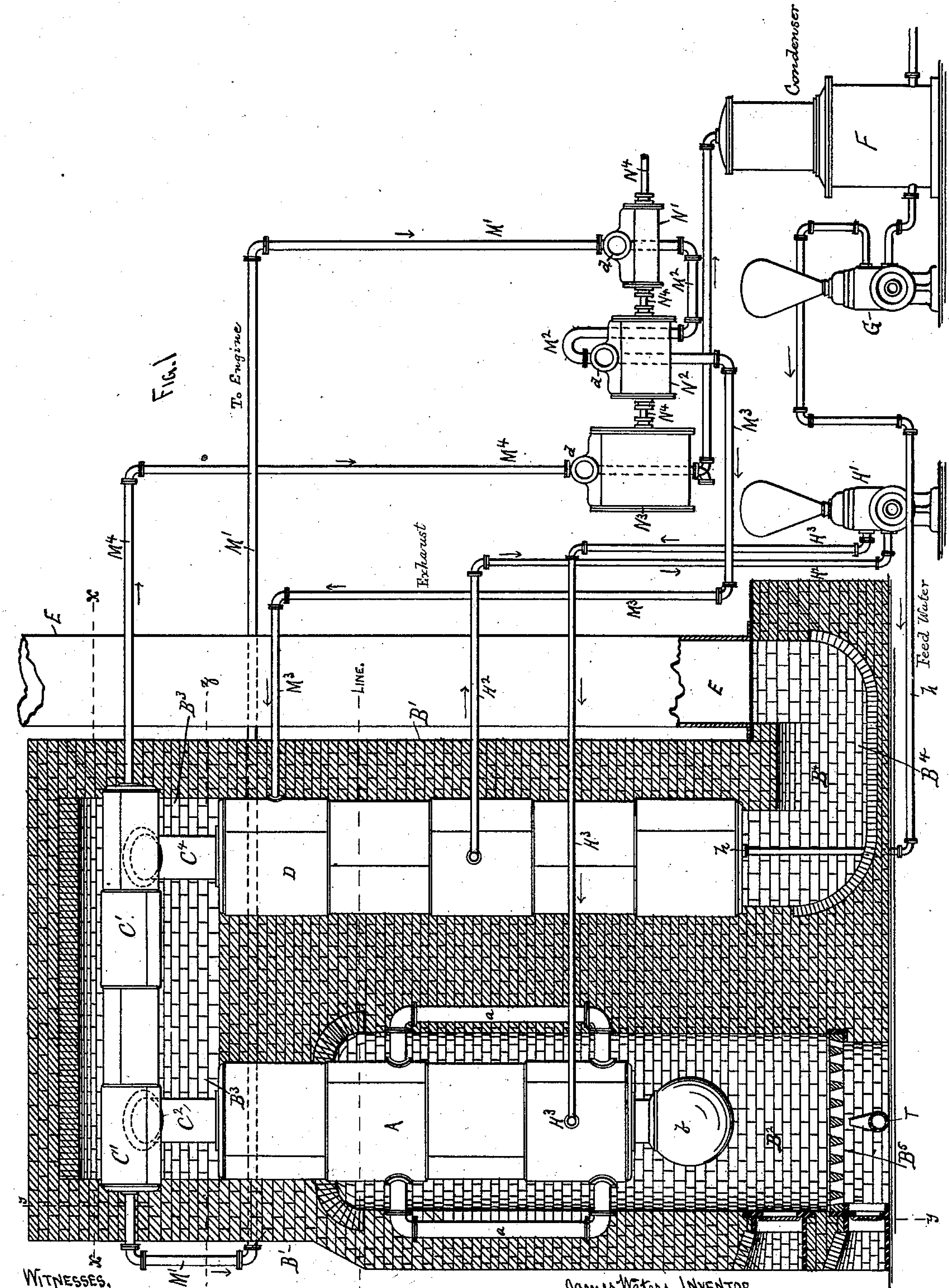
(No Model.) 3 Sheets—Sheet 1.

J. WATERS.

STEAM GENERATOR.

No. 362,558. Patented May 10, 1887.



Witnesses,
A. S. Mayo,
H. S. Webster.

James Waters, Inventor,
By Charles H. Woodward,
Atty.

(No Model.) 3 Sheets—Sheet 2.

