HEATING BY STEAM AND WATER

A PRACTICAL TREATISE ON

HOUSE HEATING

Improved Methods of Installing Heating Apparatus in the Home. Short and accurate Rules for Computing Radiation, Heat Losses, etc. Graphic Charts showing Boiler Power and Coal Consumption. Accurate data, consisting of Charts, Illustrations and Description of how best to Heat Water for Baths, Swimming Pools, etc., etc.

Specially written and compiled for THE PLUMBERS' TRADE JOURNAL

BY CHAS. B. THOMPSON

Two Hundred and Sixty-eight Original Drawings

April, 1907

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CHAPTER XLVII.

EUROPEAN HEATING SYSTEMS.

IN France and Germany, and in some other parts of the continent, a two-pipe system of steam heating is in common use. The difference between the two-pipe steam system in Europe and that employed in this country, is that in this country a pressure is supposed to be carried through the entire system and the radiators are equipped with valves on both supply and return. The return valve must be closed to prevent the pressure carrying the water into the radiators when the supply valve is closed.

The system referred to as being in vogue in Europe carries a pressure on the steam lines only, and there being no pressure on the returns, but one valve is used, and that on the supply pipe. There are no air valves on the radiators, the air being discharged with the return water. The pipe sizes are so much smaller than

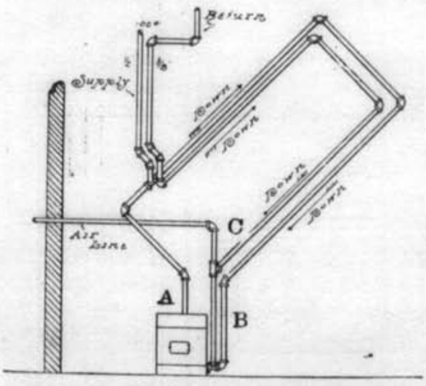


FIG. 204—PRINCIPLES UNDERLYING THE SYSTEM

those used in this country that at first glance they would seem to be entirely too small to be of any service, but the system has been in use in France and in Germany for something like twenty years, and seems to be constantly growing in favor.

Fig. 204 shows the simple principles

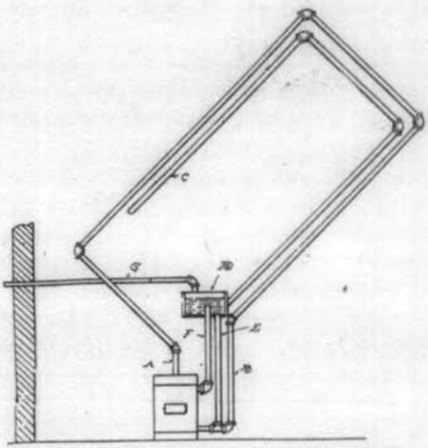


FIG. 205—STEAM HEATING IN EUROPE

underlying the system. A is the supply pipe from the steam dome of the boiler. B is the return end of the steam pipe, where it has made a circuit and re-enters the boiler. As this pipe pitches down from the boiler all the water of condensation in the pipe will be returned to the end of the line. The pipe C is the return pipe into which all the radiators drain. This pipe also enters the boiler below the water line and from the point where it drops to the boiler an air line is carried into a collecting tank and from the collecting tank a drain pipe runs to the boiler and an air pipe carries the air outside, as shown in Fig. 205.

In Fig. 205 A is the supply pipe, B the return of same to boiler, C the return main which carries the air and water of condensation, D the collecting tank, F the safety pipe, and G the air line.

The valve used on this system is a

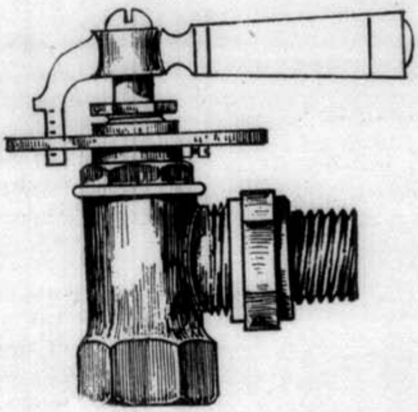


FIG. 206—A QUICK OPENING REGULATING VALVE

valve with two graduations. The first graduation, or adjustment, is set by the steamfitter who installs the work and is intended to admit no more steam than will be condensed by the radiator. When the valve is properly set and the normal pressure is on, which is usually about 1½ pounds, there will be no steam escape from the return end of the radiator.

The second adjustment of the valve is made by the householder from time to time as it is desired to use certain portions of the radiator to meet the changes in outside temperature. The valve can be so adjusted that but two loops of the radiator are in service and later in the day, when four loops are necessary, the valve is opened a little wider.

Fig. 206 illustrates one of the quick-opening regulating valves in use on this two-pipe system. The first adjustment is effected by turning down the valve stem, which decreases the opening in valve. This is done by removing the handle, which is used as a key for operating the valve stem. After the adjustment is set for the maximum quantity of steam which shall pass into the radiator, the handle is put in place and fastened with a set screw. It is then impossible for the house owner to open the valve any wider than the adjustment made by the steamfitter. The valve can be set for less steam but not for more, and after the valve is once properly adjusted for a given sized radiator, excellent results are obtained by its use.

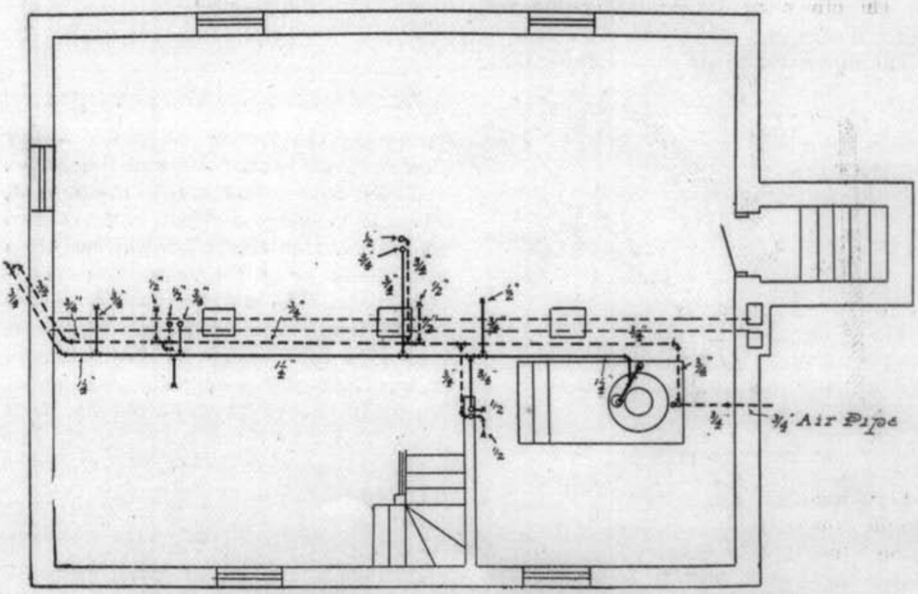


FIGURE 207—STEAM HEATING IN EUROPE—BASEMENT FLOOR PLAN

From this point of view the system described would seem to be much superior to any steam heating system in this country. But this system has its defects.

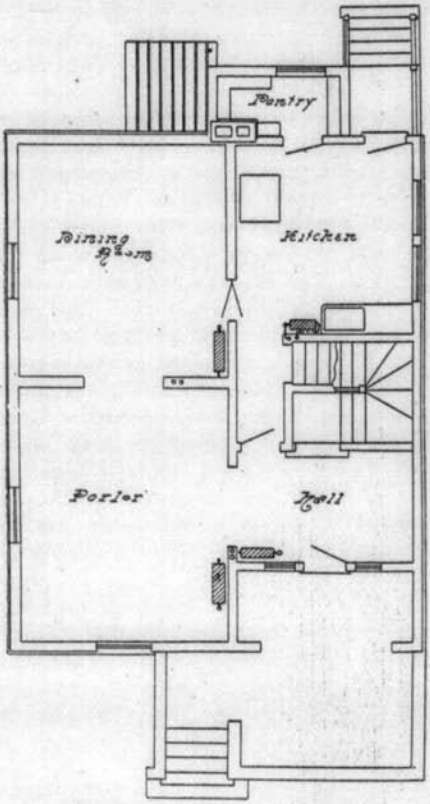


FIG. 208 FIRST FLOOR PLAN

Owing to the necessity of carrying a pressure on the steam lines and no pressure on the returns, the water will rise in the return pipe until a head is reached which will balance the initial pressure. If the pressure carried is 2 pounds then there must be a difference of about 4 feet between the water line of the boiler and the lowest part of the piping, and for this reason the engineers of Europe have been working to install the apparatus so that a pressure less than 2 pounds may be carried on the system. It is now generally conceded by the best engineers in France and Germany that 1½ pounds pressure is the minimum pressure which can be carried on this system, which necessitates a difference between the water line and the lowest point of the piping of about 3 feet. In many installations it is necessary to make a pit for the boiler, to get the necessary height in the basement above the water line.

The system described is frequently referred to as the "French" System, and at other times as the "German" system. As a matter of fact almost every engineer in Europe has his own peculiar method of installation. The principle may be the same in every case but each engineer strives to give the impress of his individuality to his work, both in design and execution.

In some installations the collecting tank is not used but the air pipe goes directly to the atmosphere and is left open at all times. In other installations a complex arrangement of tanks and condensing radiators is used, but each system is based on the principle of the regulating valve with pressure on the supply lines and no pressure on the returns.

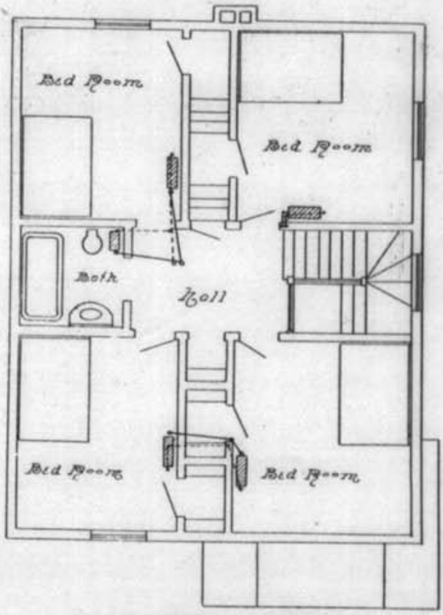


FIG. 209—SECOND FLOOR PLAN

The pipes used in this system are usually ½ inch to the radiator, with a ⅜-inch, and sometimes a ¼-inch return. It

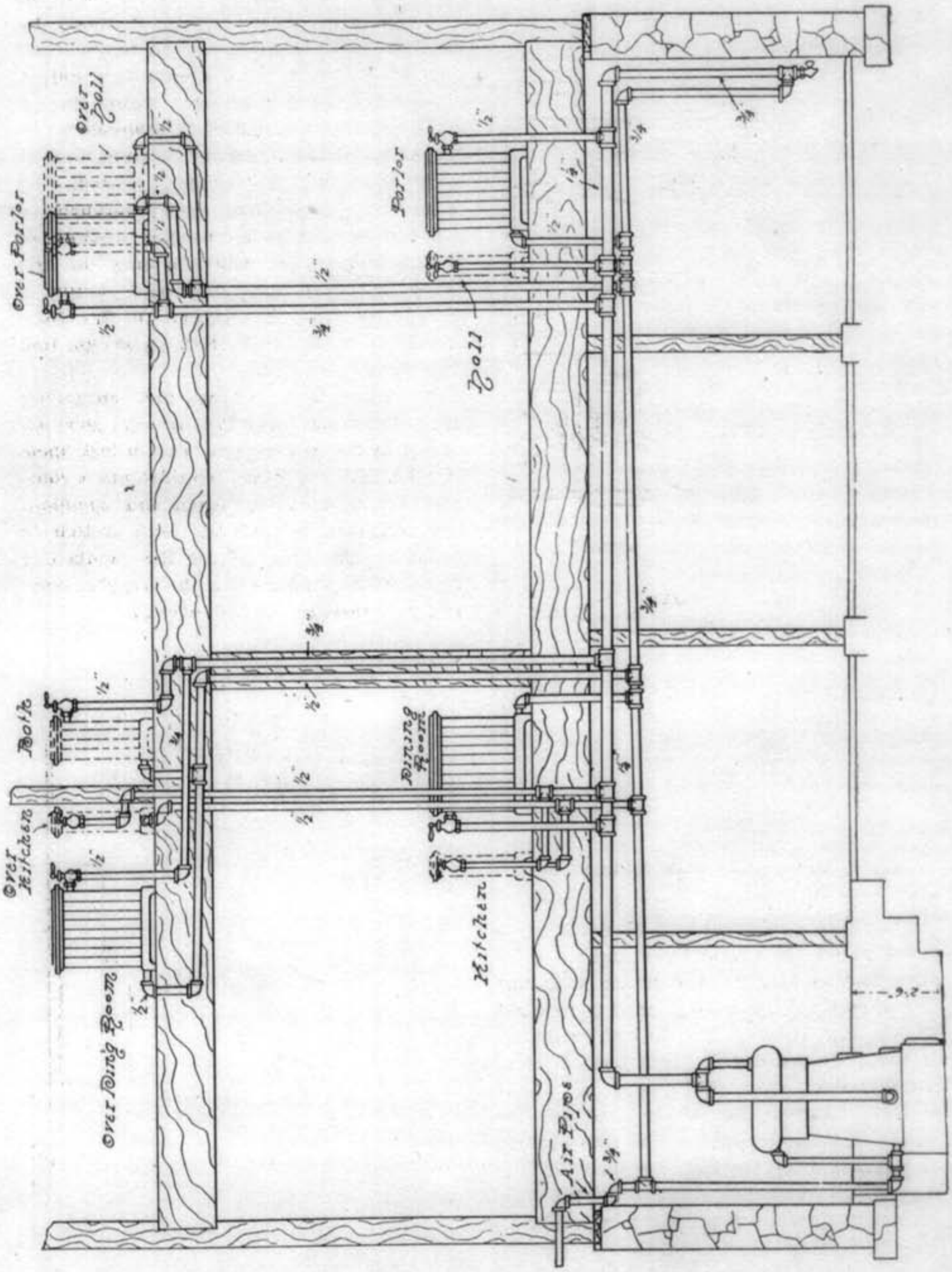


FIG. 210—ELEVATION SHOWING THE BOILER SETTING IN A PIT IN THE BASEMENT AND THE VARIOUS RADIATOR CONNECTIONS

is not unusual to see a radiator containing 100 square feet connected by a ½-inch supply and a ⅜-inch return.

