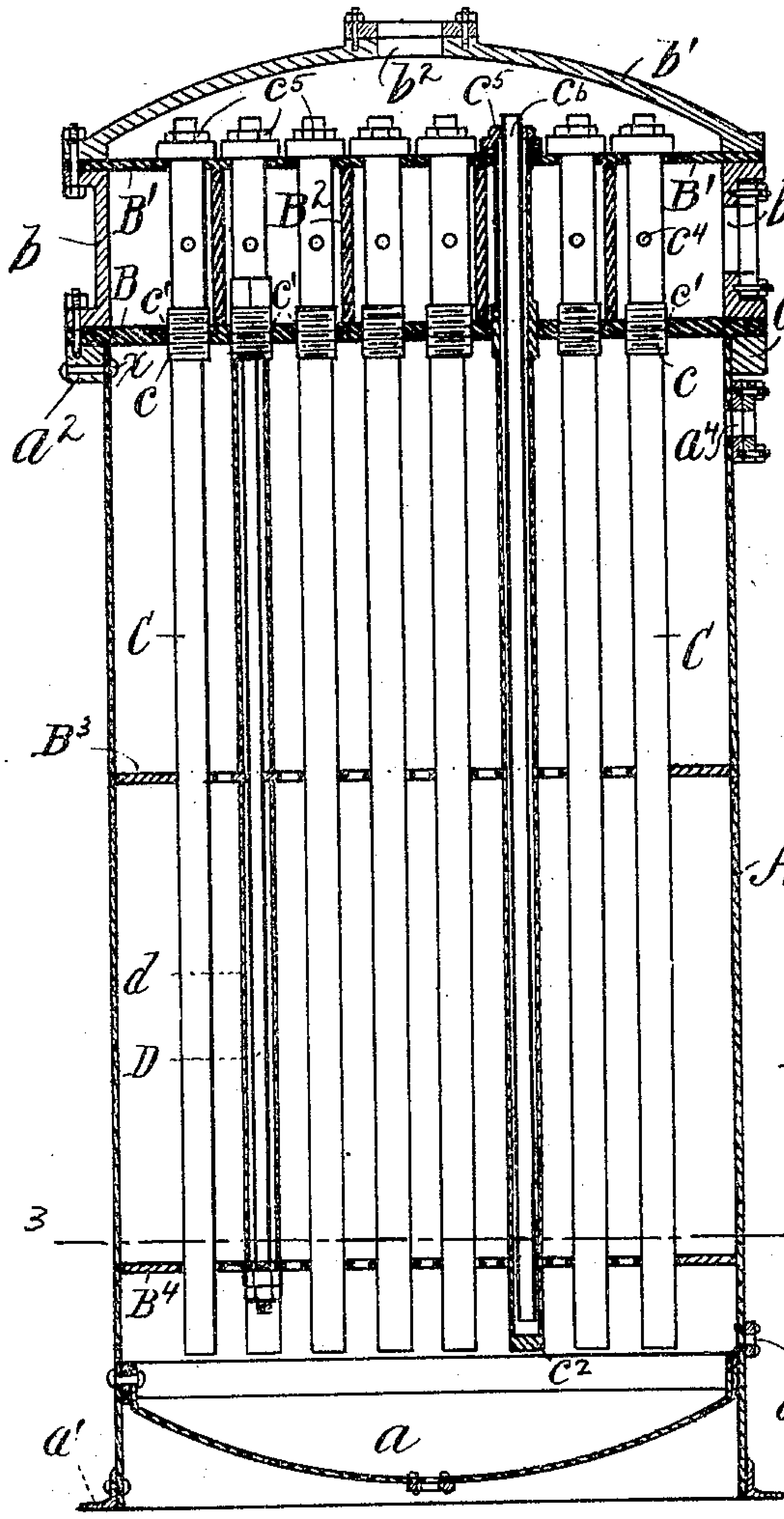

Fig. 1

