UNITED STATES PATENT OFFICE.

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IMPROVEMENT IN STEAM-GENERATORS.

Specification forming part of Letters Patent No. 47,054, dated March 28, 1865.

To all whom it may concern:

Be it known that I, ELI THAYER, of Worcester, in the county of Worcester and State of Massachusetts, have invented a new and Improved Method of Constructing Boilers for the Generation of Steam; and I do hereby declare that the following is a full and exact description thereof, reference being had to the accompanying drawings, and to the letters of reference marked thereon.

The nature of my invention consists, first, in so arranging a number of graduated tubes or pipes, (in the form of coils, or in any other form,) each independent of all the others, and each connected with the boiler, that the heat from the furnace may pass around each in succession; second, in providing for reversing the steam in all of these pipes for the purpose of clearing them of sediment; third, by providing a metallic false bottom to cover the fire-surface or bottom of the boiler, by means of which all the water which comes in contact with the fire-surface of the boiler is immediately converted into steam and forced into the steam-chamber ready for use, and by means of which also the bottom of the boiler is kept entirely free from rust and sediment, thus protecting the boiler from injury by the fire and effectually preventing the possibility of explosions.

To enable others skilled in the art to make and use my invention, I proceed to describe its construction and operation.

Figure 1 represents a transverse vertical section of the furnace-valve-chamber, return-flue, entrance to the chimney, one of the coils and its connections with the boiler, the boiler and the false or movable bottom, and one of its tubes for discharging steam. Fig. 2 represents a longitudinal section of the coils, furnace, ash-pit, and direct flue. Fig. 3 is a vertical projection of the coils, with their valves and stop-cocks and their connections with the boiler. Fig. 4 represents a transverse section of the movable bottom D, as seen on a smaller scale in Fig. 1.

A represents the boiler, and B the steam chamber or space inside the boiler, above the water. C represents the water both above and below the metallic false bottom, and also at its sides. D represents the false bottom. The numerals 1, 2, 3, 4, &c., represent the successive coils of pipe, beginning with those over the fire. *x* represents the direct flue leading from the furnace through or among the successive coils. Z represents the return-flue extending from the back to the front end of the boiler, where it enters the chimney at the point *w*. P represents the several partitions between the coils located in the direct flue. *y* represents the valve-chamber, a space between the direct and return flues, from each of which it is separated by brick. This chamber is about two feet wide, and extends in height from the floor to the roof of the furnace, and in length as far as the boiler. *b* represents each of the stop-cocks between the upper ends of the coils and the boiler. *a* represents each of the inverted check-valves between the lower ends of the coils and the boiler, with the wheel and screw attached. *r* represents a rod connected by a joint with the lever of each of the stop-cocks and extending through the plate, called the "furnace front," so that by pushing or pulling this rod all the stop-cocks can be either opened or closed by a single motion. *s* represents a similar rod connected by a joint or by gearing with a wheel attached to a spindle with a screw, (like the wheel and spindle of a globe-valve,) so that by a single motion, as in the former case, the screw is either raised or lowered. This screw, when lowered, presses upon and holds down the spindle of the inverted valve, thus allowing a free passage either way through the valve.

The coils 1, 2, 3, &c., are made of pipe of different sizes, the largest being over the fire and the smallest the most remote from it. In none of the coils will pipe of more than one inch diameter be required. The object in using pipes of smaller size in one end of the direct flue than in the other is to increase the heating-surface for the same quantity of water as the heat from the furnace diminishes. This is done both by diminishing the size of the pipes constituting the coils and by increasing their length. For example, if coil 1 be one-inch pipe and twenty feet long, and coil 10 be one-fourth-inch pipe (in both cases internal diameter is intended) and forty feet long, the surfaces exposed to the heat will be about the same, while the water to be heated in coil 10 will be only one-sixteenth of the quantity to be heated in coil 1. For this reason the coils are graduated in size from 1 to 10.

I will now describe the operation of the coils and the mode of clearing them of sediment.

Suppose the boiler A filled with water as high as its horizontal diameter, the stop-cocks in the coils open, and the valves free from the pressure of the screws. The coils are filled with water to the same level as the water in the boiler. Suppose now a fire is made in the furnace. Steam is immediately made in the successive coils and presses equally toward the point *e* and the point *d;* but that portion of the force exerted in the direction of *e* lifts the valve in the horizontal inverted check-valve *a*, which stops its further motion in that direction; but as the expansive force of the steam is increasing it acts with increased power in the direction of *d*, and, there being no obstacle in the way of its progress in that direction, it enters the boiler at that point. The pressure upon, or, rather, under, the valve *a* being thus relieved, the valve falls and a new supply of water enters the coil and acts in the same way. We then have through all the coils a very rapid passing of steam or hot water, especially through their upper portions, for the cubic inch of water which enters the coil through the check-valve becomes seventeen hundred cubic inches of steam when it passes the point *d;* hence the motion in that part of the coil nearest *d* is seventeen hundred times as great as in that portion of the coil near the check-valve. Of course, then there can be no accumulation or stopping of sediment in or near the upper end of the coils. It only remains to provide against its accumutation at or near the lower ends. This I do by reversing the steam in all the coils at pleasure. If while the steam is passing, as above described, through all the coils, from their lower extremity to the point *d*, the rod *s* be drawn forward, this motion of the rod communicating with the screw acts upon the valve *a* and holds it permanently open so long as the rod remains drawn forward. Now, if the rod *r* be also drawn forward in like manner, all the stop-cocks in the pipes will be closed. The steam in the coils and also the water will be driven with great force into the boiler through the check-valve, thus completely clearing the pipe of all obstructions. This can be done as often as necessary. Care should, however, be taken to draw the lower rod first and then immediately the upper rod, but to push back the upper rod first. If these directions are not observed, there will be danger of bursting the pipes. The rods should not remain drawn but a few seconds, or there will be danger of heating the pipes so much as to injure them. With proper management the pipes, even those over the fire, will never reach a temperature of 400°.