In many installations copper pipe is used, as it can be easily bent, and the Continental fitter uses as few fittings as possible, preferring to bend the pipe into the required shape. This process would be considered rather slow in this country.

The claim having been made that this system was of French or German origin, and the question being frequently asked why such a system was not in favor in the United States, the late Mr. Frederic Tudor, in the "Engineering Review" of September and October, 1901, explains the origin of the system, and shows by patent drawings that he was the original inventor. Mr. Tudor in his paper gives a sketch of the condition of the heating business when he entered it in 1875 in the following words:

"When I went into the business of heating and ventilating, the art was at the lowest possible ebb. The extraordinary impetus given to it by the triumvirate of genius, Walworth, Nason and Briggs, had come to naught through the want of popular appreciation and the inexplicable apathy and indifference of the architects. Ignorant of this fact then, and merely witnessing the wretched state of the art, I inferred that there was an opening for engineering skill in devising better processes than were then in vogue. Influenced by this belief, by personal reasons, and especially by a confidence that I should succeed in a new and congenial field of activity, I decided to give up my practice as civil engineer and take up that of sanitation. This was in 1875. The following ten years were years of incessant trial and struggle against established houses and antiquated customs, against precedent, prestige and prejudice, during which period I originated, developed and perfected most, if not all, of the modern systems of heating and ventilation. In doing this I utilized established principles for all they were worth. I invented and applied new ones; and the merit of my combinations rested chiefly in the fact that they were harmoniously related, practical and manageable. I set before myself the problem, exactly what was to be accomplished; then I chose, as a matter of engineering, processes that would produce the result required. The miserable condition of the trade from an engineering standpoint was due to the ignorance of many of those in whose hands it was at that time; they neither knew what they wanted to accomplish, nor had they the knowledge and skill to solve a problem when it was submitted to them.

"The complete revolution in this art that has taken place in the last twenty-five years is to be ascribed to me, and was set on foot at that time. This is all a matter of record, and I do not care to go into it further in this place, except so far as it will throw light upon the questions of Mr. Debesson. The only part of this development that I had no hand in at all is the so-called American system of low-pressure gravity steam-heating. This had already been brought to perfection by Massachusetts and, chiefly, Boston mechanics. It must be admitted, as Professor Carpenter and other members of the Society of Heating Engineers claimed, that it is a perfect working system, extremely simple in its construction and operation.

"But these are virtues that can be appreciated by the engineer only; he alone understands what has been accomplished by the system, and how, through it, a perfect and

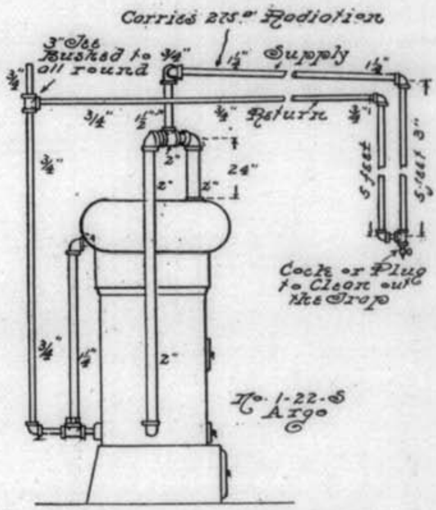


FIG. 211—BOILER CONNECTION

noiseless circulation has been made possible. The users of the system know nothing about this, and they ask how it is that engineering skill is unable to do away with the coarse pipes and fittings that are in the way of furniture, and besides occupying valuable space, overheat their rooms even when the radiators are shut off; nor why the heat of the latter cannat be graduated to the requirements, and controlled in a simple way. Why can one not turn on a little heat, just as one turns on gas or water, by a single, easily manipulated valve? Why should it be necessary to send for a man or stout boy to operate the two factory-like implements that control the heat, whenever it is necessary to change the heat of the room? The whole steam-heating outfit is adapted more appropriately to factories than dwellings, and seems to be intended for work-

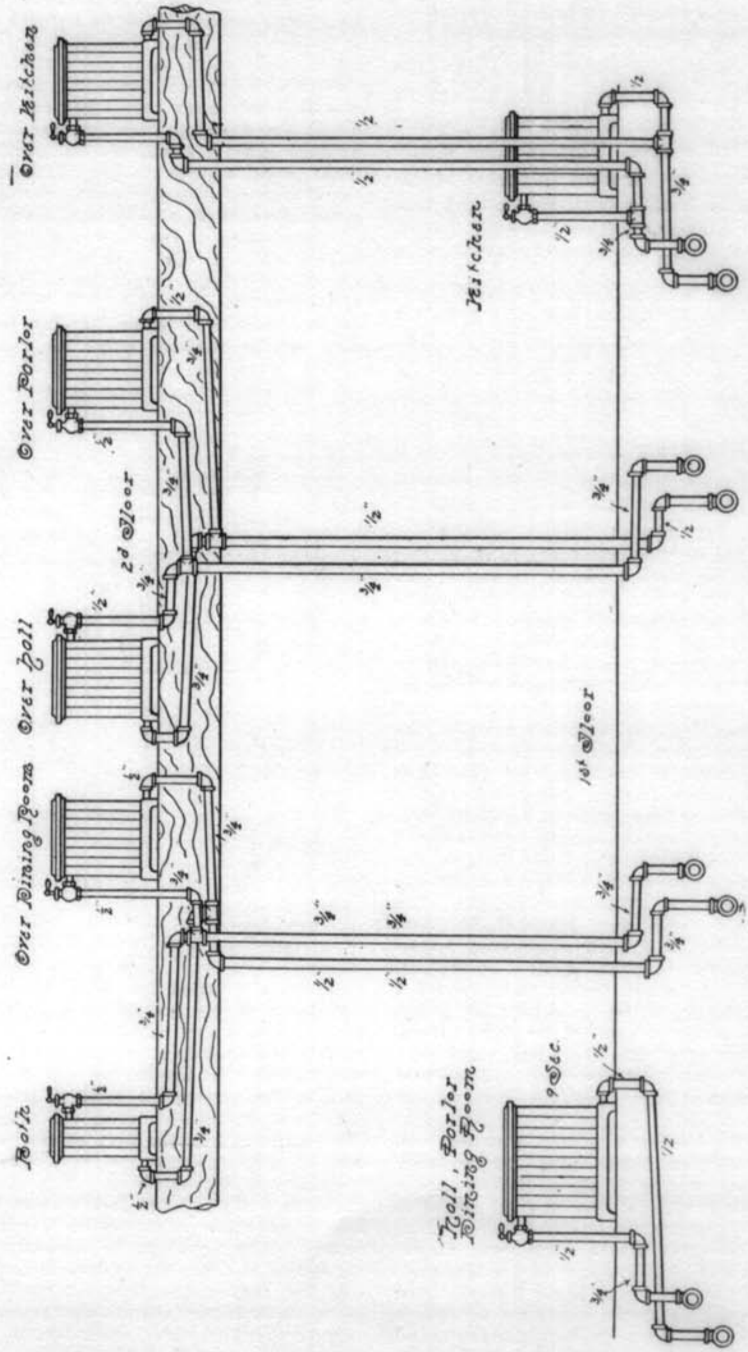


FIGURE 212—STEAM HEATING IN EUROPE—SECTIONAL VIEW SHOWING THE RISERS

ing mechanics to handle. The comfort and convenience of the average citizen, and especially of the average woman, have not been considered by steam-heating engineers.

"All these objections were perfectly plain to me when I entered into the business of heating, but previous to 1880 I had all that I could attend to in improving the art of ventilation in connection with heating, and I had very little to do with heating by direct radiation. After all its advantages have been summed up, in the important respects of health and comfort, it is seen to be a vile system, and it did not interest me except to imagine how it could be improved."

Mr. Tudor then goes on to explain the various systems which he had patented and how a restricted nipple into a radiator led to the invention of the regulating supply valve.

He also states that it is his belief that the reason the system was not adopted in the United States was due to the fact that he controlled the patents and no one was willing to pay him any royalty, but instead did everything in their power to discourage the use of any device which he had patented.

Figs. 207, 208 and 209 are the basement, first floor and second floor plans of a building equipped with the French or Tudor system of steam heating.

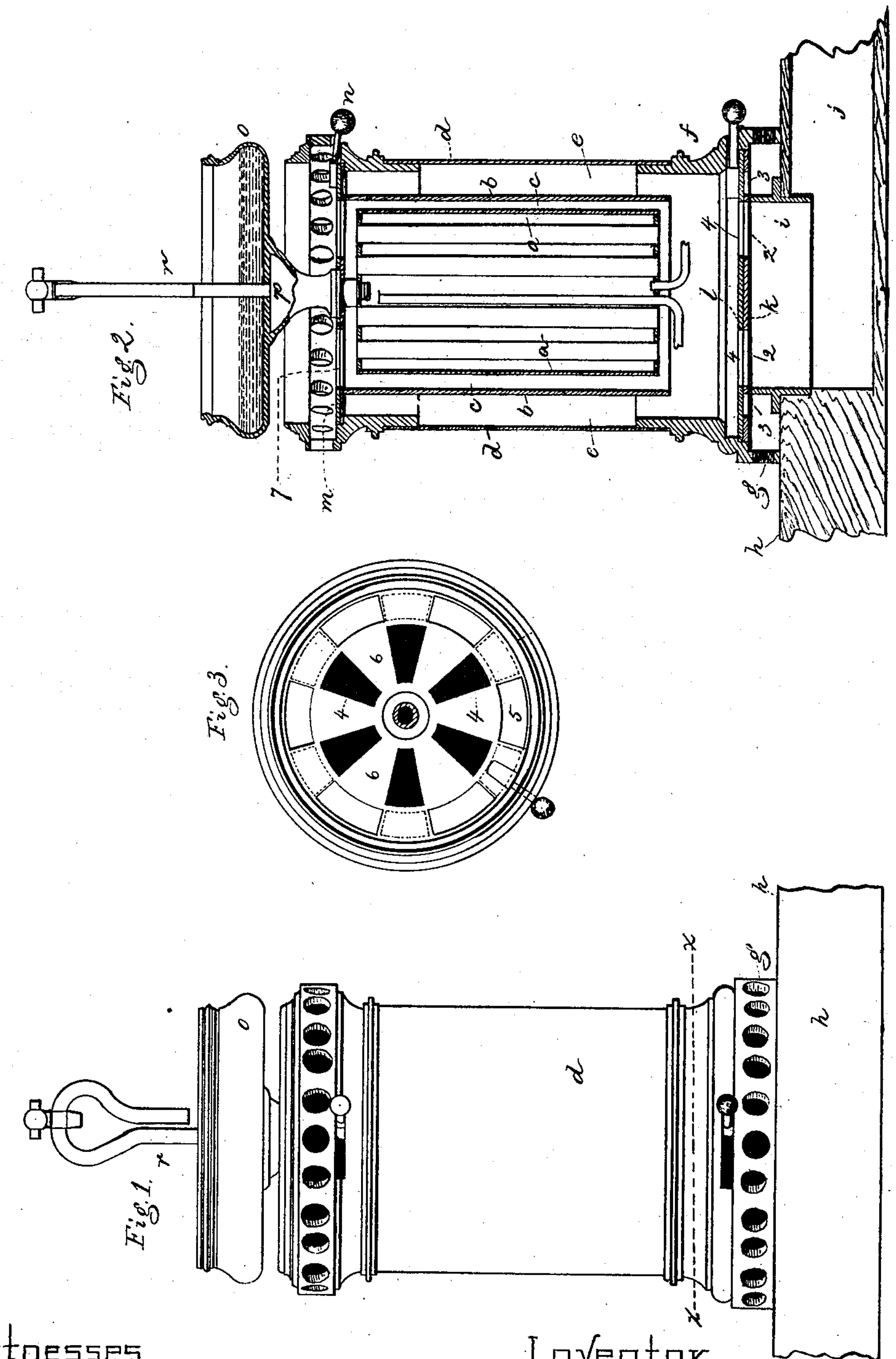
Fig. 210 is an elevation showing the boiler setting in a pit in the basement, and the various radiator connections.

Fig. 211 is a view of the method of connecting the piping to the boiler.

F. TUDOR.

STEAM RADIATOR.

No. 185,146. Patented Dec. 5, 1876.



Witnesses.

L. H. Latimer.

W. J. Pratt.

Inventor.

Frederic Tudor

per Crosby & Gregory Attys.