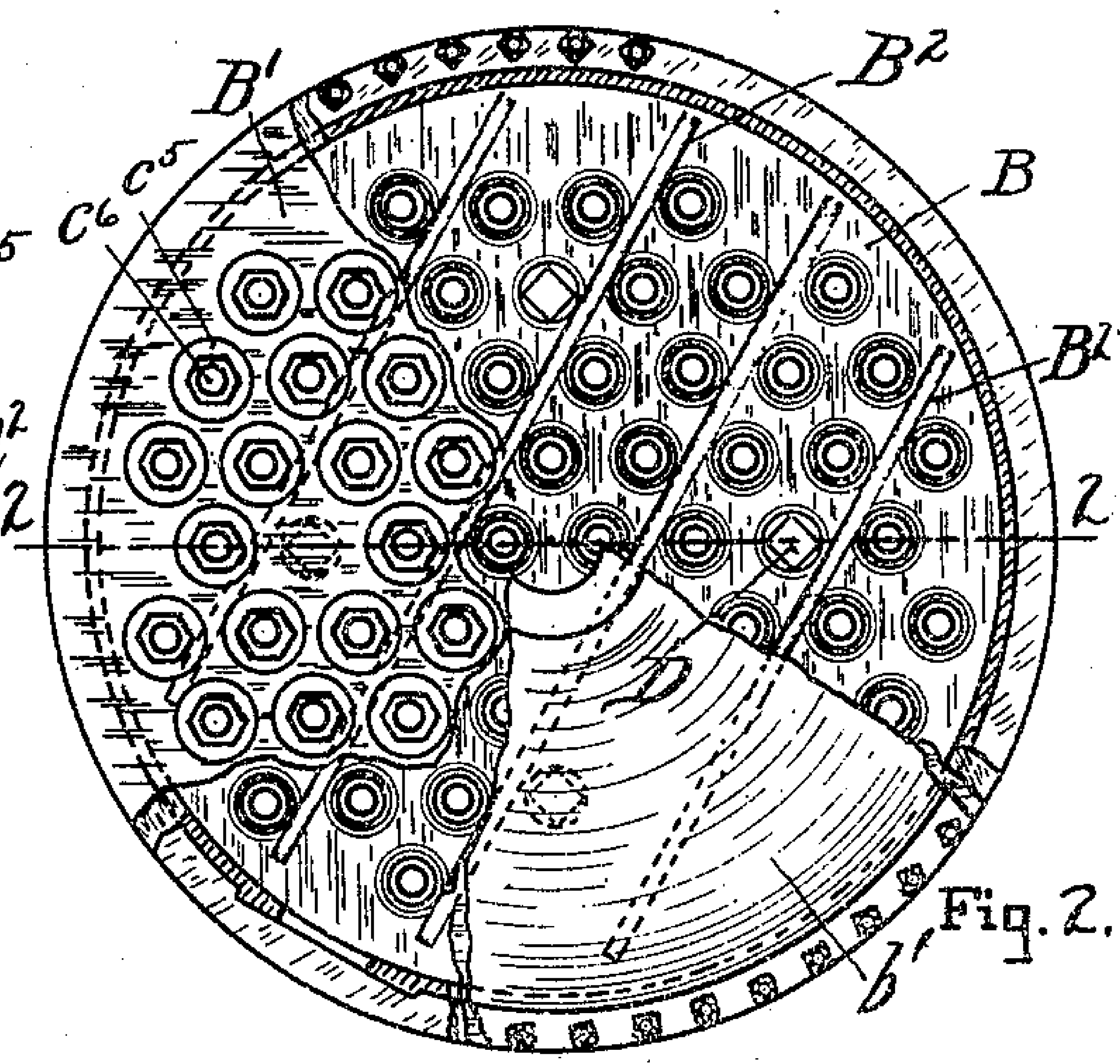

Fig. 2.