It is not necessary that these pipes should be in the form of coils. They might be used to make the partitions and the roof of the flue, or be put in any other form; but the coil is the most conveniently constructed and can be made of one continuous piece without joints or couplings. The number of coils to be used will depend upon the length of the boiler and upon the power required.

Fifty or even one hundred coils could be conveniently attached to a boiler forty feet in length by putting two in each of the spaces between the partitions. The number and length of the coils can be easily determined when the capacity of the furnace and the desired power are known.

These pipes can be made either of iron or copper. I regard iron, however, as preferable on account of both cheapness and durability. By its use as above described there can be no danger from the decomposition of water, as the pipes will never be within 400° of a red heat. Hence, they are as safefor this purpose as copper would be.

Having now very carefully and accurately described the construction and use of so much of my invention as is contained in the furnace, direct flue, and valve-chamber, I proceed to a particular description of the construction and use of the boiler A, which may be used either with or without the coils.

I make the bottom of the boiler flat and subtending from seventy degrees to one hundred and twenty degrees of the circle—*i. e.*, so that a transverse section of it, as seen in Fig. 1, would be a chord somewhere between the side of an inscribed square and that of an inscribed triangle. In every case it should be a chord less than the diameter. Fitting closely to this bottom, and extending very nearly to the walls or sides and ends of the boiler, is the false bottom or movable metallic plate D. This plate should be double, or be composed of two sheets, with a narrow space for air between the two inner surfaces, as seen in Fig. 4. They can be kept from collapsing by the pressure by means of props or supports, as seen in the same figure. A double pipe open at top and bottom is screwed or riveted tightly into and through these two sheets, so as to serve to convey steam from the lower side of the movable plate to the steam-chamber. I am unable to direct in relation to the thickness or weight of this plate. I have used lead plates from one-fourth of an inch to two inches in thickness without detecting any difference in their working. No weight, however great, seems to prevent the vibration. The outer edge of the upper surface is slightly elevated, as seen in Fig. 4. If in practice it should be found necessary, the lower surface may have a like projection downward. If the water above the upper plate were very shallow, this would prevent the steam from going up the sides of the plate.

In the experiments which I have made the lower surface has had no downward projection. The plates which I have used are made of lead and cast in the boiler when I have used them, the only space allowed between the plate and the boiler being that occasioned by the contraction of the lead in cooling. The object in making the false bottom and the tube leading from its lower surface to the steam-chamber double is to prevent any immediate loss of steam by contact with one surface of metal while cold water is in contact with the other surface. I think that these plates could be best made of cast-iron. It would be well to protect the upper surface of the upper sheet from rust by covering it with tin or lead. This double plate may be in one piece or in several sections.

So much for the construction of the false or movable bottom. I now proceed to describe its uses.

In order the better to consider this subject we will for the present regard the boiler as separated from all connection with the coils and used as an ordinary boiler over the furnance and direct flue, which, under this supposition, would be represented by Z. Suppose now that a fire is made in the furnace Z and that the boiler A is filled with water for one or two feet above the movable plate. If the water be introduced before the fire is made, it will surround the movable plate and rise as high in the tube *o* (Fig. 4 and Fig. 1) as it is outside of it. The heat immediately converts the very thin sheet of water under the plate into steam, which, on its passage to the tube *o*, raises the plate D and admits another thin sheet of water, which, in its turn, is converted into steam, raises the plate D, and passes into the steam-chamber through the pipe *o*. In this way it continues to act, vibrating regularly, and admitting water just in proportion to the heat of the fire. This self-adjusting power will be apparent when it is considered that the more rapidly steam is made between the bottom of the boiler and the movable plate the higher the plate will be lifted and the larger the quantity of water admitted.