THE GRAPHIC CO. N.Y.

UNITED STATES PATENT OFFICE.

FREDERIC TUDOR, OF BOSTON, MASSACHUSETTS.

IMPROVEMENT IN STEAM-RADIATORS.

Specification forming part of Letters Patent No. **185,146**, dated December 5, 1876; application filed September 7, 1876.

To all whom it may concern:

Be it known that I, FREDERIC TUDOR, of Boston, in the county of Suffolk and State of Massachusetts, have invented an Improved Steam-Radiator, of which the following is a specification:

This invention relates to a radiator for warming and ventilating buildings or apartments; and consists in the combination, in a steam-radiator, of casings and air passages or valves, whereby both the volume of fresh air admitted and the temperature of the air warmed are easily regulated; also, in the combination, with the radiator, of an evaporator or reservoir of water, which is heated by the steam circulating within the radiator, whereby a more abundant evaporation of water is obtained than by the ordinary shallow vessel, which is heated chiefly by radiation or conduction from the hot surfaces of the source of heat.

Figure 1 represents, in front elevation, a radiator constructed in accordance with my invention; Fig. 2, a vertical section thereof; and Fig. 3, a horizontal section on line *x x*, Fig. 1.

In the drawing, *a* represents the source of heat, it being a system of steam-pipes, as shown. About this source of heat *a* is placed a casing, *b*, leaving an air-space, *c*, and about the casing *b* is placed an outer casing, *d*, leaving a space, *e*, for the circulation of cold air. In this form of this invention the base of the apparatus is shown at *f*, it being provided with air-passages *g*, communicating with the air of the apartment near the floor *h*. A flue, *i*, connects the base with the passage *j*, communicating with the outer or cold air. In a disk, *k*, of the base, placed above these passages *g i*, I form a series of openings, 2 3, those marked 2 communicating with the external cold-air passage *j*, and those 3 with the air-passages *g*, opening into the apartment. Above the disk *k* I place a receiving-valve, *l*, provided with openings 4 5, so located, with relation to each other, that when one of the series of passages, 2 or 3, is uncovered the other series is closed by a portion of the valve, (see Fig. 3,) wherein opening 5 of valve *l* communicates with the opening 3, the portion 6 of the valve then covering the openings 2. Above the source of heat is placed a delivery-valve, *m*, made substantially as valve *l*, and adapted to communicate with either the cold-air space *e* or the hot-air space *c*.

In cold weather the valve *m* will be made to close the openings leading from chamber *e*, and the cold air then passing through the chamber *c* will be heated by the source of heat *a*, and be discharged from the openings 7 of the valve *m* into the room. This air to be heated may be supplied to chamber *c* from either the outer cold-air flue *j*, or from the apartment near the floor, through openings *g*.

If the weather is mild the valve *m* may be turned, and cut off the passage of air upward from chamber *c*, and then the air passes through chamber *e*, and is not heated, for the casing *b* does not become sufficiently heated by radiation to affect the air in space *e*.

From the foregoing explanation, and the construction shown in the drawing, it is evident that the air admitted from the apartment near the floor, or from the outside of the building, may be conducted either through the space *c*, when it will be heated, or through the space *e*, when it will not be heated. In apartments occupied with but few persons the air may be taken at openings *g*, near the floor of the apartment. By this apparatus the volume of heated or cold air may be regulated at will.

In some forms of heating apparatus hot air from the source of heat, and fresh air from without, are led into a common duct, and mixed by means of valves working independently of each other. Such forms of apparatus required two cold-air ducts—one to the source of heat, and one to the mixing-chamber—and if the valve of one duct was closed, the volume of fresh air admitted was reduced one-half.

With my apparatus the volume of fresh air admitted is a fixed quantity, and the temperature is regulated by simply causing a portion to pass outside the inner casing, through chamber *e*, by partially or wholly closing the hot-air-delivery valve or register *m*. The quantities of air taken simultaneously from within and without the building may be regulated by the valve *l*.

It is understood that the form of the outer casing *d* and of the valves *l m* may be changed without departing from this invention. I prefer to have each valve so constructed that when it closes one series of openings it will open the other series; but instead of this single valve *l* or *m* I may employ two or more independent valves, which may be operated separately.

By covering the source of heat *a* with a casing, *b*, leaving an air-space, *c*, and closing the openings leading from *c* into the apartment, I am enabled, practically, to shut off the radiation of heat into the apartment. The evaporator *o* is a pan with a hollow shell, *p*, into and from which steam from the source of heat passes, thereby heating the contents of the pan, and evaporating the water more rapidly than if the pan was simply placed on a heated plate, as commonly done. The size of this evaporator and its hollow shell are proportioned, as shown in the drawing, so that the heat will never be sufficient to boil the water in the evaporator. The outer casing *d* may be an inclosing-wall.

In some instances I may omit the valve that covers the top of space *e*, leaving such space always open. In such case the area of space *e* will be equal to, or greater than, the area of the cold-air box.

I claim—

1. The source of heat *a*, casing *b*, and outer casing, in combination with a valve to close or open the chambers *c e* for the passage of heated or cold air, and with a valve to regulate the cold-air supply from outside the apartment.

2. The source of heat *a*, casing *b*, and outer casing, in combination with a valve to close or open the chambers *c e* for the passage of heated or cold air, and with a valve to regulate the cold-air supply from without or within the apartment, substantially as described.

3. In a steam-radiator for warming and ventilating buildings, an evaporator, *o*, provided with a hollow shell, *p*, in combination with, and connected with, the source of heat *a*, to permit the circulation of the steam in the casing of the evaporator, all constructed and proportioned, with relation to each other, substantially as described.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

FREDERIC TUDOR.

Witnesses:
G. W. GREGORY,
L. H. LATIMER.

F. TUDOR & Q. N. EVANS.
Steam-Radiator.

No. 224,055. Patented Feb. 3, 1880.

Fig:1.

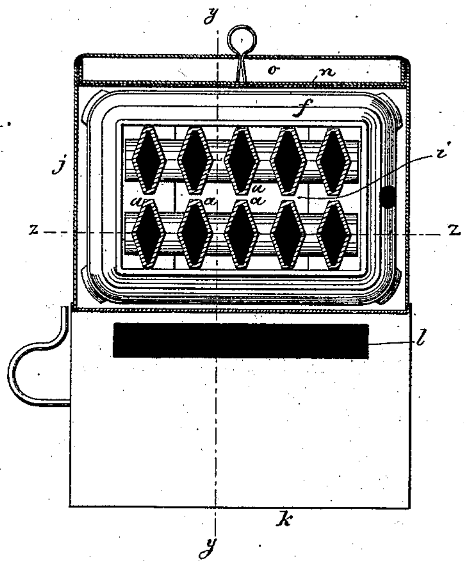


Fig:2.

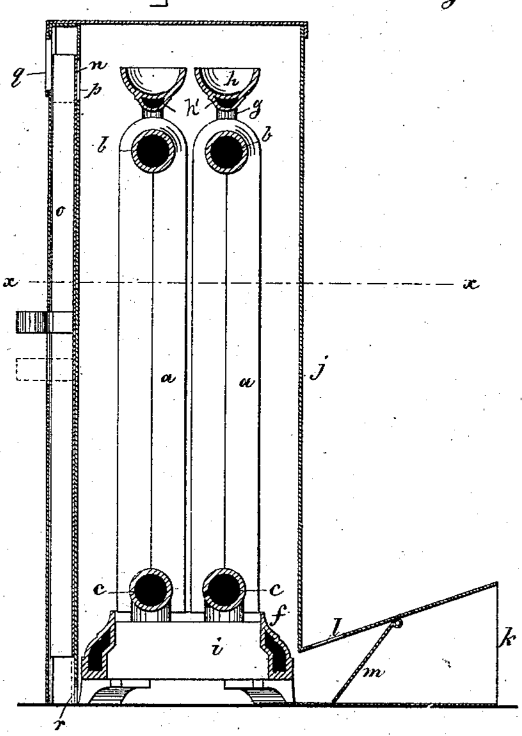
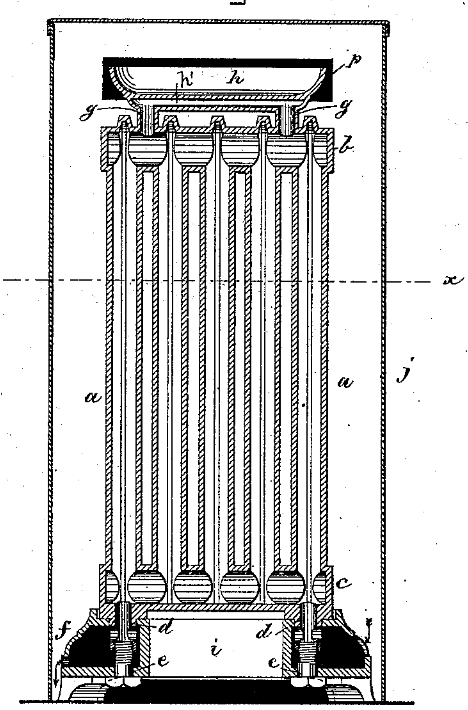


Fig:3.



Witnesses.
W. J. Pratt.
E. C. Perkins.

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Frederic Tudor and Quinby N Evans
by Crosby & Gregory
Attys

United States Patent Office.

FREDERIC TUDOR AND QUIMBY N. EVANS, OF BOSTON, MASSACHUSETTS.

STEAM-RADIATOR.

SPECIFICATION forming part of Letters Patent No. 224,055, dated February 3, 1880.

Application filed September 18, 1877.

To all whom it may concern:

Be it known that we, FREDERIC TUDOR and QUIMBY N. EVANS, both of Boston, in the county of Suffolk and State of Massachusetts, have invented an Improvement in Steam-Radiators, of which the following is a specification.

This invention relates to steam-radiators; and it consists in the combination, with a section of a radiator, of attached hollow steam-legs adapted to fit openings in a radiator-base, and fastened thereto by tap-bolts which serve to draw the section and base together; also, in the combination, with the cast-iron section, of a base having a central air-space, the lower portion of the section being placed across the opening of the air-space to permit the air to impinge against the bottom of the section and circulate freely among the pipes; also, in the combination, with a steam-radiator, of an inclosing-case adapted to be supplied with air from within or outside of the building, and provided with a register to regulate the quantity of heated air to be admitted into the room.

Figure 1 represents a sectional top view of one of our radiators placed within a case, the section being on the line *x x*, Fig. 2; Fig. 2, a vertical section thereof on the line *y y*, Fig. 1; and Fig. 3, a vertical section on line *z z*, Fig. 1.

The hollow cast-iron pipes *a a* composing each section—preferably from six to twelve pipes—are cast as integral parts of the steam-chambers *b c*, such chambers connecting the ends of the pipes.

Each steam-chamber *c* is provided with hollow steam-legs *d*, provided at their lower ends with screw-threads to be engaged by a tap-bolt, *e*, inserted through the base *f*, to enable the section to be held in close contact or steam-tight with relation to the base.

The steam-chamber *b* is bored to receive the hollow steam-supplies *g*, projecting from the hollow shell *h'* of the evaporating-pan *h*, so as to afford free circulation of steam from the chamber through the hollow portion of the pan.

The base *f* is provided with an open central air-space, *i*, directly across which the base of each section is placed, as shown in the drawings, so that air rising through such air-space meets the lower end of the section and circulates freely upward. Allowing the air to pass in this way in contact with the entire section heats it more effectually than if the air merely passed upward between the sections.

Casting the sections in one piece, but with separated pipes, and connecting the sections with the base, as described, enables the production of a radiator at a much less price than if the legs or pipes were screwed independently to the base, as heretofore common.

The case *j*, surrounding the radiator, has an inlet, *k*, to receive air from without the building, and an inlet, *l*, to receive air from the apartment in which the case is placed. A register, *m*, controls the openings of these two inlets, and determines which shall admit air into the casing. This casing is also provided with a register, *n*, with an air-space, *o*, and with air-passages *p q r*.

When the register is placed to close the air-passage *r*, the air admitted to the case circulates freely over the radiator and out through the passages *p* and *q*.

When register *n* is closed *r* will be open, and the admitted air passes beneath the radiator through passage *r*, space *o*, and passage *q*.

The mean temperature of the air discharged at *q* will depend upon the position of the register *n* with relation to the passages *p* and *r*.

We claim—

1. A steam-radiator section composed of hollow tubes and steam-chambers, cast together, as described, and provided with hollow steam-legs, in combination with a radiator-base and tap-bolts, substantially as described.

2. The combination, with the cast-iron section, of a base provided with a central opening, the bottom of the section being extended directly across such opening, substantially as and to operate as described.

3. The combination, with a steam-radiator, of an inclosing-case provided with passages *k l r p q*, and with registers *m n* and air-space *o*, to operate substantially as described.

In testimony whereof we have signed our names to this specification in the presence of two subscribing witnesses.

FREDERIC TUDOR.
QUIMBY N. EVANS.