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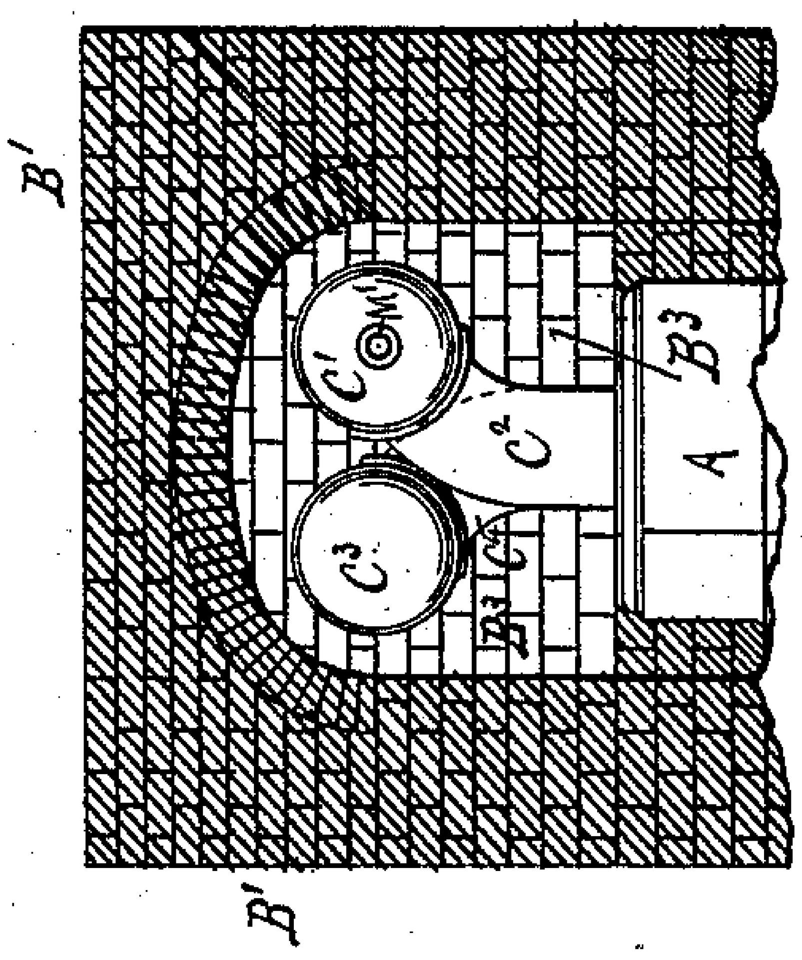