The very rapid motion of the water and steam under the plate D keeps its lower surface and the bottom of the boiler perfectly clean and ever smooth and bright. No sediment can ever be deposited between these two surfaces, but will be carried up through the tube *o* and deposited on the upper surface of the plate. In my experiments I have mixed clay and lime with the water, but in no case has anything been left on the bottom of the boiler, but all solid substances have been deposited on the upper plate. By thus keeping the fire-surface of the boiler free from rust there can be no danger of explosion, even though water be put into the boiler when highly heated, for there will be no oxidized iron to furnish oxygen to combine with the hydrogen set free by the decomposition of water. But besides greatly increasing the durability of boilers and removing the cause of their explosion, there is another important advantage gained by this invention—to wit, the readiness with which steam is generated and made available. In ordinary boilers no steam is made till all the water above the fire-surface has reached the temperature of 212°. By this method steam can be made and used before the water above the plate is 10° hotter than when it entered the boiler. There is no need in this boiler of any more water than sufficient always to completely cover the upper plate, a depth of one inch above that plate being as good as any other quantity. If only so much water as is actually needed be admitted, it would be necessary in marine engines to have several of these plates separated from each other by partitions extending from the bottom of the boiler into the steam-chamber. For stationary engines also I think it better to have the false bottom consist of several plates, each one reaching across the bottom of the boiler and the same distance longitudinally. The partitions, however, in this case need not extend more than an inch above the plates. The size of the tubes to convey the steam to the steam-chamber must be determined by the amount of fire-surface for which each is to act.

If the bottom of the boiler be of considerable width, it will be necessary, as usual, to strengthen it by stays or rods passing through the top, and the same would pass through the partitions between the movable plates on the bottom. These partitions, riveted firmly to the bottom of the boiler, will materially add to its strength.

Although a flat or concave form of bottom for the fire-surface, with a corresponding form of the false bottom D, would afford a more economical application of heat, still in some cases a convex form may be used to advantage. This is the ordinary form of bottoms of boilers now in use. Such may be improved by the use of this invention without any other change than the introduction of the plate D, made so as to correspond in form. For example, suppose an ordinary cylinder-boiler, the fire-surface of which is its whole external surface below its horizontal diameter. Suppose, also, the plate D is made of the same form and of a size to fit inside of such fire-surface and to extend to the same height. This construction would give just as perfect results as the flat or concave form. The only difference would be a change in the direction of the current. In this case the steam formed between the fire-surface and the movable plate D will not issue through the tube *o*, as in the case above described, but will ascend all along the sides of the boiler, between the fire-surface and the plate D, while the water will descend through the tube *o*. This method of applying the principle of this invention will be of great use in concentrating fluids by evaporation, as the sediment or product of evaporation will be deposited away from the fire-surface about the tube within or upon the plate D, whence it can easily be removed. The vibrations of the plate D can easily be made to work a pump which shall supply the boiler with water.

The description of the construction and operation of the plate or false bottom D (Figs. 1 and 4) in the foregoing pages is applicable especially to horizontal boilers. In the application of the same principle to vertical boilers certain modifications in its construction will be desirable.

In my experiments with this kind of boiler I have found the best form of bottom to be the convex surface of a cone, the apex of which extends upward in the center of the boiler. The plate D is made of the same form and size with an opening at the apex sufficient for the escape of steam formed between the two plates. This movable cloak or covering for the fire-surface is made double for the purpose of producing steam in the shortest possible time. I have tried the operation of this plate or covering in various ways. In some experiments I have made it fast at a very little distance from the bottom, and in others I have loaded it with heavy weights, and in others still have left it free with no weight but of the two sheets of metal of which it was composed. I have found that when made fast or very heavily loaded it would work well, provided the heat from the furnace was uniform and the water in the boiler kept at the same height; but that if the heat were made very intense, or the water in the boiler were reduced to a low point, the bottom of the boiler became highly heated and dry, producing superheated steam. I have therefore concluded that neither of these methods would be desirable in practice. In the free motion of the movable plate, however, neither of these difficulties occurs. The cone constituting the bottom of the boiler is constantly kept wet to its very apex by the constant vibration of the surrounding or covering plate, even till the very last gill of water is exhausted. As in the case of the flat plate and horizontal boiler, the greater the fire the more frequent and more violent the vibrations, each one of which carries water entirely over the surface of the boiler exposed to the fire, and is an exact measure of the heat of the furnace. As the exterior surface of this plate is at an angle with the horizon of some forty-five degrees, more or less, it is not adapted, like the flat plate, to retain the sediment which is constantly being deposited upon it. I have therefore provided a shelf or trough extending around it about midway between the top and bottom, which receives and retains all the sediment, so that none remains upon or near the fire surface of the boiler.

It will readily be seen that by this arrangement the fire-surface of boilers can be indefintely increased and the cost of making steam very much diminished. In a space of ten feet in height ten of these surfaces could be placed one above another and the fire made to pass through and around them alternately.

Other forms of fire-surface may be used with the corresponding coverings, but for vertical boilers I regard the conical form as the best.

Having thus fully described its construction and mode of operation, what I claim as my invention, and desire to secure by Letters Patent, is—

1. The method of clearing the coils of sediment by reversing the steam in them.

2. The false bottom or movable plate D, to be used in the manner and for the purposes above described.

ELI THAYER.

Witnesses:
B. FRANKLIN CLARK,
S. P. POND.