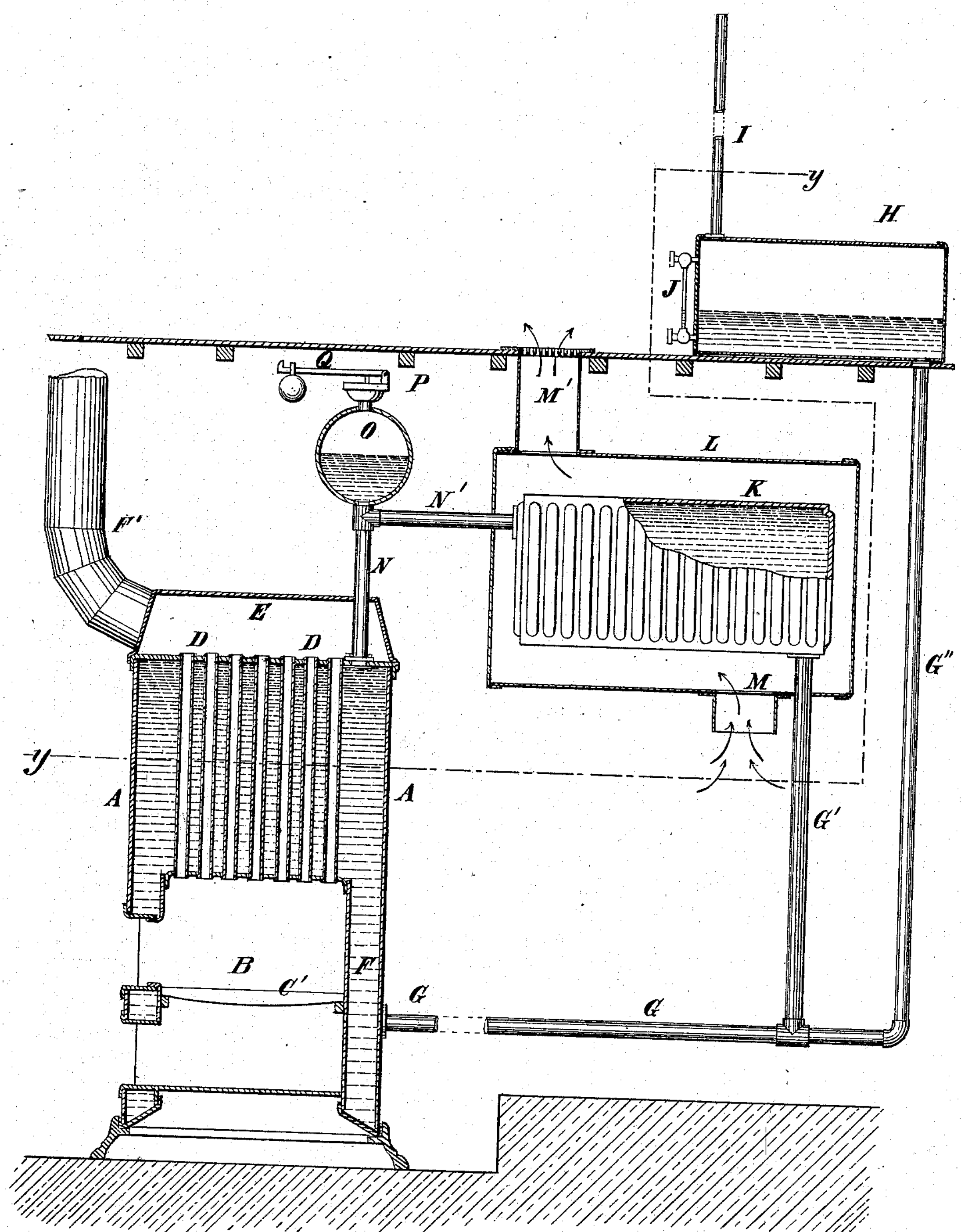
Witnesses:
G. W. GREGORY,
W. J. PRATT.

(No Model.)

F. TUDOR.

STEAM AND HOT WATER HEATING APPARATUS.

No. 278,636. Patented May 29, 1883.



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Jno. E. Gavin

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Attorney

N. PETERS. Photo-Lithographer, Washington, D. C.

UNITED STATES PATENT OFFICE.

FREDERIC TUDOR, OF BOSTON, MASSACHUSETTS.

STEAM AND HOT-WATER HEATING APPARATUS.

SPECIFICATION forming part of Letters Patent No. 278,636, dated May 29, 1883.

Application filed October 5, 1882. (No model.)

To all whom it may concern:

Be it known that I, FREDERIC TUDOR, of Boston, in the county of Suffolk and State of Massachusetts, have invented an Improvement in Steam and Hot-Water Heating Apparatus; and I do hereby declare that the following is a full, clear, and exact description of the same, reference being had to the accompanying drawing, forming part of this specification.

My invention relates to apparatus of the kind named, whether the heat be applied by what is known as "direct" or "indirect" radiation. The drawing, however, illustrates the improvement only as used in a system of apparatus for supplying heat by indirect radiation; and as the principle and action of the invention are sufficiently shown in such an apparatus, it will be unnecessary to elaborately show or describe its application to a system of direct radiation.

The object of the improvement is to supply an apparatus which can be used either for heating by hot water or by steam, according to the degree with which the fire is urged in the furnace—that is to say, it circulates hot water with a moderate heat maintained in the furnace, and steam when a more intense heat is kept up, the heating by hot water being more desirable and more easily controlled in moderate weather than steam-heating, while for intensely-cold weather steam-heating is preferable.

The drawing represents partly a side view and partly a sectional view of an apparatus designed to effect the object set forth.

The boiler A is shown as a vertical tubular boiler; but the invention is not confined to this type of boiler, and any other approved kind of boiler may be used.

B represents the furnace; C, the grate; D, the vertical tubes; E, the smoke-box, and F' the uptake. The water-space is shown by shade-lines between the shell A and tubes D, which latter are inserted into the crown-sheet and flue-sheet and fastened by expanding them in the usual manner.

At F is shown a water-leg which passes around the furnace B, and into the lower part of which is inserted a pipe, G. The pipe G connects the water-leg F with a relief-tank, H, which also, within certain limits, performs the functions of a hydrostatic-pressure regulator for regulating the pressure at which steam will circulate through the system of pipes and radiators employed for distributing heat, as will hereinafter appear. From the relief-tank H rises a stand-pipe, I, which acts as hereinafter explained, and to the side of said tank is attached a water-gage, J, for indicating the height of water in the said tank. A branch pipe, G', leads from the pipe G to the bottom of the indirect radiator K, which is inclosed in of the usual case, L, and supplied with an inlet, M, and outlet M' for ingress and egress of air to be heated and circulated. A pipe, N N', also leads from the top of the water-space in the boiler A to the upper part of the radiator K. The part N of the pipe N N' is in this example of my improvement placed in a vertical position, and at its top is affixed an air-trap, O, preferably of spherical form. This air-trap is furnished with a valve, P, held to its seat by a weighted lever, Q, after the manner of a safety-valve, which it is in fact. When this valve is opened it will permit escape of the air, which, when expelled from the water by heat, rises first to the top of the boiler, and thence passes through the pipe N into the air-trap O. This valve P will therefore serve as a safety-valve, so as to open automatically when the pressure to which it is set is exceeded, and thus relieve the apparatus of undue pressure, and it will at the same time serve as an air-cock to permit the removal of air accumulated in the trap O when the valve is opened by hand, as will be understood.

Now, the apparatus will act either as a hot-water heater or as a steam-heater, according to the intensity of the heat maintained in the boiler-furnace. The drawing shows it as when performing the function of a hot-water heater. In this use of the apparatus only a moderate heat is maintained in the furnace, and the pressure in the boiler is, by the water-column rising from the water-leg of the boiler to the level in the tank H, maintained at a point at which the nascent steam generated in the boiler will not be sufficient to depress the water-level in the water-space of the boiler A. The boiler therefore remains filled with water, which also fills the pipes G N N', radiator K, and rises in the tank H to the level shown. This level of the water in the tank should be sufficiently above the top of the boiler to provide a water-column sufficient to keep the water under some tension in the boiler, and thus compel it to become heated therein to a temperature corresponding to this tension, yet not allow it to generate steam sufficient to expel the water from the boiler or its connected circulating-pipes, &c., as will be understood. The normal level of the water in the tank, or rather the position of the water-tank above the boiler, may hence be higher or lower, according to the tension or temperature desired to be imparted to the water-circulation, without its giving off free steam, as will be understood, and which may be varied as circumstances require. Under these conditions, therefore, the water will be effectually heated in the boiler to or above the boiling-point, (according to the height of the tank H,) and will thence circulate through the pipes N N′ into and through the radiator K, and thence back to the boiler through the pipes G′ and G, thus maintaining a constant circulation of hot water through the radiator K and boiler A; the boiler, when the apparatus is thus used, being a water-heater rather than strictly a boiler.

It may be noted that the water-tank H is closed at the top, and from the top a stand-pipe, I, rises to any suitable height, limited by the limit of steam-pressure permissible in the apparatus, the stand-pipe being preferably open at the top to the atmosphere, although it may be closed, if desired. Now, the tank should be of such a size that the space between its closed top and its normal water-line, as shown, should be equal to the capacity of the pipes N N′, the radiator K, and the steam-space of the boiler when used for generating steam—that is, the space from the flue-sheet of the boiler to its steaming water-line *y y*. It will therefore be now understood that if, while the apparatus is acting as a circulating-water heater, as previously described, and as shown in the drawing, the fire be now urged in the furnace so as to heat the water rapidly in the boiler and to a high temperature sufficient to generate a pressure of steam exceeding the pressure of the water-column from the tank H, this steam will then immediately accumulate in the top of the boiler and in the upper part of the heating system, and thus commence to at once expel the water from the boiler and the pipes N N′ and radiator K through the pipe G′ and G″ into the tank H. The water will thus continue to flow out of the boiler and out of the pipes and radiators, being displaced by the steam, and the expelled water will thus continue to rise in the tank H until the water of the boiler is depressed to the water-line *y y*, and until the water is all expelled from the radiator K and its pipes N N′ from the upper part of pipe G′ down to the water-line *y*, by which time the water-tank will be filled to the top, and the water will thence commence to rise in the stand-pipe I. As the water begins to rise in the stand-pipe a sudden and greatly increased hydrostatic pressure will thus be exerted on the mass of water, which will hence cause the limit of the expelling action of the steam to be reached, so that the water will now remain supported in the tank by the pressure of steam, and the water-column in the stand-pipe will oscillate up and down slightly as the pressure of the steam increases or diminishes, while the steam will continue to flow from the boiler through the pipes N N′ into the radiator, and there condense and give off its heat, while the condensation will trickle into the pipe G′ and return to the boiler, thus maintaining a nearly constant water-level in the boiler, while the water is being constantly distilled off and diffused through the pipes and radiators in the form of live steam under any desired pressure—say, preferably, five to ten pounds to the square inch—and thence returned to the boiler after condensation. The apparatus thus forms a most efficient steam-heater when operated in this way, and which becomes self-acting and very safe and economical. If the pressure of steam increases in the boiler and radiator, the water-column will rise correspondingly in the stand-pipe I, and thus tend to check, restrain, or limit the pressure; but if the steam-pressure at any time exceeds the pressure which it is desired to maintain the safety-valve P will open and relieve the apparatus of the excess, as will be readily understood. In practice, however, the boiler will be provided with a damper-regulator, in precisely the same manner as commonly employed in heating boilers, so that the steam-pressure, when at its maximum, will act to distend the diaphragm of the regulator, raise a weighted lever, and thus close the damper, while the descent of the lever when the pressure falls will act to open the damper in the usual way, thus tending to maintain a uniform steam-pressure in the heating system, as will be understood.

When steam heat is not desired any longer, owing to the mildness of the weather or other cause, the fire in the boiler-furnace may be checked or allowed to decline, when the steam-pressure will immediately fall and the water will gradually subside from the tank I and return into the radiator and boiler, so as to fill the same, as before, and thus form a hot-water-circulating apparatus, as first described, and shown in the drawing, which will provide a more gentle heat than the steam, as will be understood. The entire apparatus thus becomes self-acting, so that to operate as a water-heater it is only necessary to shut the ash-pit door, and thus check the fire, while to operate as a steam-heater the ash-pit door is opened wide, thus allowing the fire to burn brightly, when the damper-regulator will now automatically control the pressure of steam generated, as will be understood.

The proper level for the normal water-line in the tank H, as shown in the drawing, when the apparatus is acting as a water-heater, will be indicated by a distinct mark on the gage-tube J, so that the space above the water-line will be of the correct capacity to receive all the water expelled from the boiler, the pipes, and radiators when the action of the apparatus changes to steam-heating. This water-level can be readily found by calculation or experiment, and when marked on the gage no further attention is necessary, except to occasionally add some water to the tank, so as to make up for any slight losses by evaporation or leakage, and thus keep its normal water-line constant, or nearly so.

If desired, the stand-pipe I might be dispensed with and in its place a float-valve substituted, which would act to shut the air-vent at the top of the tank when the water rose to the desired limit, thus preventing the further rise of the water, or confining a cushion of air above it, which would be the equivalent of the stand-pipe in offering a sudden increased resistance to the motion of the water, which would prevent any more from being expelled from the boiler, and thus compel the apparatus to then act as a steam-heater, as already described. I much prefer the stand-pipe, however, as it is very simple, inexpensive, and efficient. Hence by this means a simple and efficient heating apparatus is provided whose action can be automatically and economically adapted or changed for either high or low heating, suited for either mild or severe weather, thereby enabling the heating effect to be readily adjusted to the changes in the weather.

A very convenient means of preventing the overheating of apartments in mild weather is thus afforded by the automatic substitution of hot water for steam, controlled solely by the intensity of the fire in the furnace; and one of the important difficulties in the management of steam-heating apparatus as heretofore constructed is thereby removed. An economy of fuel is also secured as a collateral advantage, because all surplus heat supplied to apartments is of necessity, for the most part, allowed to go to waste, windows or ventilators being opened wider for its escape, which excessive wasteful and unpleasant disposition of the heat is obviated in my system.