Fig. 3

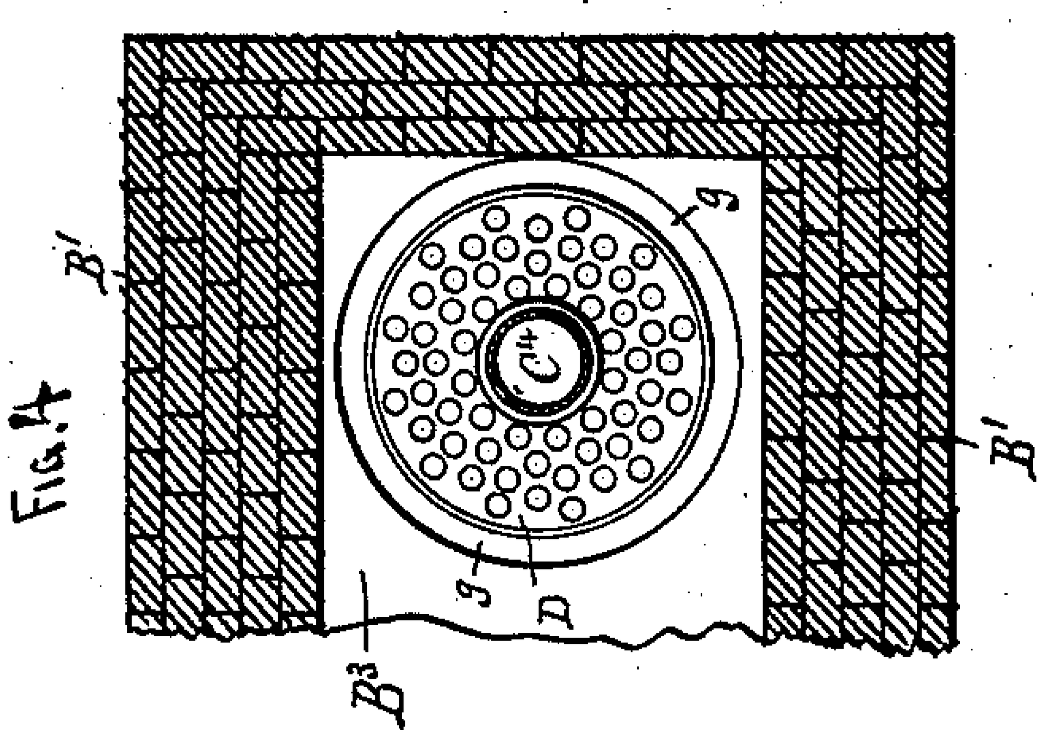

Fig. 4

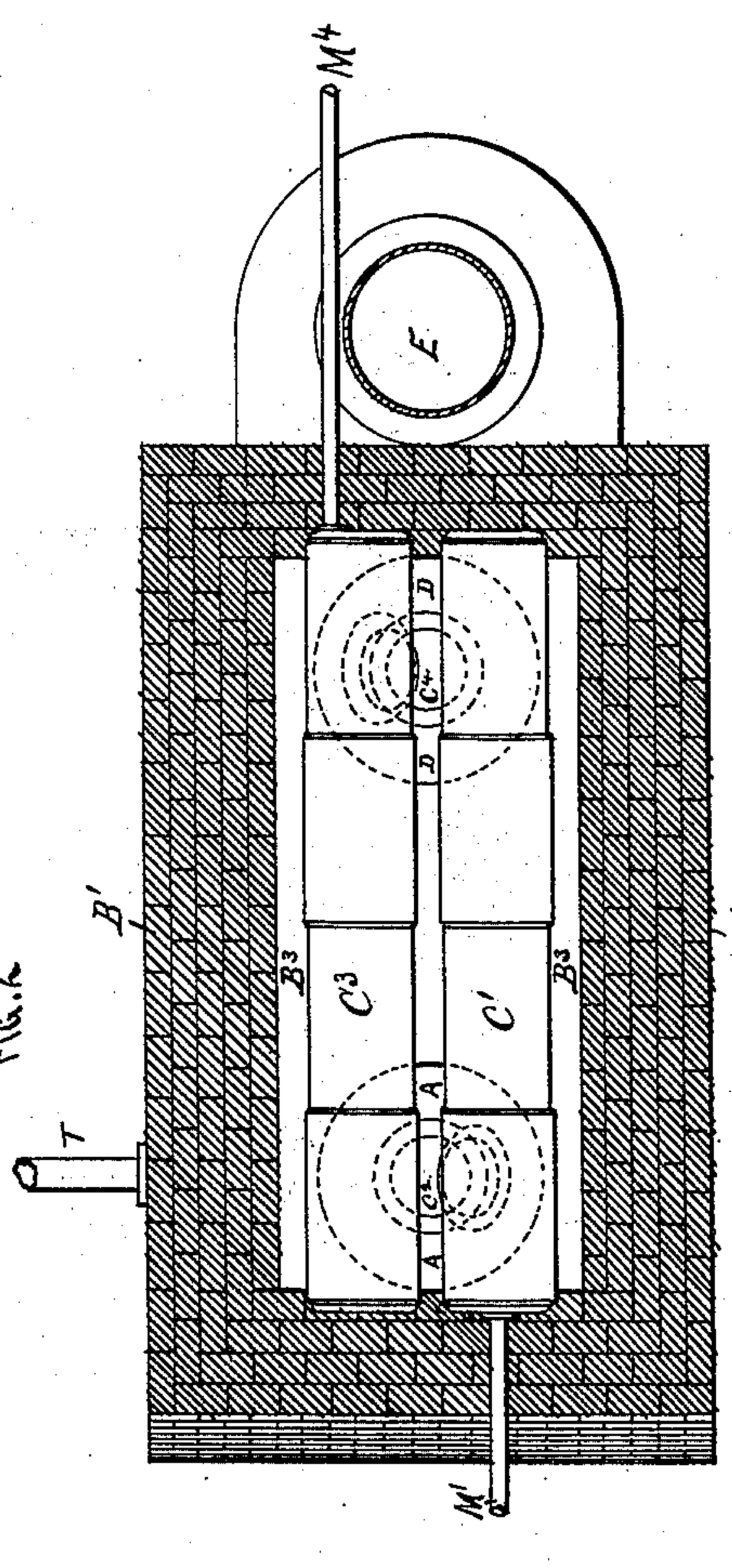

Fig. 2

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(No Model.) 3 Sheets—Sheet 3.