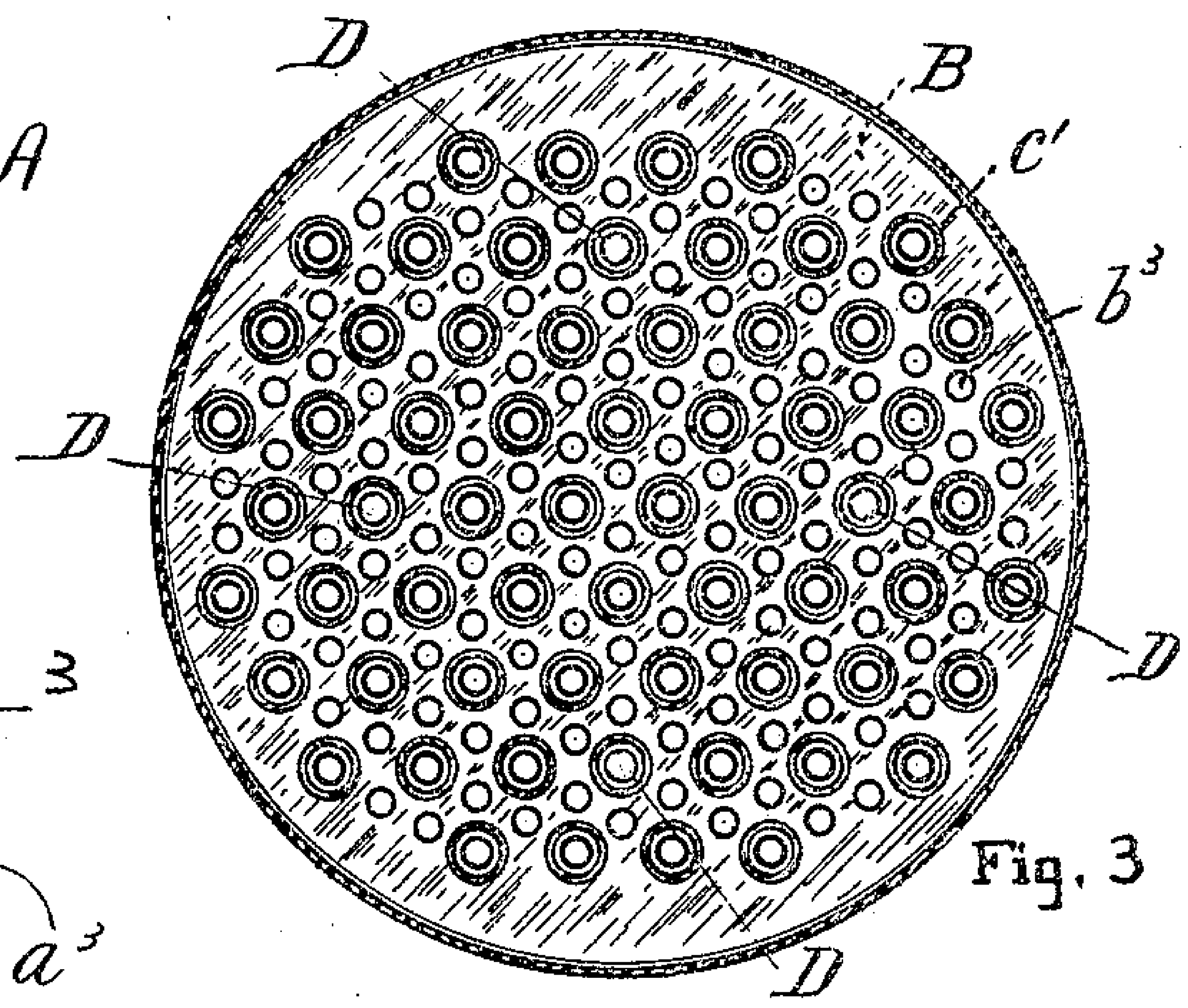

Fig. 3

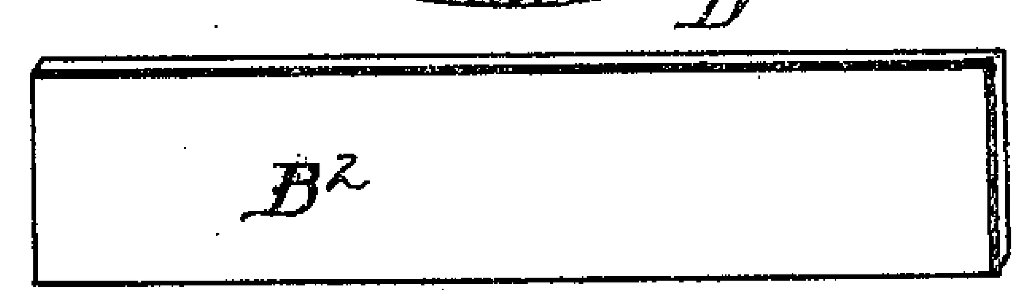

Fig. 4.

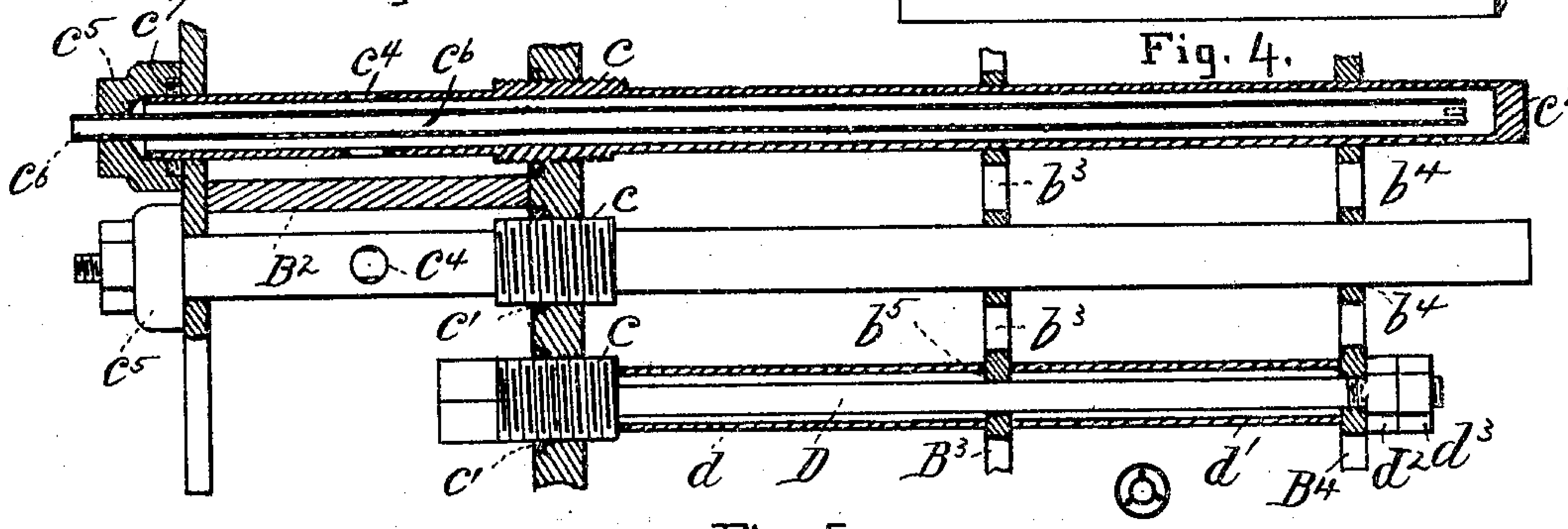

Fig. 5.

WITNESSES

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2 SHEETS—SHEET 2.