The radiator K may of course be replaced by any other appliance for receiving hot water or steam and emitting a distributing heat therefrom without in any wise departing from the principle and operation of my invention.

Having thus described the construction and operation of my improvement, what I consider as my invention is as follows:

1. A heating apparatus adapted to heat either by circulating water or steam, and to shift from one condition to the other, as required, consisting of a boiler, in combination with one or more radiators connected with the top and bottom of the boiler, with a charge of liquid filling the same and forming a water-circulating system, together with an overflow tank or receptacle connected with the base of the system, and adapted to receive the liquid from the circulating system down to the steaming water-line of the boiler when said water is expelled by generation of steam, and to resist the further expulsion of liquid, whereby the apparatus will act as a steam-heater when the fire is increased and as a water-heater when the fire is decreased, substantially as set forth.

2. A combined water and steam heating apparatus, consisting in the combination, with a boiler, A, of a radiator, K, placed above the steaming water-line of the boiler, and connected with the top and bottom thereof, and a charge of liquid filling said boiler, radiators, and connections, together with the closed tank H, connected with the base of the boiler or its connections, and acting to receive the liquid expelled from the radiator and steam-space of the boiler, and to resist the further expulsion of liquid, substantially as and for the purpose herein shown and described.

3. The combination, with a boiler, A, of a radiator, K, connected with the boiler to form a water-circulating system, with the closed tank H, connected with the base of said system, and stand-pipe I rising from said tank, substantially as and for the purpose set forth.

4. The combination, with the boiler A, radiator K, and tank H, connected substantially as set forth, of the air-trap O and valve P, substantially as herein shown and described.

FREDERIC TUDOR.

Witnesses:

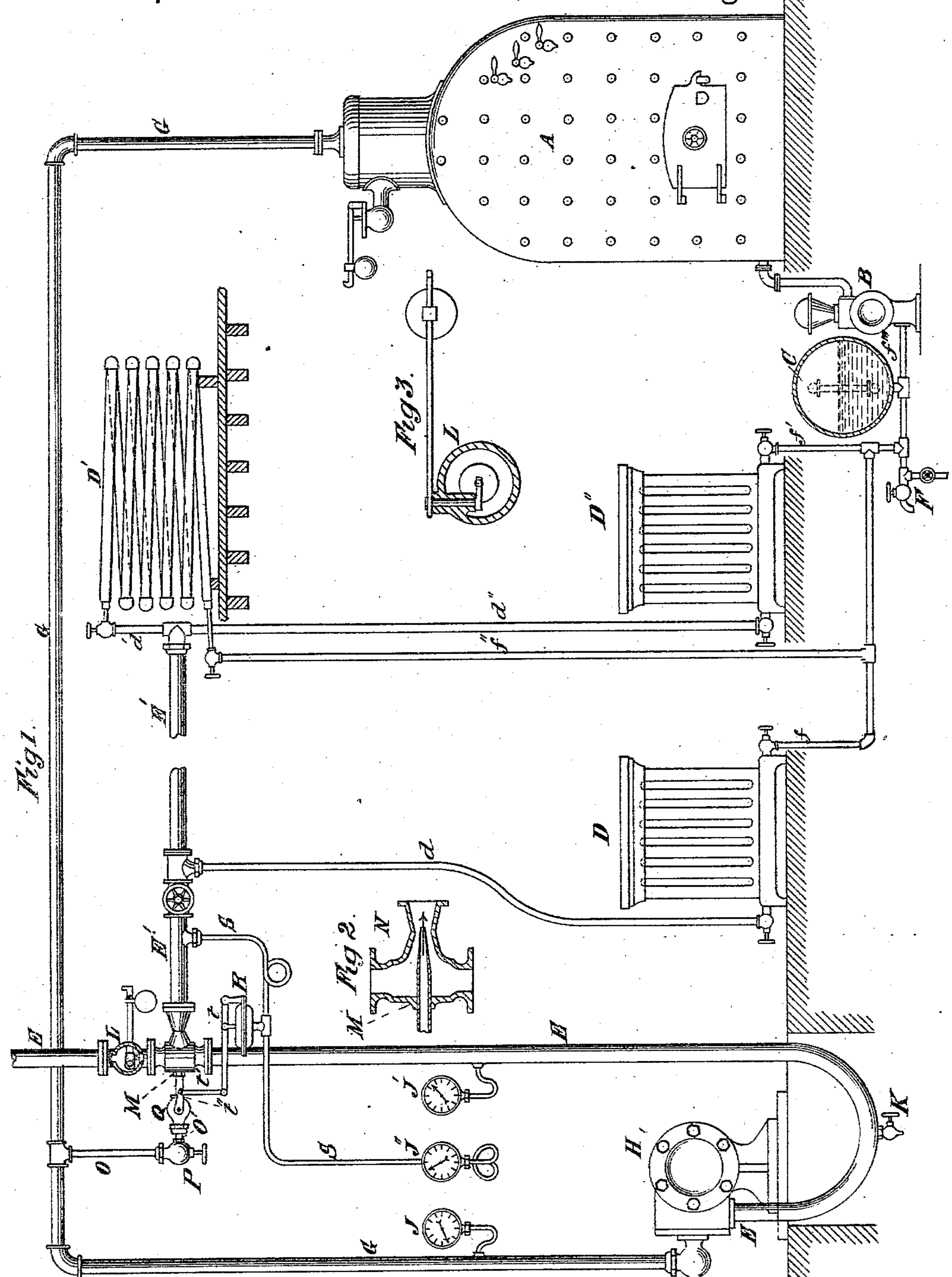
ROBERT JACKSON,
JNO. E. GAVIN.

(No Model.)

F. TUDOR.

APPARATUS FOR HEATING BY EXHAUST STEAM.

No. 283,537. Patented Aug. 21, 1883.



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UNITED STATES PATENT OFFICE.

FREDERIC TUDOR, OF BOSTON, MASSACHUSETTS.

APPARATUS FOR HEATING BY EXHAUST-STEAM.

SPECIFICATION forming part of Letters Patent No. 283,537, dated August 21, 1883.

Application filed October 14, 1882. (No model.)

To all whom it may concern:

Be it known that I, FREDERIC TUDOR, of Boston, in the county of Suffolk and State of Massachusetts, have invented an Improvement in Apparatus for Heating by Exhaust-Steam; and I do hereby declare the following to be a full, clear, and exact description of the same, reference being had to the accompanying drawings, forming part of this specification.

I am aware that sundry attempts have been made to utilize exhaust-steam for motive power and to remove "back-pressure" from the exhaust side of the pistons of steam-engines. My invention, however, relates to heating apparatus supplied by exhaust-steam from the steam-engine, which exhaust requires to be delivered into the heating system under some positive pressure, and this pressure, in such apparatus as heretofore organized, reacts upon the engine-piston, and thus subjects it to considerable resistance or back-pressure, which greatly detracts from the full power of the engine; and I am not aware that any attempt has been heretofore made to relieve the engine of such back-pressure and yet maintain an effective pressure in the system of heaters by means such as I here describe. A pressure of from five (5) to ten (10) pounds is required in ordinary steam-heating systems of pipes and radiators to maintain a sufficiently-effective circulation of the steam, and it is obvious that when this pressure is allowed to react on the piston of a steam-engine it reduces by a large percentage the mean effective pressure and motor efficiency of a steam-engine, either when working under a moderate pressure with a late cut-off, a higher pressure and an earlier cut-off, or when steam is allowed to follow the piston through the entire stroke. The loss of efficiency from this cause is, however, largest in cut-off engines, and it is the object of my invention to obviate this loss.

The invention consists, partly, in the combination, with the exhaust-pipe of a steam-engine which delivers steam into a system of heating-pipes, radiators, &c., of a steam inspirator or injector attached to and in connection with the exhaust-pipe of the engine, between the exhaust-port of the engine and the principal part of the system of heating-pipes, radiators, &c., which inspirator or injector delivers a jet of live steam from the boiler or steam-pipe into the exhaust-pipe in a direction toward such system, and by its eductive action reduces the pressure between it and such exhaust-port and maintains a pressure in the heating system into which it discharges.

The invention also consists in certain details of arrangement and construction herein set forth.

Figure 1 in the drawings represents a partial section and partial elevation of a boiler, engine, and their attachments, and a system of pipes, radiators, &c., with their attachments, constructed to carry out and illustrate my invention. Figs. 2 and 3 represent details.

A represents a boiler, with the usual attachments, including feed-pump B, which takes its water from a receptacle, C, which receives from the heating system of pipes, &c., the entire water of condensation, to be returned by the pump B to the boiler A.

D D′ D″ are radiators connected by pipes *d d′ d″* with the exhaust-pipe E E′, and with the receptacle C, and with the pump B, and it is provided at F with a valve for discharging the contents of the receptacle C and draining the pump when necessary.

G is the induction-pipe leading from the boiler A to the engine H. The induction-pipe G and the branches E E′ of the exhaust-pipe are each provided with a gage, (represented at J J′ J″,) for denoting the respective pressures in said pipes. The exhaust-pipe is also provided at any convenient part with a drain-cock, K. A weighted lever-valve, L, allows steam to escape from the branch E of the exhaust-pipe whenever the pressure rises therein above the proper point, and this escape gives warning to the attendant that the apparatus is not working properly, this branch of the exhaust-pipe being the part from which the pressure is removed when the parts of the apparatus yet to be described are in working order. The branches E and E′ of the exhaust-pipe are connected, preferably at a right angle, with each other, and at their junction is placed an inspirator or injector, M. (Shown partly in section in Fig. 2.) The nozzle N of this inspirator or injector is inserted into the branch E of the exhaust-pipe in such manner as to deliver its stream toward the system of pipes, radiators, &c., which constitutes the heating system, and in a direction away from the exhaust-port of the steam-engine.

Live steam is conveyed to the inspirator or injector M by a branch pipe, O O′, from the induction-pipe G. A drain cock or valve is attached to O O′ at P to keep this pipe free from accumulated water or other obstruction. At any convenient part of the pipe O O′ there is placed an automatic cock or valve, Q, for regulating the flow of live steam to the inspirator. Various means may be employed to cause this valve to act automatically, and I do not confine myself to any particular one.

In the example of my improvement shown in the drawings I use an ordinary diaphragm-regulator, R, for controlling the valve Q. Steam from any point between the inspirator and the radiators is brought under the diaphragm in R by connecting the lower part of R with a pipe, S, which may also lead to and connect with the pressure-gage attached to E′. The diaphragm is connected with the valve O by link and lever mechanism $t\ t'\ t''$ in the ordinary well-known manner of constructing such mechanism, and when the pressure falls in E′ such mechanism opens the valve Q farther to increase the jet of steam through M into said pipe, and vice versa.

It may now be seen that by the means described, when the engine is in action and the steam-jet m' is emitted at the proper force, the exhaust-steam will be rapidly educted from the engine by the powerful eductive action of the steam-jet, and the mixture of this exhaust from the engine and the live steam from the jet will be forcibly injected into the system of heating-pipes and radiators. In this way an effective pressure—say five pounds per square inch, or more—will be maintained in the heating system, and at the same time all back-pressure will be removed from the exhaust-pipe E, thus greatly increasing the efficiency of the engine and enabling it to work up to its full power. Not only will the steam-jet thus remove the back-pressure from the exhaust of the engine, but, in addition to this, it will in most cases actually form a vacuum or partial vacuum in the exhaust-pipe, which will greatly assist the working of the engine and increase its power in a positive manner in proportion to the degree of vacuum effected; hence, while the power of the engine is increased both in a negative and positive manner by this improvement and a system of heaters is maintained by the same means, yet the amount of steam used to sustain the jet need be little or no greater than that used through the engine when the exhaust is directly delivered under pressure into the heating system, and hence, while the consumption of steam is the same, the power of the engine is greatly increased, and the heating effect in the heating system is also increased, for, as a large portion of the steam forced into the heating system is live steam, it thus contains much more heat than would be the case if it were all at first passed through the engine, where its expansion would remove a great portion of its heat, so that by these means a great improvement is effected, both in the working of the engine and in the action of the heaters, without increased cost.

What I claim is—

1. In a heating system for using exhaust-steam for heating purposes, the combination, with the exhaust-pipe of the steam-engine and a system of heating-pipes, radiators, &c., supplied with steam from the exhaust, of a steam inspirator or injector placed in relation with the exhaust-pipes, heating-pipes, radiators, &c., as set forth, and operating substantially as and for the purpose herein described.

2. The combination, in a steam-heating system, of an exhaust-pipe, an inspirator or injector, a system of pipes, radiators, &c., and an automatic valve for regulating the injection of steam through said inspirator, substantially as and for the purpose specified.

3. The combination, in a system for heating by exhaust-steam from a steam-engine, of an exhaust-pipe delivering steam from the engine to and into the heating system, a steam injector or inspirator for removing pressure from the exhaust-pipe between the injector and the engine and accumulating or maintaining pressure in said system, and a relief and alarm valve for permitting escape of steam from the part of the exhaust-pipe between the inspirator or injector and the engine, substantially as and for the purpose specified.

FREDERIC TUDOR.