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STEAM GENERATOR.

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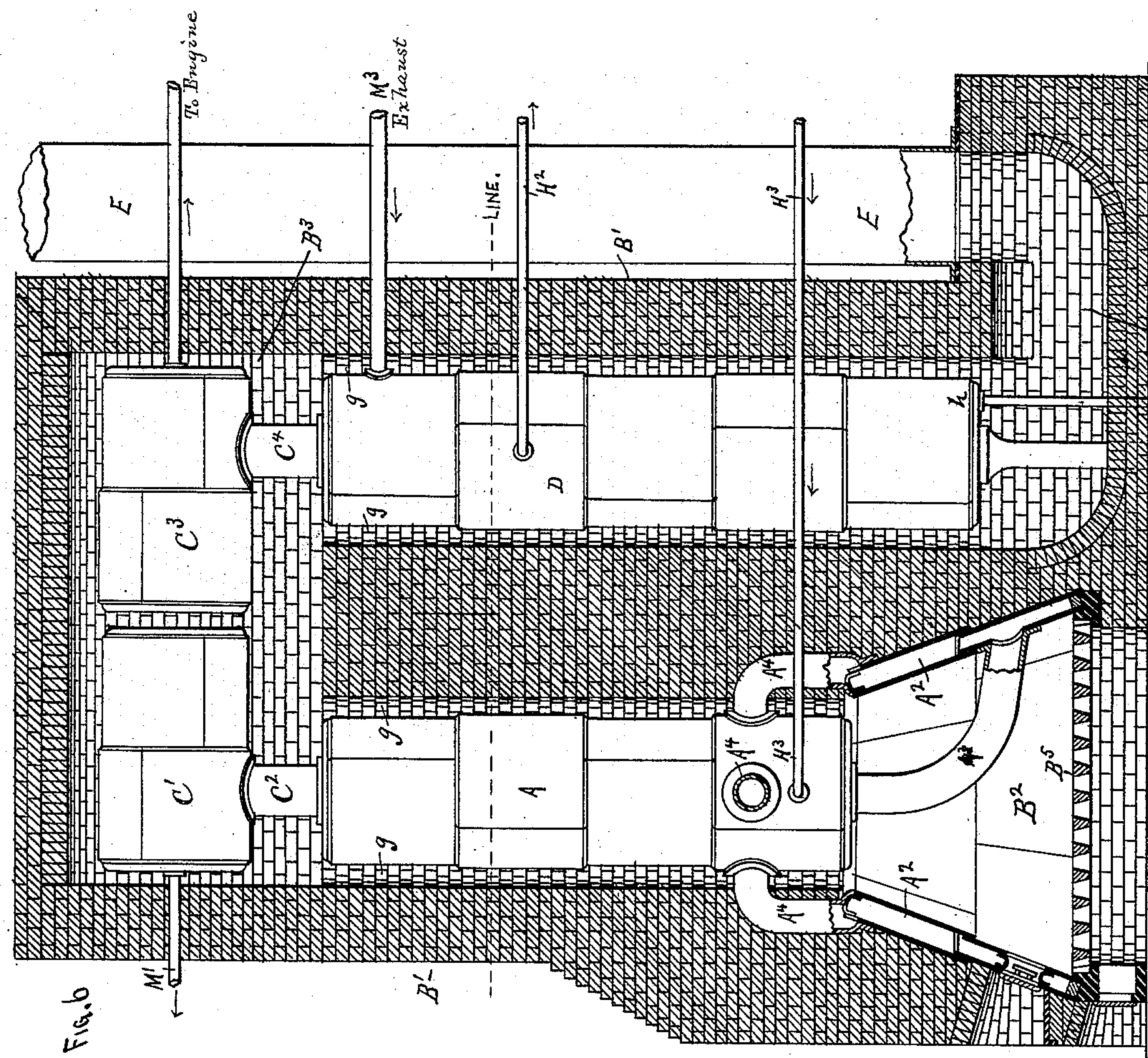