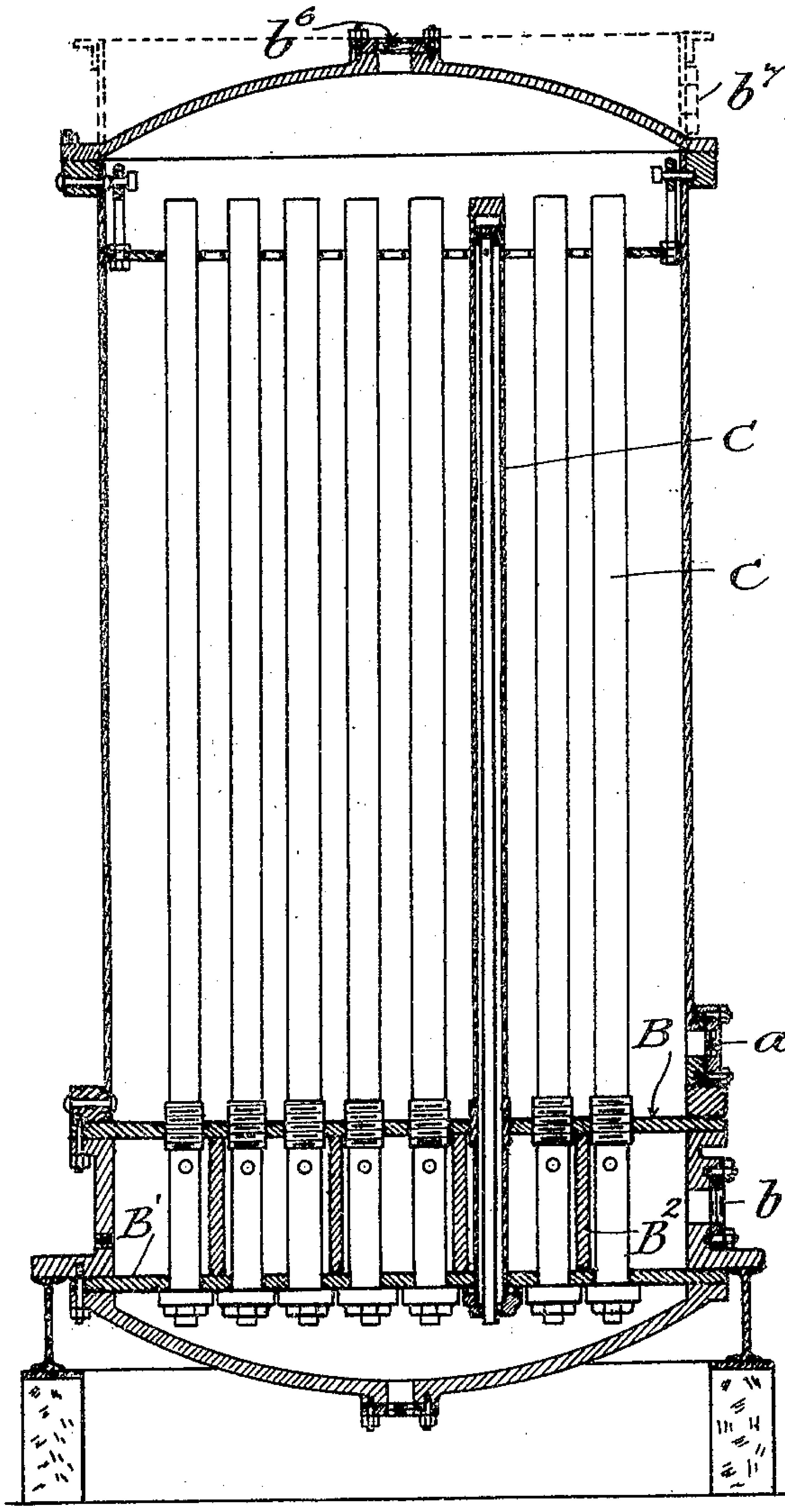

Fig. 6.

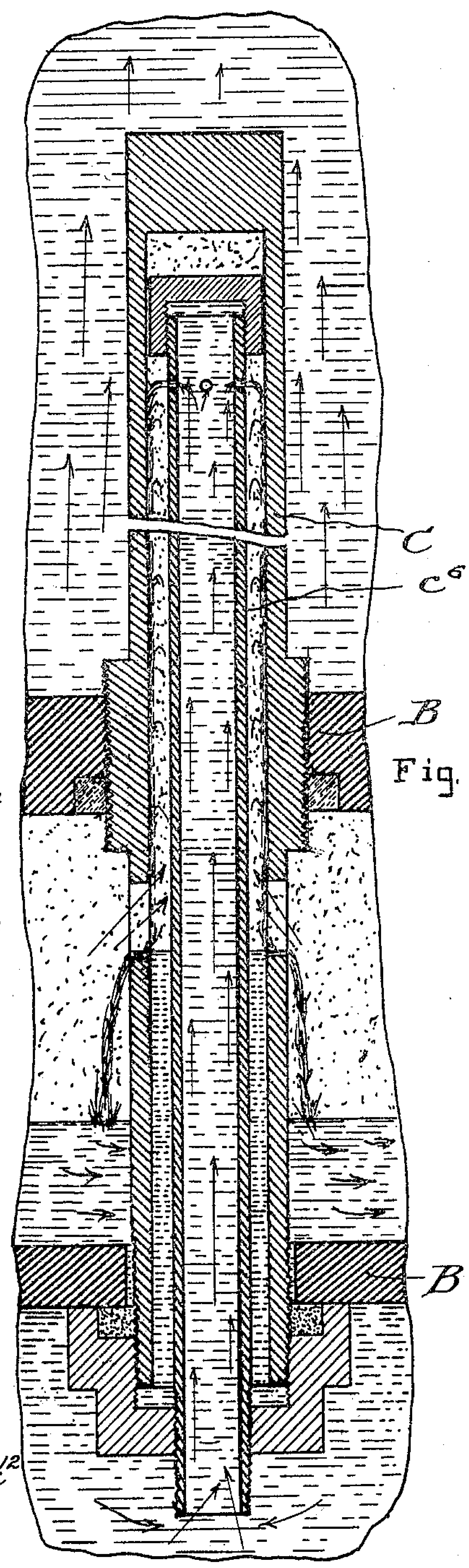

Fig. 7.