Witnesses:

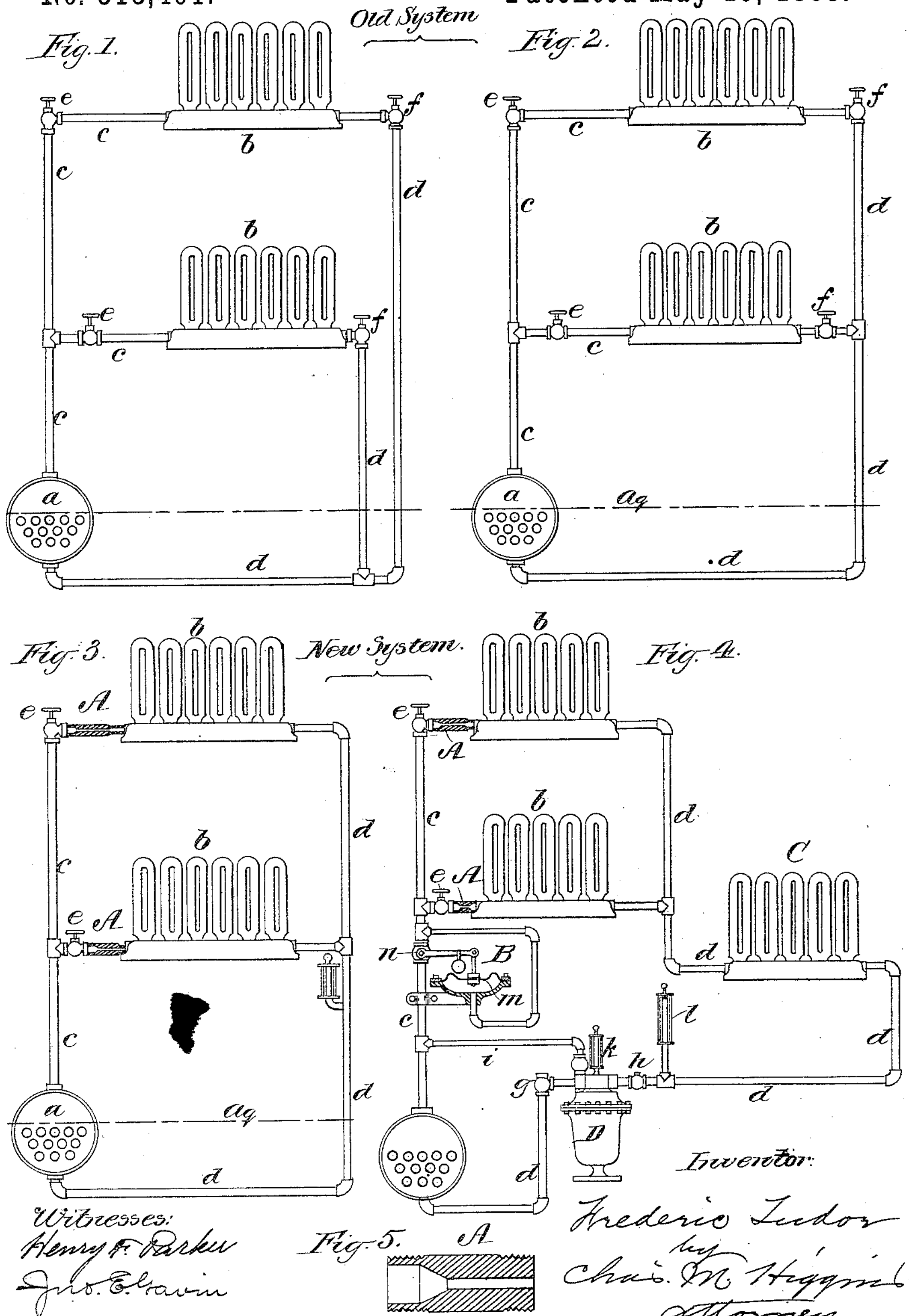
ROBERT JACKSON,
JNO. E. GAVIN.

(No Model.)

F. TUDOR.

STEAM HEATING APPARATUS.

No. 318,401. Patented May 19, 1885.



Witnesses:
Henry F. Parker
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UNITED STATES PATENT OFFICE.

FREDERIC TUDOR, OF BOSTON, MASSACHUSETTS.

STEAM-HEATING APPARATUS.

SPECIFICATION forming part of Letters Patent No. 318,401, dated May 19, 1885.

Application filed January 18, 1884. (No model.)

To all whom it may concern:

Be it known that I, FREDERIC TUDOR, of Boston, in the county of Suffolk and State of Massachusetts, have invented certain new and useful Improvements in Steam-Heating Apparatus, of which the following is a specification.

My invention relates to the ordinary system of steam-heating for buildings, where the steam is distributed from a central source or boiler through pipes to a series of radiators throughout the building, and the condensation from which is usually returned through separate pipes to the boiler. In this system, as usually constructed for high pressure, there is no means whereby the amount of steam and consequent amount of heat can be regulated to or reduced at each radiator, and hence whenever the radiators are put in action they must always be put in full maximum action, or supplied with the full maximum or more than the full maximum amount of steam, the valves on both steam and return pipes being opened fully.

Now, the object of my invention is to enable the steam to be reduced or regulated at each radiator as may be required for the desired amount of heat from an extreme minimum to an extreme maximum, according to the wish of the occupant or the state of the weather, and also to dispense with the necessity of valves between the radiators and return-pipe, and yet prevent any pressure in the return-pipe and any accumulation or regurgitation of water therein, and also prevent the supply of more than a true maximum amount of steam to the radiator when in full action—that is, an amount beyond its capacity for full condensation.

To these ends the chief feature of my invention may be stated to consist in a supply orifice or nozzle between the steam-pipe and the radiator having a definite relation with the condensing capacity or surface of the radiator and with the normal steam-pressure—that is, so proportioned as to be capable of admitting only the maximum amount of steam which the radiator can condense; hence when the steam-valve on the radiator is opened fully only the true maximum amount of steam can be admitted to the radiator, and all this will be rapidly condensed therein without forming any pressure in the radiator or return-pipe, and the full heating effect will be obtained, whereas by closing the valve partially the amount of steam admitted will be reduced corresponding to the amount of closure, and the desired regulation of heat thus obtained without admitting any pressure to the return-pipe, which in the present system is impracticable. At the same time the use of cut-off valves between radiator and return-pipe is obviated.

My invention therefore consists, mainly, in the feature above outlined, and in certain details in combination therewith, as hereinafter fully set forth.

In setting forth my invention I shall describe and illustrate it in contrast with the old or ordinary system now in use.

Referring, therefore, to the drawings, Figures 1 and 2 represent diagrammatic elevations of the old system, one figure showing a slightly different arrangement of piping from the other. Fig. 3 is a diagram or elevation of my improved system adapted for very low pressure, and Fig. 4 is an elevation or diagram of my improved system adapted for high pressure. Fig. 5 is an enlarged sectional view of one of the graduated or proportioned supply-nozzles used in my system.

Referring to Figs. 1 and 2, *a* indicates the boiler or source of steam, and *b* the radiators. *c* is the steam-pipe proceeding from the boiler and connecting with one side of each radiator, and *d d* are the return-pipes proceeding from the opposite side of the radiators and extending down to connect with the base of the boiler. *e e* are the steam-throttling valves between the steam-pipe and radiators, and *f f* similar valves between the radiators and return-pipes.

Fig. 1 represents the arrangement usually employed for low pressure, an independent return-pipe extending down directly from each radiator to the main return-pipe in the cellar, which goes to the base of the boiler, whereas Fig. 2 represents the arrangement generally used for high pressure, each radiator opening into a common return-pipe. Either of these arrangements, however, may be used for low or high pressure, and referring to these arrangements, as shown in Figs. 1 and 2, it will be readily seen that when steam is formed in the boiler *a*, and the valves *e f* opened, the steam will be admitted to and condensed in the radiators *b b*, and the water of condensation will be returned from thence to the boiler, and hence heat will be given out at the radiators, the quantity depending on the pressure of steam and the superficial extent and exposure of the radiators. It will be noted, however, referring to Fig. 2, that in order to have the apparatus act properly as described both valves *e f* must be fully or equally opened to obtain the full and free admission of the steam to the radiators and returns, so that the pressure in the radiators and returns shall be nearly equal to the pressure in the steam-pipe; hence the radiator must always be run with a full head of steam, for it will be readily seen that if the steam-valves are partially closed with the view to reduce the quantity of steam and consequently the amount of heat emitted from the radiators the pressure will then become reduced in the radiators and return-pipes, and the full or confined pressure now acting upon the water in the boiler will force the water back through the return-pipes and into the radiators, where it will accumulate so as to deprive the boiler of its proper quantity of water and expose the radiator to danger from frost, as well as cause noisy shocks when this water again comes in contact with the steam; hence it is obvious that in the system described a pressure must always be maintained in the radiators and return-pipes, and that the heat cannot be regulated by regulating the steam-valves, but these valves must either be turned fully on or fully off in order to raise or lower the heat, and no intermediate reduction or uniform low rate of heat can be maintained.

It will be noted that the use of a check-valve in the return pipe between boiler and radiators will not obviate the difficulty, as the water would soon accumulate from condensation above the check-valve and produce the same effect. The difficulty, however, can of course be obviated in a great measure by limiting the apparatus to low pressure, so that the column of water in the lower part of the return-pipe below the first radiator will balance the steam-pressure in the steam-pipe, and form a seal between the boiler and return side of the radiators; but the use of low pressure is not practicable in apparatus adapted for extensive heating, and it is the use of high pressure for extensive heating which my invention more particularly contemplates, although it is also adapted to low pressure, as will now appear.

The particular difficulty above stated can of course be obviated by the use of an ordinary steam-trap between the boiler and return-pipe, as is frequently used; but while this would prevent the backing up of the water in the returns and radiators it would not enable one radiator to act independently of the other, so that one could give out a low heat under a low supply of steam, and the other a high heat under a full supply of steam; for it will be obvious that if the valves on one radiator were only partly opened to let in a limited supply of steam with a view to obtaining a reduced heat, while the valves on another radiator were opened wide to obtain the full heat, the high pressure of steam in the latter radiator would of course flow out through the returns and into the former radiator until the pressure was equal, or nearly so, in both. It is therefore the independent regulation of the heat in the individual radiators from one extreme to the other which I aim to accomplish, and which chiefly distinguishes my invention, as will be now made apparent.

Referring, therefore, to Figs. 3 and 4, it will be seen that corresponding parts referred to in Figs. 1 and 2 are lettered similarly, and from this it will be noted that no throttle-valves are used between the radiators *b b* and the return-pipe *d*, which pipe is common to all the radiators. The steam-pipe *c*, however, instead of connecting with the radiators through an opening of indefinite and ample size, as heretofore, connects thereto through a special nozzle, nipple, or throat, A, of restricted or definite size, having a definite relation or proportion to the capacity or surface of the radiator—that is, the area of the orifice of the steam-supply throat A is so proportioned to the area or heating-surface of the radiator at a certain pressure of steam as to admit only the quantity of steam at that pressure which the radiator can fully condense under normal conditions, without allowing any appreciable pressure to accumulate in radiators or returns. This proportion of the orifice to the radiator is of course determined by experiment at first, for each case and each radiator of a certain area may always afterward be supplied with the orifice of proper size therefor, suited to its surface and to the pressure to be used in it, as will be readily understood. I thus find that the supply-orifice may be made very small, and while it is not necessary to here specify the proper sizes of orifices for radiators of every size and for various pressures, I would give the following general rule of proportion, which I have found practical—that is, a circular hole one-fourth inch diameter will pass enough steam at two pounds' pressure to heat a radiator containing about one hundred and twenty-five square feet.

The restricted supply throats or nozzles A may be formed, as shown in Fig. 5, in the shape of an ordinary nipple or fitting threaded externally at each end and bored with an orifice of definite proportioned size, as described, and these may be employed to connect the steam-pipe with the radiators, as shown in Figs. 3 and 4. The restricted throats may, however, be used between radiator and steam-pipe in any other suitable way, the object, as before described, being to produce a restricted opening having a definite relation to the size of the radiator, or pipes and radiators supplied by it, and its distance from the source of steam. I prefer to embody the restricted throat within the throttle or regulating valve itself, and I have designed for this purpose a special form of valve, which, however, need not be described here, but which I have made the subject of a separate application, filed March 1, 1884, Serial No. 122,664. It will therefore be seen that as my system uses no throttle-valves between the return-pipe and radiators, hence the return-pipe requires to be entirely free, or almost free, from steam-pressure when the steam-valves *e e* are closed. In the low-pressure apparatus shown in Fig. 3 this is accomplished by the column of water in the return-pipe below the radiator, which will always equal or overbalance the steam-pressure, as usual in low-pressure apparatus. In the high-pressure apparatus shown in Fig. 4, however, the return water discharges into a trap, D, on the return-pipe, through which it is returned to the boiler, the trap illustrated being what is known as the "Albany" trap, which I prefer to employ; but any other suitable trap may be employed. This trap is arranged on the return-pipe near the boiler in the manner usual in high-pressure steam-heating apparatuses, as illustrated, and check-valves *g h* are arranged on the return-pipe on each side of the trap and open toward the boiler in the well-known manner, and thereby prevent the backing up of any water in the return-pipe. A small pipe, *i*, supplies a vent of steam from the steam-pipe to the trap when the trap acts to discharge its accumulation into the boiler in the well-known manner. The trap is fitted with an air-valve, as shown at *k*, and the return-pipe is fitted with a similar air-valve, as shown at *l*, which allow air to escape in advance of the steam, but close automatically by thermal expansion as soon as the steam arrives at and heats the valve, as well known by steam-engineers. I prefer to employ a pressure-regulator, as shown at B, to reduce and regulate the pressure between the boiler and the pipes which supply the radiators, and thus maintain a uniform pressure in the supply-pipe. This regulator works in the ordinary manner of pressure-regulators, as well shown in Fig. 4, and therefore needs no detailed description. It will therefore be now understood that when a steam-heating circuit such as Fig. 3 or Fig. 4 is provided with the restricted supply-throats A, as described, and means employed, as set forth, for preventing the rise of water in the return-pipe, when the steam-valves *e e* are opened fully all the steam will be admitted to the radiators which they can condense, and no more, and hence the full or maximum heating effect will be obtained. If, however, it is now required to obtain a reduced heat in any particular radiator, it is only necessary to partially close the valve thereof, and the amount of steam admitted thereto will be reduced correspondingly; and hence the heat may be maintained regularly at any desired rate from maximum to minimum, according to the degree which the valve is opened or closed, which is a novel and very important advantage in steam-heating. It will be further seen that as the radiator can at the most receive only the amount of steam which it can fully or nearly fully condense, hence little or no pressure will exist in the radiator or return-pipe during the emission of heat, and hence the condensation will flow into the returns with certainty, and a positive circulation will be insured, as the pressure will always be greater in the supply-pipe than in the radiators or returns, the pressure being thus always greatly preponderating in the direction of the flow of the water toward the boiler, as is always desirable and necessary in steam-heating apparatuses for certain circulation and effective action.