FIG. 6

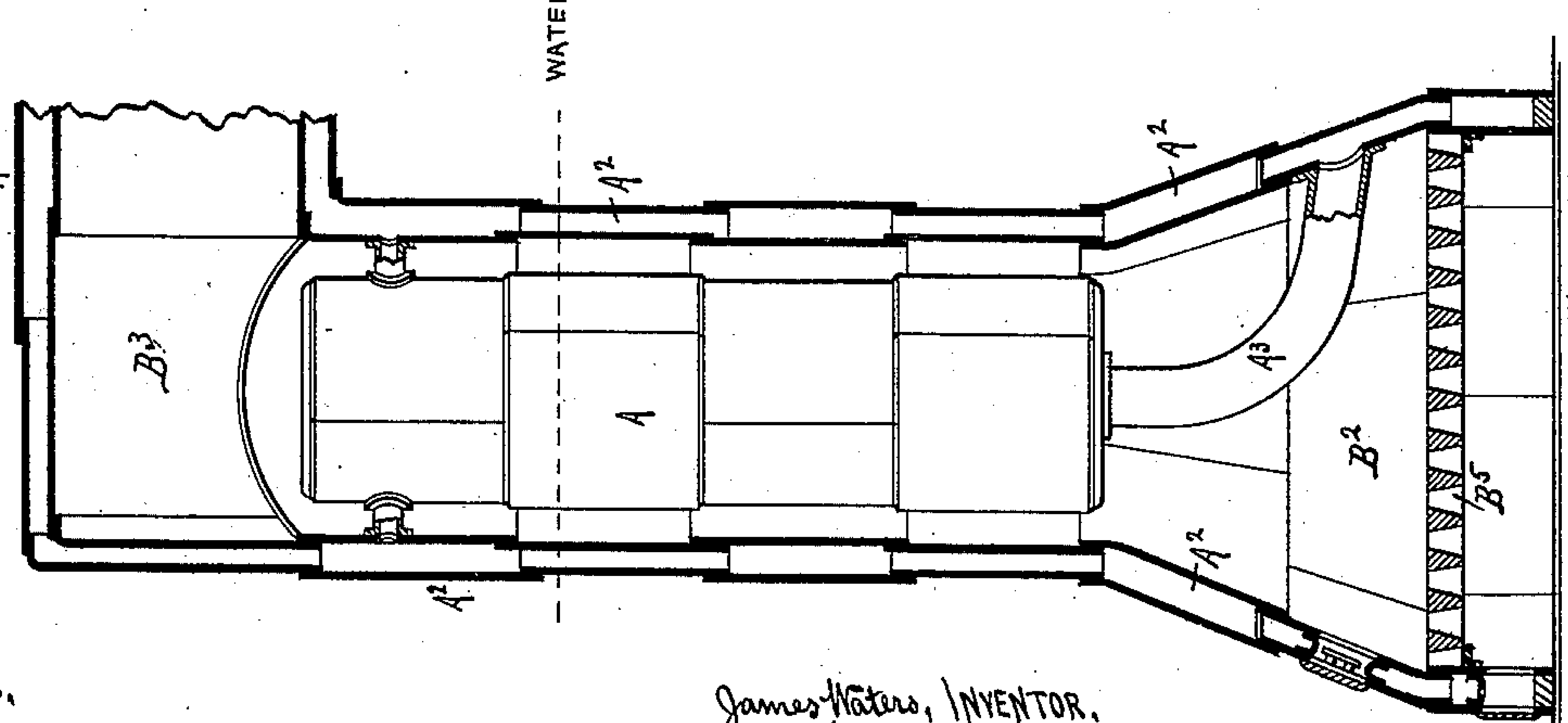

FIG. 5

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UNITED STATES PATENT OFFICE.

JAMES WATERS, OF MINNEAPOLIS, MINNESOTA.

STEAM-GENERATOR.

SPECIFICATION forming part of Letters Patent No. 362,558, dated May 10, 1887.

Application filed February 26, 1886. Serial No. 193,376. (No model.)

To all whom it may concern:

Be it known that I, JAMES WATERS, a citizen of the United States, and a resident of Minneapolis, in the county of Hennepin and State of Minnesota, have invented certain new and useful Improvements in Steam-Generators and Methods of Utilizing the Heat and Steam Generated Therein, of which the following is a specification.