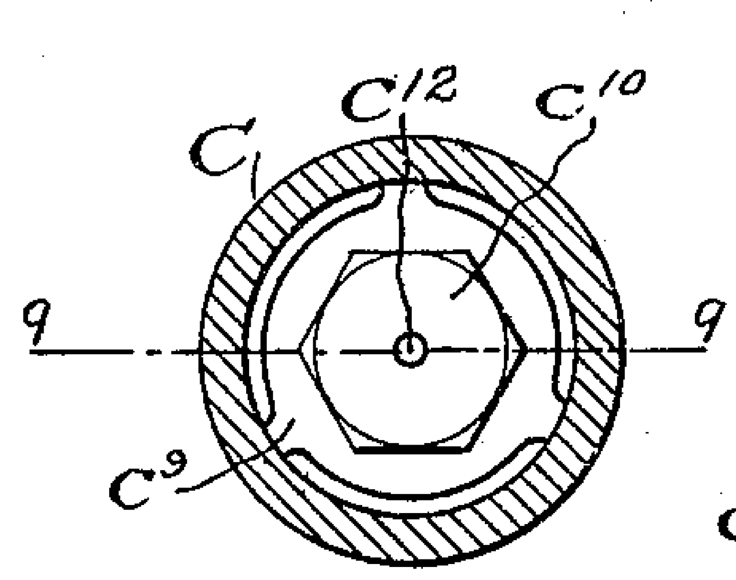

Fig. 9.

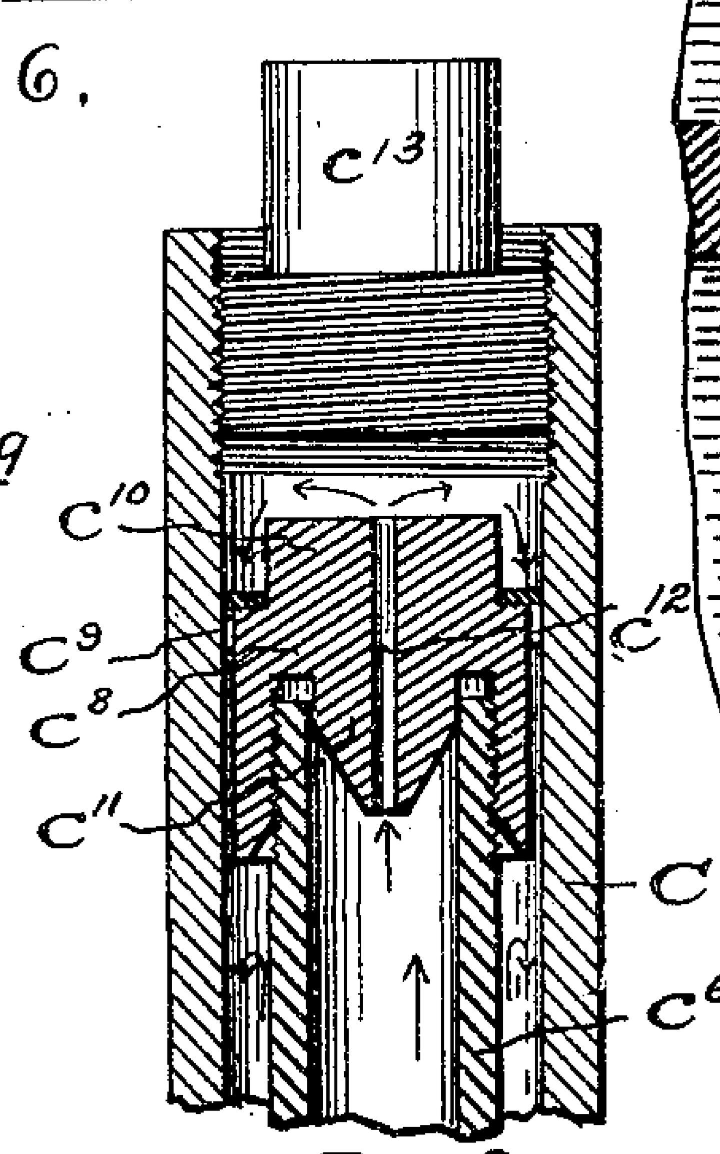

Fig. 8.

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UNITED STATES PATENT OFFICE.

GARDNER T. VOORHEES, OF BOSTON, MASSACHUSETTS.

REFRIGERATING APPARATUS.

SPECIFICATION forming part of Letters Patent No. 793,696, dated July 4, 1905.

Application filed January 28, 1901. Serial No. 44,985.

To all whom it may concern:

Be it known that I, GARDNER T. VOORHEES, a citizen of the United States, residing at Boston, in the county of Suffolk and State of Massachusetts, have invented certain new and useful Improvements in Refrigerating Apparatus, of which the following is a specification, reference being had therein to the accompanying drawings.