As it will not always be possible in extensive apparatuses to so proportion the restricted throats A as to prevent the passage through them of a quantity of steam greater than the radiators can condense, I prefer to provide the apparatus in Fig. 4 with what may be termed a "condenser," C, to condense any slight overplus of steam, and thus keep the returns free from any objectionable amount of steam-pressure. This condenser, as shown, is located, of course, upon the return-pipe, and may be employed as a heater for heating air or water, and when the apparatus is in action it will be seen that no pressure can exist in the return-pipe until this condenser is fully heated. It will be also noted that the rise of pressure in the supply-pipe beyond the normal point for which the restricted throats and their radiators are adjusted is prevented by the pressure-regulator B, and hence no excess can enter the radiators and return-pipes from that cause, for when the pressure rises abnormally in the boiler the diaphragm *m* will act to close the steam-valve *n*, so as to admit less steam to the supply-pipe, and thus maintain practically the same pressure therein.

Having now fully set forth my invention, the advantages which it possesses may be here briefly recapitulated: First, a more equal distribution of steam to the several radiators, and especially at the lowest pressure, when very little heat is desired; second, the control of the supply of steam at any radiator or set of pipes and radiators fed by one valve without retaining water in the radiator or interfering with the circulation in other radiators; third, a difference of pressure in the supply and return pipes, whereby the circulation is rendered more positive, condense-water is more surely kept where it belongs, and noise and water-hammering in the pipes prevented; fourth, the expulsion of air from the radiators into the return-pipes, whence it may be allowed to escape at the air-valves *k* or *l*, thus dispensing with the necessity of an air-valve on each radiator, with their complication of drip-pipes to drain the air-valves, as is customary; fifth, dispensing with the necessity of throttle-valves between radiators and returns.

I am of course aware that heretofore in

steam-heating practice there has always been some attempted proportion of the supply-pipes to the radiators; but in all such cases the pipe or valve is generally so proportioned as to admit a large excess of steam over what the radiator can condense, and not the restricted or limited quantity proportioned to its condensing-power under normal conditions, as in my improvement, where the supply-throat is so proportioned to the radiator as to admit only the quantity of steam which it can condense under normal conditions; hence in my system no appreciable pressure will exist in the radiator during its heating action, while a considerable pressure will exist in the old system, whose proportion of parts does not aim to limit the supply of steam to the normal condensing-power of the radiator, but only to prevent an unnecessary excess of pressure in the radiator.

What I claim as my invention is—

1. A steam-heating apparatus constructed with restricted supply-throats between supply-pipes and radiators, having a definite relation or proportion to the condensing-surface of the radiator, so as to admit practically only the amount of steam which the radiator can condense, substantially as and for the purpose set forth.

2. A steam-heating apparatus consisting of a boiler or source of steam, one or more radiators, a supply-pipe extending from the steam-space of the boiler and connecting with each radiator, and provided with throttling-valves at each radiator and with restricted supply-throats so proportioned to the radiator as to admit only the quantity of steam which it can condense under normal conditions, and a return-pipe without throttling-valves extending from each radiator to the water-space of the boiler, arranged and operating substantially as and for the purpose set forth.

3. An improved steam-heating apparatus formed by the combination, with a steam-boiler and a series of radiators, of a return-pipe extending from the water-space of the boiler and connecting to all the radiators in common at points above the water-line, and a steam-supply pipe extending from the steam-space of the boiler to the radiators, with restricted supply-throats between the radiators and the supply-pipe so proportioned to the radiators as to admit only the quantity of steam which it can condense under normal conditions, substantially as herein shown and described.

4. A steam-heating apparatus consisting of a boiler or source of steam and one or more radiators, a supply-pipe extending from the steam-space of the boiler to each radiator and provided with throttling-valves and with restricted supply-throats so proportioned to the radiator as to admit only the quantity of steam which it can condense under normal conditions, with a return-pipe extending from the radiators to the water-space of the boiler and provided with an air-valve common to the system, substantially as herein shown and described.

5. A steam-heating apparatus substantially such as set forth, having restricted supply-throats A, so proportioned to the radiators as to admit only the quantity of steam which they can condense under normal conditions, between supply-pipe and radiators, and a condenser, C, upon the return-pipe, substantially as and for the purpose set forth.

6. A steam-heating apparatus substantially such as set forth, having a pressure-regulator, such as B, between the boiler and radiators and supply-throats between the supply-pipe and radiators, with a return-pipe so proportioned to the radiators as to admit only the quantity of steam which they can condense under normal conditions, opening freely from each radiator and finally discharging into the boiler, and provided with means to prevent the backing up of water therein, substantially as herein set forth.

7. A steam-heating apparatus substantially as shown in Fig. 4, consisting of a boiler, *a*, supply-pipe *c*, with valves *e*, and restricted throats A, so proportioned to the radiators as to admit only the quantity of steam which they can condense under normal conditions, radiators *b b*, return-pipe *d*, condenser C, and trap D, arranged and operating substantially as herein shown and described.

8. A steam-heating apparatus substantially such as shown in Fig. 4, consisting of a boiler, *a*, supply-pipe *c*, pressure-regulator B, valves *e*, restricted throats A, so proportioned to the radiators as to admit only the quantity of steam which they can condense under normal conditions, radiators *b b*, return-pipe *d*, condenser C, and trap D, arranged and operating substantially as and for the purpose set forth.

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(No Model.) 5 Sheets—Sheet 1.

F. TUDOR.
VALVE.

No. 319,939. Patented June 9, 1885.

Fig. 1.

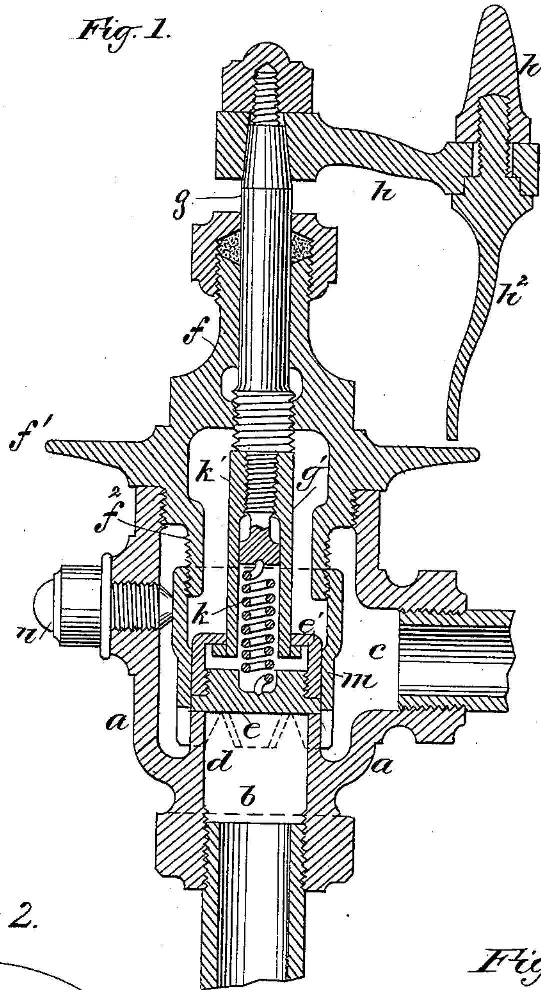


Fig. 2.

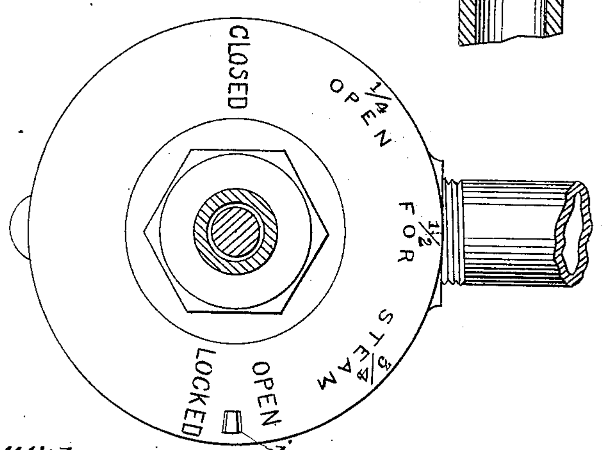
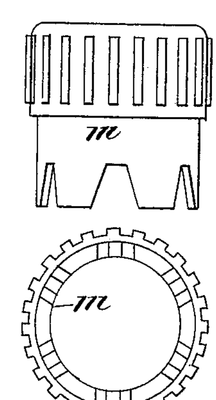


Fig. 3.



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VALVE.

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Fig. 4.

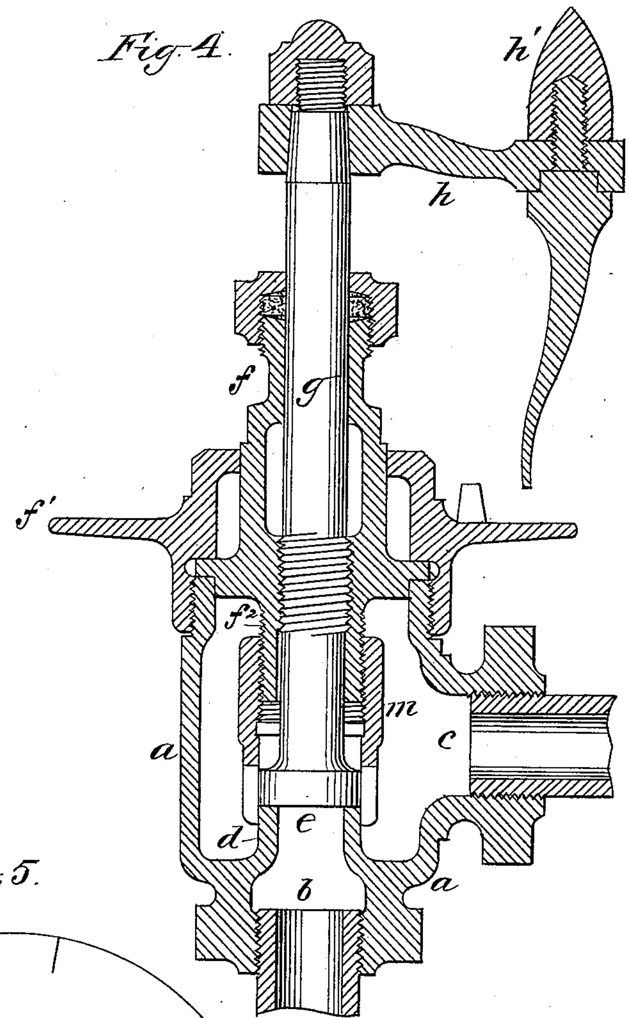


Fig. 5.

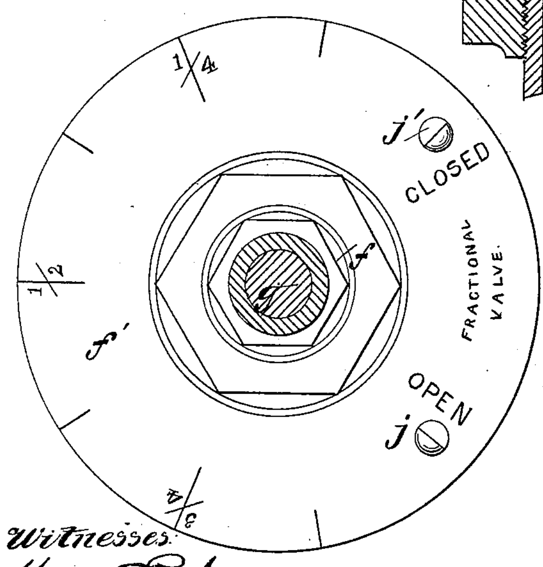
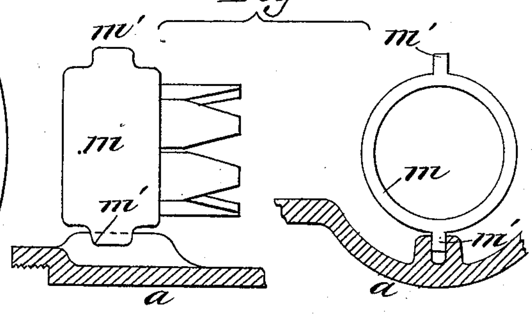


Fig. 6.