This invention relates to steam-generators and the method of utilizing the steam and heat generated therein, as hereinafter shown and described, and as illustrated by the accompanying drawings, in which—

Figure 1 is a sectional side elevation of the boiler-plant and an outline detail of the system of engines, pumps, and condensers used in connection therewith. Fig. 2 is a plan view in section on the line *x x* of Fig. 1 of the boiler-plant. Fig. 3 is a sectional detail of the upper part of the boiler-plant on the line *y y* of Fig. 1. Fig. 4 is a plan view of the secondary boiler on the line *z z* of Fig. 1. Figs. 5 and 6 are sectional side elevations of the boiler-plant, illustrating modifications in its construction.

A represents an upright boiler, preferably of that kind of boiler which has flues extending through it endwise, such as is shown in Fig. 4. This boiler is set in a brick-work arch, B′, and with the furnace B^2, beneath it, arranged in the ordinary manner. This boiler has circulating-tubes *a* on its sides, and a globular circulating-drum, *b*, suspended beneath it, while it is connected at its upper end to a superheating-drum, C′, by a large tube, C^2, this latter drum being supported at its ends above the boiler A by the brick-work B′ in a closed chamber, B^3, as shown.

D represents another boiler similar to the boiler A, and supported in an upright position in the brick-work B′, and with its upper end connected by a tube, C^4, to a superheating-drum, C^3, lying alongside the drum C′ in the chamber B^3, as shown in Figs. 2 and 3.

The lower ends of the flues in the boiler D (shown in Fig. 4) open down into a flue, B^4, leading into the smoke-stack E.

In Figs. 1, 2, and 3 the boilers A D are shown embedded into the brick-work B′, so that all products of combustion pass through the smaller flues in the boiler; but the boiler may be arranged, as shown in Figs. 4 and 6, with a space, *g*, between their shells and the brick-work B′ for the passage of a portion of the products of combustion, or, as in Fig. 5, with a water-leg, A^2, surrounding the main shell A, and between which and the main shell a portion of the products of combustion pass. By this means the heated-air flame, gases, &c., come in contact with the boiler on all sides, thereby greatly increasing the heating-surface. By this arrangement the hot air, smoke, and other products of combustion pass upward through the flues in the boiler A, through the chamber B^3, where it envelops the drums C′ C^3, thence downward through the flues of the boiler D into the flue B^4, and thence out through the smoke-stack E, as in Fig. 1, or upward through and around the boiler A, and down through and around the boiler D, as in Figs. 5 and 6.

The feed-water is supplied to the lower part of the boiler D, as shown at *n*, from the condenser F by a pump, G, or from a feed-water heater, where no condenser is used. The feed-water, being supplied at the farthest point from the furnace, will not influence the heat of the products of combustion until after they have passed through the boilers and an opportunity has been given for the extraction of the heat. The water will generally be kept standing in both the boilers A D at about the same height, as indicated by the dotted line (marked "water-line") in Figs. 1, 5, and 6; but the water-line in the two boilers need not necessarily be kept at the same height, as they are entirely independent and distinct.

H′ represents a pump connected to the boiler D, just below its water-line, by a pipe, H^2, and the boiler A by a pipe, H^3, near the bottom of the latter, so that the water may be taken from the boiler D at the point of its greatest heat—that is, as near as possible to the top of the water-line—and discharged into the boiler A at a point far enough removed from its steam-chamber to not affect the steam. By this arrangement of the boilers I extract from the fuel and the products of combustion almost all the heat, and transmit it into the water in the boilers before the air, smoke, and other products of combustion reach the flue B^4 and smoke-stack E; hence a great economy of fuel results and no waste heat is discharged through the smoke-stack. I also claim a great advantage in arranging the second boiler, D, so that the smoke and heated air pass downward through and around it in contact with a constantly-cooling surface, as the air will give up its heat much more freely while thus passing through the decreasing temperature.