Figure 1 is a vertical section of a cooler on line 2 2 of Fig. 2. Fig. 2 is a plan of Fig. 1, showing portions of the main-tube plate into which the main tubes are secured and also the trusses which lie between the main-tube plate and the secondary-tube plate, together with other details, portions of the dome and portions of the secondary-tube plate being broken away. Fig. 3 is a transverse section on lines 3 3 of Fig. 1. Fig. 4 is a perspective view of a truss or rib. Fig. 5 is an enlarged detail showing the method of securing the tubes to the main and secondary tube plates and one of the numerous trusses between said plates. It also shows one of the stays and the plates which support the main tubes when not in a vertical position. Fig. 6 is a longitudinal section of substantially the same form of device shown in Fig. 1, but adapted to be used as an absorber. Fig. 7 is an enlarged detail of one of the tubes and plates of said absorber. Fig. 8 is a section of the same on line 9 9 of Fig. 9. Fig. 9 shows a section of the preferred form of perforated plug to be used at end of inner tube of absorber.

The present form of cooler used with refrigerating apparatus, although vastly superior to any known form of expansion-coil, is open to many objections. It generally consists of an outer vertical cylindrical shell having domed heads bolted, respectively, to the top and bottom flanges thereof. Each of these heads has a row of holes through which pass the coil tails or ends of several long closely-wound spiral brine cooling-coils of pipe, lock-nuts or stuffing-boxes, together with rubber gaskets, being used to make tight joints between coil-tails and the domed heads. These coil-tails outside of the cooler are gathered together in headers, one at the top and one at the bottom of the cooler, and are provided with more lock-nuts or stuffing-boxes. The cooler is usually supported some little distance above its foundations either on cast-iron legs or structural-iron frames, so that the lower header is accessible. Liquid ammonia is fed into the cooler near the bottom thereof and surrounds the comparatively warm brine-coils inside the cylindrical shell. This liquid ammonia is thus vaporized and passes off as vapor through an outlet at the top of the cooler. The following are the vital points wherein this type of cooler is at fault: The great length and comparatively small cross-sectional area of each of these spiral coils offers an excessive frictional resistance to the passage of the brine. In order to force the requisite amount of brine therethrough, there must be a difference of from twenty-five to seventy-five pounds pressure per square inch between the pressures at the inlet and outlet brine-headers. This is a serious objection. It means that extra work must be done by the brine-pumps, which is a source of unnecessary expense. These long spiral coils are heavy and difficult to handle, are difficult to repair, and difficult to replace quickly. If from any cause one of these spiral coils should leak, the operation of the whole cooler must be stopped until the leak is discovered and repaired. The insulating of the spiral-coil coolers is expensive, as much difficulty is experienced in getting at and working around the coil-tails and headers. Having now pointed out some of the objections which I have found in these coolers, the following description of my cooler will clearly show how I overcome them.

In the drawings illustrating the principle of my invention and the best mode now known to me of applying that principle, A is an upright cylindrical shell of a cooler having a main domed head a riveted thereon near the bottom thereof. The casing projects below the main domed head a and, with an angle-iron a', which is riveted to the shell, forms the base of the cooler. This construction thus does away with the usual cast-iron legs. To the top of the shell is riveted a wrought-iron flange a^2, and to this flange is bolted a wrought-iron main-tube plate B and a cast-iron ring b. Secured to top of this cast-iron ring b is bolted a wrought-iron secondary-tube plate B′ and a cast-iron secondary domed head b', having therein a flanged port b^2. The main-tube plate B is preferably of wrought-iron and is tapped for a great number of main tubes C. Each of these tubes is provided with a threaded portion c, which screws into its respective hole in the main-tube plate B.

To insure a permanently gas-tight joint between the main-tube plate and each of its tubes, I preferably employ a solder-joint c'. It is made by countersinking each tube-hole in the main-tube plate B and then while the tube is heated and in position in the plate by filling the depression with melted solder. Each main tube C is closed at its end adjacent to the main head a, and its upper portion extends through the middle chamber formed by the cast-iron ring b and the main and secondary tube plates B B′ and also up through an opening therefor in the secondary-tube plate B′. Part way between said plates B B′ each main tube C has two holes c^4 in its walls. That portion of each main tube C that projects through the secondary-tube plate and is adjacent to the secondary domed head b' (see Fig. 5) is threaded and receives thereon a cast-iron cap c^5, that carries a secondary tube c^6. The latter has an exterior diameter less than the interior diameter of the main tube, and a portion of said secondary tube is within the main tube C and extends nearly to the closed end of the latter. Each cap c^5 has a gasket c^7 in contact with the secondary-tube plate B′ and the main tube C. A tight joint is thus formed between said plate B′ and said tube C. The main and secondary tube plates B B′ are thus securely bolted together by the threaded main tubes C and the caps c^5. To brace these main and secondary tube plates B B′, and thus prevent their bulging by reason of an excess of pressure on either side of either plate, I provide strips or ribs of wrought-iron B^2, which are mounted on edge between said main and secondary tube plates B B′ and which extend between lines of said main tubes. This combination of the plates, tubes, and ribs is somewhat similar in construction to that of a plate-girder, and each plate so braced is strong enough to withstand very great pressure exerted on either side of it.