Another point to be noted is that the heated products of combustion pass from the hottest toward the coldest part of the boiler D, (*i. e.*, from the boiler A to the lower end of the boiler D, where the comparatively cool feed-water is fed to the boilers;) hence the temperature of the products of combustion is gradually reduced and the heat therefrom transmitted into the water just where it will accomplish the greatest benefit, the greatest amount of the heat being transmitted into the boiler A. In other words, the flame, smoke, hot gases, and other products of combustion, in their course through the boiler D, are continuously coming in contact with water of a constantly-decreasing temperature; hence the heat is extracted continuously, whereas in boilers as ordinarily constructed the heated air, in passing from one part of the boilers to the other, passes through long sections of the boiler heated to a uniform temperature, the sections decreasing in temperature toward the smoke-stack or other exit. By this means none of the energy of the heat is wasted in raising the temperature, but, on the contrary, all the energy is utilized to heat the water in the boilers and evaporate it into steam as the products of combustion, as before stated, are coming in contact with a medium of a constantly-decreasing temperature in their progress through the boiler D.

The steam, as it is generated in the boiler A, will rise and fill the drum C′, in which it will be superheated, and from this drum the steam will be conducted to the engine by a pipe, M′.

The steam generated in the boiler D will rise into the drum C^3, where it will also be superheated, but will not be raised to so high a temperature or expanded to produce so great a degree of pressure as in the drum C′, as the heat coming in contact with the boiler D is not so great as that coming in contact with the boiler A, having given up a portion of its heat in passing through the boiler A and chamber B^3. With an ordinary arrangement of the plant, in which the boiler A is about fourteen feet long and with a forty-eight-inch shell, the pressure in the boiler A will be raised to about one hundred and twenty pounds and in the boiler D to about ten pounds; but these pressures may be varied as required.

An important advantage obtained by the manner shown of constructing the boilers is that no unequal strains occur when first getting up steam, as the heat comes in contact with all sides equally. Consequently all parts will be expanded alike. Another important advantage gained by this arrangement is that the boiler D serves as a precipitator of the sediment in the feed-water, as well as a heater for the feed-water.

I have shown in the drawings a system of engines, pumps, and condensers connected to the boiler-plant to illustrate one method of economically utilizing the steam generated therein.

Engines embodying the "compound" principle can best be used in connection with this system of generators, although ordinary single engines can also be used.

N′ N^2 N^3 represent three steam-cylinders with one single piston-rod, N^4, common to all, and each cylinder provided with its own set of steam-chests *d*. I have shown merely the three cylinders and their steam-chests, and have not shown the cranks, connecting-rods, slides, &c., as the parts shown are sufficient to illustrate the invention. The cylinder N′ is smaller in its bore than the cylinder N^2, and the cylinder N^2 is smaller in its bore than the cylinder N^3, being proportioned according to the pressure of the steam which is supplied to them. The cylinder N′ receives its steam direct from the drum C′ through the pipe M′, and exhausts through a pipe, M^2, into the steam-chest *d* of the cylinder N^2, and is thus utilized on the compound principle to operate in the cylinder N^2. If the initial steam-pressure in the cylinder N′ be about one hundred and twenty pounds, the initial pressure in the cylinder N^2 will be about forty-eight pounds; hence the exhaust from the cylinder N^2 can be readily forced into the boiler D through a pipe, M^3, above its water line, as the terminal pressure therein will be about the same as in boiler D after being expanded in cylinder N^2. The cylinder N^3 is supplied with steam from the drum C^3 by a pipe, M^4, as shown, and exhausts into the condenser F, the vacuum created thereby in the cylinder N^3 increasing the power of the engine.

If only the two cylinders N′ N^2 should be used, then the exhaust from N′ would be discharged into the boiler D and the exhaust from the second cylinder, N^2, would be conveyed into the condenser F, as will be readily understood. By this arrangement the steam is used very economically, and very little waste of heat or steam occurs, the heat being extracted from the fuel and products of combustion before it reaches the exit-flue E, and the steam used over and over again and utilized as long as it possesses any power or energy. The extraction of the heat from the products of combustion to so nearly an absolute degree renders it necessary to use an artificial draft to carry off the air, smoke, gases, &c., as the air and gases by the time they reach the stack E have so little heat left in them that they will not rise in the stack of themselves.

I have shown in the drawings a blast-nozzle, T, beneath the grate B^5, to illustrate the fact that an artificial draft will be generally used. Any suitable form of fan, air-pump, or other power may be employed to produce this artificial draft.

The fan or other draft-producing power may be placed in the flue B^4, or stack E, if preferred. By this arrangement of the boiler-plant the steam is superheated in the drum C′

before going to the first cylinder, N′, so that it will do its work without loss by condensation, and there, after use in the cylinder N^2, exhausted into the boiler D, where it is again superheated in the drum C^3, so that it will do its work in the cylinder N^3 without loss by condensation. This superheating can be regulated by the height of the water in the boilers.

The secondary boiler D serves the fourfold purpose of a feed-water heater, precipitator for the main boiler A, and a reheater and receiver for the exhaust-steam from the first or second cylinders, and as an independent generator for direct steam-supply for the second or third cylinders, and performing all of these functions at the same time.

Another advantage of the secondary boiler D is that it receives the exhaust-steam from the first cylinder, or the first and second cylinders, reheats it, and returns it to the second or third cylinder, with the addition of what steam is generated within itself. Still another advantage gained by this arrangement of the boilers in separate and distinct relations is that by carrying steam in boiler A at about one hundred and twenty pounds' pressure the temperature in A would be about 345°, and by carrying steam in boiler D at about ten pounds' pressure its temperature would be about 241°, or 104° less than in boiler A; hence the flame, smoke, hot gases, and other products of combustion, in passing from and around the boiler A, will pass directly into and around the boiler D and into contact with a greatly-reduced temperature, which will cause the heat to be transmitted into the water in the boiler D very rapidly. By this construction and arrangement the heat is utilized in a double sense by being passed from a high-pressure boiler, after expending sufficient of its force to create steam therein for a high-pressure engine, through and around another boiler, in which it is utilized to create steam for a low-pressure engine.

In Figs. 5 and 6 I have shown some modifications of the construction, consisting in forming a conical water-leg, A^2, around the furnace and connecting it with the main boiler by a large circulating-tube, A^3. In Fig. 5 the water-leg A^2 is carried up around the boiler A, leaving a space, g, for the passage of a portion of the flame, smoke, heated gases, and other products of combustion, so that the boiler A is entirely surrounded by them. The water-leg is also shown forming the outer walls of the chamber B^3, this being the form which will generally be employed when used as a marine boiler. In Fig. 6 the water-leg A^2 extends about even with the lower edge of the boiler A, and is connected to the boiler by circulating-tubes A^4, in addition to the tube A^3. In this latter modification the brick-work B′ is shown formed with the space g between it and the boilers A D, so that the flame, smoke, heated gases, and other products of combustion can come in contact with all parts of the boilers.

Another slight modification is shown in Fig. 6, consisting in forming the drums C′ C^3 in the same line horizontally, instead of side by side, as in Figs. 2 and 3.

The functions and mode of operation of the parts are substantially the same in all the modifications.

Having thus described my invention, what I claim as new is—

1. The combination of two upright boilers, a flue connecting the upper ends thereof, a combustion-chamber beneath the first boiler, and a smoke-conducting flue leading from the lower end of the second boiler, substantially as set forth, whereby the heated products of combustion after leaving the first boiler first encounter the upper end of the second boiler and then pass downward in contact therewith, so that the heated products of combustion as they become cooler come successively in contact with successively cooler portions of the second boiler.

2. In a steam-generator, a main upright boiler, A, through which the flame and other products of combustion pass in an upward direction, a secondary boiler, D, distinct from and independent of said main boiler, through and around which the flame and other products of combustion pass in a downward direction after passing upward through the said main boiler, chamber B^3 above both of said boilers, drum C′, connected to said boiler A by tube C^2, and drum C^3, connected to said boiler D by tube C^4, both of said drums being suspended in said chamber B^3, substantially as and for the purpose set forth.

3. In a steam-generator, a main upright boiler, A, through which the flame and other products of combustion pass in an upward direction, a secondary upright boiler, D, distinct from and independent of said main boiler, and through and around which the flame and other products of combustion pass in a downward direction after they have passed through said main boiler, chamber B^3 above both of said boilers, drum C′, connected to said main boiler, and drum C^3, connected to said secondary boiler, both of said drums being suspended in said chamber B^3, an engine comprising a high-pressure cylinder adapted to receive steam from said drum C′ or boiler A, and one or more low-pressure cylinders adapted to receive steam from drum C^3 or boiler D, a condenser, F, connected to said low-pressure cylinder or cylinders, means for supplying said boiler D at or near its lower end from said condenser, and means for supplying said boiler A with water taken from said boiler D at or near its water-level, substantially as and for the purpose specified.

In testimony whereof I have hereunto set my hand in the presence of two subscribing witnesses.

JAMES WATERS.

Witnesses:
A. T. NETTLETON,
H. S. WEBSTER.