As the main tubes C need support in case they are not in a vertical position, as is the case during shipment, they are provided with two supporting-plates B^3 B^4, that fit within and bear on the shell A. These plates B^3 B^4 have holes b^3 b^4 b^5 therein for the free circulation of any refrigerant liquid for each main tube C and also for the rods D, which support the plates B^3 B^4. Each of these rods D is fixed to the main-tube plate B in the same manner as are the main tubes C, already described, and it freely passes through the supporting-plates B^3 B^4; but incasing each of the said rods D and between the main-tube plates B and the supporting-plate B^3 and also between the latter and the supporting-plate B^4 are two pieces of piping d d' of larger diameter than the supporting-rod holes b^5. Threaded on the bottom portion of each of said rods D are two nuts d^2 d^3, which when screwed up tight against the supporting-plate B^4 rigidly secure both of said supporting-plates B^3 B^4 to the main-tube plate B, and thus keep the tubes C in proper alinement, whatever the position of the cooler, and reduce the chances of injuring the tight joint between the main tubes C and the main-tube plate B.

The operation of this cooler is as follows: Brine enters through the flanged opening b^2 in the cast-iron secondary domed head b', filling the secondary chamber or space between said domed head and the wrought-iron secondary-tube plate B′. Here the brine enters each secondary tube c^6, flows downward and out at the bottom thereof, and then returns upward through the annular space formed between the outer wall of the tube c^6 and the inner wall of tube C. It will be noticed that this annular space is of comparatively small cross-section, so that every particle of the brine must come in contact with the cold inside wall of tube C, the outer wall of which is immersed in the cold liquid ammonia surrounding the outside of each tube. The brine continues up this annular space between the outer and inner tubes, finds exit through the holes c^4, into the middle chamber formed by the cast-iron chamber b and the main and secondary tube plates B B′ and then passes out through the flanged port b^5. Liquid anhydrous ammonia is fed in by an expansion-valve through opening a^3 near the bottom of the shell A. This liquid ammonia fills the space between the shell A and the outside of the main tubes C, where it is evaporated by the heat given to it by the brine in said tube C. The vapor given off from this liquid anhydrous ammonia then passes out of the cooler through flanged outlet a^4 to the compressor or absorber.

The total cross-sectional area of the great number of comparatively short tubes employed by me offers but little frictional resistance to the passage of the brine, so that, as above described, instead of twenty-five to seventy-five pounds friction-head, as is the case in the ordinary cooler, my cooler has a friction-head of from two to five pounds per square inch. In brief, the points that should be noticed in favor of this cooler are its simplicity of construction, the ease with which it can be repaired, and the small frictional resistance offered to the passage of the brine.

What has been said in reference to the faults in the construction of coolers applies to all devices which in refrigerating apparatus employ long coils of pipe, and while I have shown and described my invention as embodied in an improved cooler I desire to be understood as claiming my invention in the broadest manner legally possible. It may be embodied in not only coolers, but exchangers, condensers, absorbers, analyzers, and rectifiers. For instance, substantially the same device as the above cooler can be very successfully used as an absorber by simply inverting the cooler—that is, inverting the position of the tubes C, their plates B B', and trusses B^2, as shown in Figs. 6 and 7. In this case water as a cooling medium enters the main chamber through a port a^4 near the main-tube plate B, circulates through the main chamber, and then leaves it either by a port, as b^6, in the head of the main chamber or a port b^7 in the extended walls of the shell, the ammonia-gas entering middle chamber at b^8 and being absorbed by the weak liquor in tubes C C.

In Figs. 8 and 9 I have shown the preferred form of a perforated cap c^8 to be used to close the end of inner tube c^6 of absorber. It is of smaller diameter than the main tube C, is interiorly threaded to engage threads cut exteriorly upon the end portion of the inner tube c^6, and has a polygonal head c^{10}. Extending downwardly from the top of the inside of said cap is a conical projection c^{11}. Ribs or guides c^9 hold said cap and the inner tube in the axis of the main tube. A hole c^{12} extends axially through said cap. A threaded plug c^{13} closes the main tube. To secure the cap c^8 to the inner tube c^6, the threaded plug c^{13} is removed from the main tube C. The ribbed cylindrical cap c^8 is dropped down upon the inner tube c^6, the conical projection c^{11} entering the open end thereof, and then by means of the polygonal head c^{10} and a wrench the cap is screwed down into the position shown in Fig. 8. In operation the weak liquid ammonia flows up through the inner tube c^6, the hole c^{12}, and trickles down between the main tube C, ribs c^9, and the cap c^8, where, as shown in Fig. 7, it mingles with the ammonia-gas, absorbs it and becomes enriched and escapes into the middle chamber.

What I claim is—

1. A refrigerating apparatus having a shell; an end therefor; a main-tube plate, and a secondary-tube plate, within said shell; a plurality of tubes passing through said plates; means rigidly to fix said tubes in the main plate; trusses lying between said plates and also between said tubes, to support and stiffen said plates; means on the portion of each of said tubes, extending through said secondary plate, whereby the plates and trusses are rigidly bound together; and proper inlets and outlets for said apparatus.

2. A refrigerating apparatus, having a shell; an end therefor; a main-tube plate, and a secondary-tube plate, within said shell; a plurality of tubes passing through said plates; means rigidly to fix said tubes in the main plate; a solder-joint between each tube and the main plate; trusses lying between said plates, and also between said tubes, to support and stiffen said plates; means on the portion of each of said tubes extending through said secondary plate, whereby the plates and trusses are rigidly bound together, and the joint formed by each tube and the secondary plate, hermetically sealed; and proper inlets and outlets for said apparatus.

3. In a refrigerating apparatus, a device made up of a shell; ends therefor; a main-tube plate and a secondary-tube plate within said shell; a plurality of tubes passing through said plates; means rigidly to fix said tubes in the main plate; trusses lying between said plates and also between said tubes, to support and stiffen said plates; means on the portion of each of said tubes, extending through said secondary plate, whereby the plates and trusses are rigidly bound together; and proper inlets and outlets for said device.

4. In a refrigerating apparatus, a device made up of a shell; ends therefor; a main-tube plate and a secondary-tube plate within said shell; a plurality of tubes passing through said plates; means rigidly to fix said tubes in the main plate; a solder-joint between each tube and the main plate; trusses lying between said plates, and also between said tubes, to support and stiffen said plates; means on the portion of each of said tubes extending through said secondary plate, whereby the plates and trusses are rigidly bound together, and the joint formed by each tube and the secondary plate hermetically sealed; and proper inlets and outlets for said device.

5. In a refrigerating apparatus, a device made up of a shell; ends therefor; a main-tube plate and a secondary-tube plate within said shell; a plurality of tubes passing through said plates; means rigidly to fix said tubes in the main-tube plate; a sealed joint between each tube and the main-tube plate; trusses lying between said plates and also between said tubes, to support and stiffen said plates; means on the portion of each of said tubes extending through said outer plate, whereby the plates and trusses are rigidly bound together; the joints formed by each tube and the secondary plate being hermetically sealed; means to support the tubes and hold them in alinement so as to avoid injury to the joints and consequent leakage; and proper inlets and outlets for said device.

6. In a refrigerating apparatus, a device made up of a shell; ends therefor; a main-tube plate and a secondary-tube plate within said shell; a plurality of main tubes passing through said plates, the free ends of said tubes being closed; means rigidly to fix said tubes in the main plate; outlets in said tubes, to communicate between the inside of said tubes and the chamber formed between said plates and the shell; trusses lying between said plates

and also between said tubes, to support and stiffen said plates; means on that portion of each of said tubes extending through said secondary plate, whereby the plates and trusses are rigidly bound together; a secondary tube within each of said main tubes, one open end of which is near the bottom of said larger main tube, while the other end opens into the chamber formed by the secondary-tube plate and the adjacent end of the shell of the device and thus forms a communication between said chamber and the chamber between the tube-plates; an inlet into said chamber formed between the end and the secondary-tube plate; an outlet from chamber formed between said tube-plates and the shell; an inlet and an outlet to the chamber formed by the shell, the main-tube plate and the end of said device.

7. In a refrigerating apparatus, a device made up of a shell; ends therefor; a main-tube plate and a secondary-tube plate within said shell; a plurality of main tubes passing through said plates, the free ends of said tubes being closed; means rigidly to fix said tubes in the main plate; outlets in said tubes, to communicate between the inside of said tubes and the chamber formed between said plates and the shell; trusses lying between said plates and also between said tubes, to support and stiffen said plates; means on that portion of each of said tubes, extending through said secondary plate, whereby the plates and trusses are rigidly bound together; means to seal the joints between said tubes and said plates; a secondary tube within each of said main tubes, one open end of which is near the bottom of said larger main tube, while the other end opens into the chamber formed by the secondary-tube plate and the adjacent end of the shell of the device and thus forms a communication between said chamber and the chamber between the tube-plates; an inlet into said chamber formed between the end and the secondary-tube plate; an outlet from chamber formed between said tube-plates and the shell; an inlet and outlet to the chamber formed by the shell, the main-tube plate and the end of said device.

8. In a refrigerating apparatus, a device made up of a shell; ends therefor; a main-tube plate and a secondary-tube plate within said shell; a plurality of tubes passing through said plates; the free ends of said tubes being closed; means rigidly to fix said tubes in the main plate; means to seal the joints between said tubes and plates; outlets in said tubes to communicate between the inside of said tubes and the chamber between said plates and the shell; trusses lying between said plates and also between said tubes, to support and stiffen said plates; a threaded cap on that outer portion of each of said tubes extending through said secondary plate whereby the plates and trusses are rigidly bound together; a packing on the under side of said cap to hermetically seal the joint between the cap and the secondary plate; a secondary and smaller tube within each of said main tubes; one end of which is near the bottom of said larger tubes, while the other end opens into the chamber formed by the secondary-tube plate and the adjacent end of the shell of the device; said outer portion of the secondary tube passing through and secured in said cap and extending into said chamber; an inlet for said chamber formed between the end and the secondary-tube plate; an outlet from chamber formed between said tube-plates and the shell; an inlet and outlet to the chamber formed by the shell, the main-tube plate and the end of the device.

9. In a refrigerating apparatus, a device made up of a wrought-iron shell, a wrought-iron end, a main wrought-iron tube-plate, said three parts being secured together forming one chamber; a cast-iron piece secured to said shell and a secondary wrought-iron tube plate secured to said cast-iron piece whereby a second chamber is formed; and a cast-iron end secured to said cast-iron piece whereby a third chamber is formed; a plurality of tubes passing through said plates; means rigidly to fix said tubes in the main plate; trusses lying between said tube-plates and also between said tubes, to support and stiffen said plates; means on that portion of each of said tubes extending through said secondary plate, whereby the plates and trusses are rigidly bound together; and proper inlets and outlets for said device.

In testimony whereof I affix my signature in presence of two witnesses.

GARDNER T. VOORHEES.

Witnesses:
EDWIN B. THAYER,
FRANK T. HIER.