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(No Model.) 5 Sheets—Sheet 3.

F. TUDOR.

VALVE.

No. 319,939. Patented June 9, 1885.

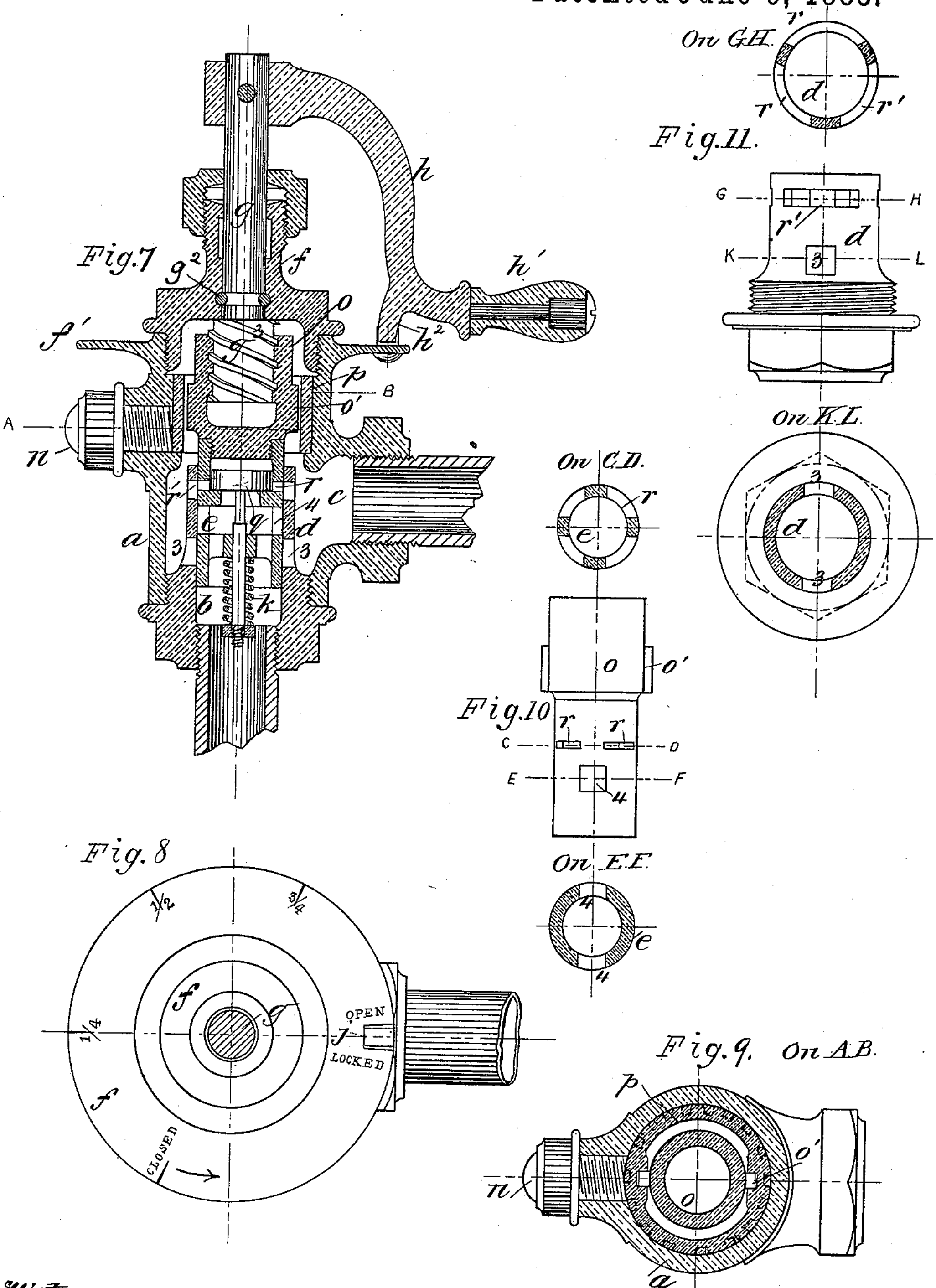

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Fig. 12.

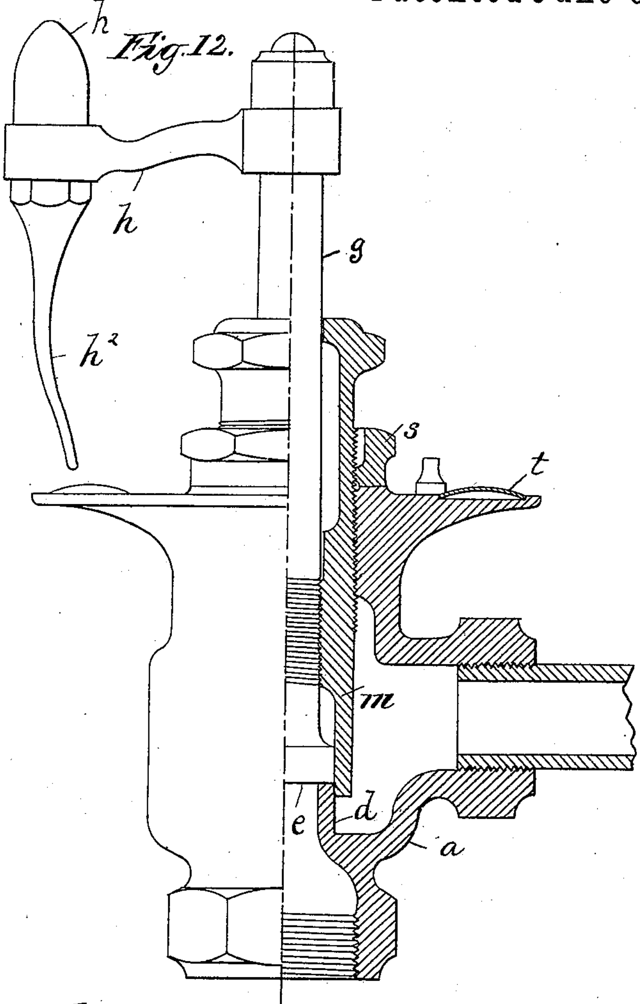
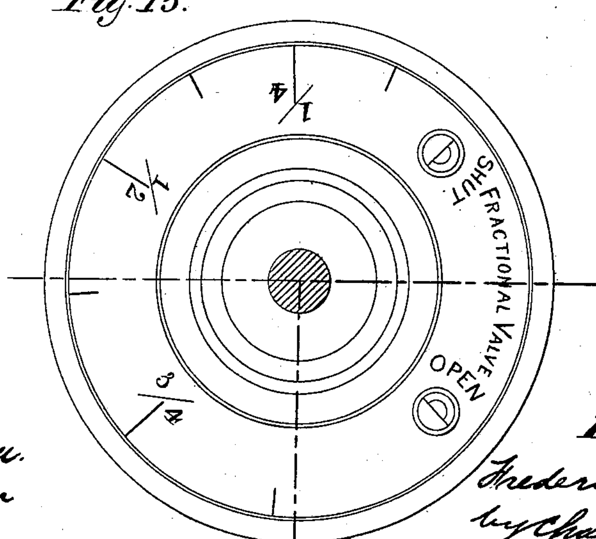


Fig. 13.



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(No Model.)

5 Sheets—Sheet 5.

F. TUDOR.

VALVE.

No. 319,939.

Patented June 9, 1885.

Fig. 14.

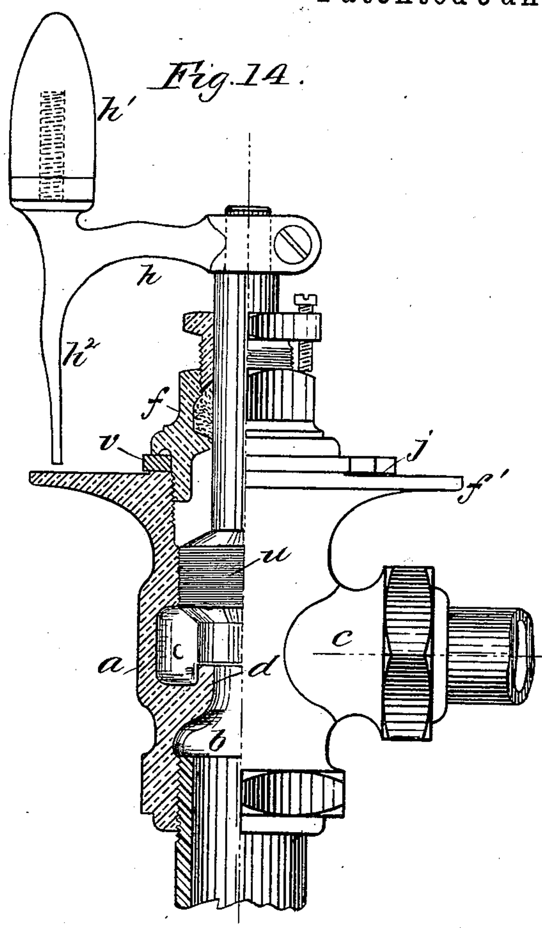
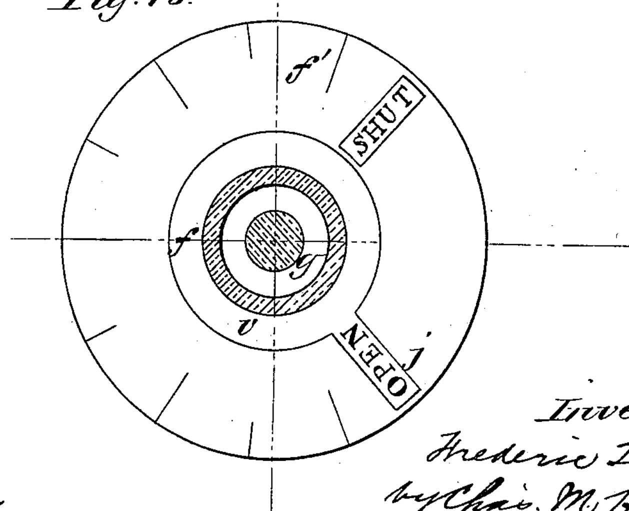


Fig. 15.



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UNITED STATES PATENT OFFICE.

FREDERIC TUDOR, OF BOSTON, MASSACHUSETTS.

VALVE.

SPECIFICATION forming part of Letters Patent No. 319,939, dated June 9, 1885.

Application filed March 1, 1884. (No model.)

To all whom it may concern:

Be it known that I, FREDERIC TUDOR, of Boston, in the county of Suffolk and State of Massachusetts, have invented certain new and useful Improvements in Valves, of which the following is a specification.

The invention relates to regulatable valves or cocks for regulating the feed of fluids from the source of supply to the points where they are used or consumed.

My invention applies more especially to steam-supply valves for connection with radiators or heating apparatuses, and it aims to provide valves for this purpose which will possess the following advantages: First, an adjustability of the internal supply orifice or "way," adapted to the condensing capacity of the radiator to which the valve connects, whereby only a determined quantity of steam can pass at a certain pressure, so that when the valve is opened to its maximum only the true maximum quantity of steam can enter the radiator without any appreciable excess; second, a means for graduating the flow of steam by regulating the distance which the operating handle can be moved, so as to reduce the flow to any desired degree between maximum and minimum, and thereby enable the heat in the radiator to be regulated as desired; third, means whereby steam may be admitted to the radiators, even after the manual regulatable valves have been closed, by simply increasing the steam-pressure, and thereby forcing a circulation of steam through the heating apparatus to keep the apartments from becoming too cool during the times when the occupants are absent therefrom.

The latter object is accomplished by means shown and described in a former patent issued to me January 8, 1884, No. 291,818, on which my present invention is partly an improvement, and the other features of my present invention are in part supplemental to the improvements shown in my application No. 117,923, filed January 18, 1884.

In carrying out my invention, therefore, I render the internal supply-orifice or steam-way of the valve adjustable in area, preferably by means of an adjustable perforated sleeve controlling the way, with means for fastening said sleeve at the desired adjustment, and in combination with this feature I employ a valve-disk or stopper, which is arranged to have a limited movement between stops which represent the zero and the maximum of opening, and I graduate the range between said points, whereby any desired flow may be obtained from minimum to true maximum. In connection with the aforesaid features I employ an auxiliary yielding valve or stopper in connection with the main or manually-controlled valve or stopper arranged to yield to increased pressure, and thus permit the flow of steam, even after the main valve has been manually closed.

My present invention therefore consists in the features above outlined, as well as in certain minor features of construction, as hereinafter fully set forth.

In the drawings annexed, Figure 1 presents a central vertical section of a valve embodying my invention, and Fig. 2 is a plan view thereof. Fig. 3 shows, respectively, an elevation and inverted plan of the adjustable sleeve which controls the internal way of the valve. Fig. 4 is a vertical section similar to Fig. 1, showing a slightly-modified construction, omitting the yielding or relief valve; and Fig. 5 is a plan view thereof, and Fig. 6 gives views of the adjustable sleeve thereof. Fig. 7 gives a vertical section of another form of valve, embodying the auxiliary or yielding stopper. Fig. 8 is a plan view of the same, and Fig. 9 a cross-section on line A B of Fig. 7. Fig. 10 gives an elevation and cross-section of the main stopper of the valve removed, and Fig. 11 similar views of the tubular seat or throat in which the stopper moves. Fig. 12 gives a half-elevation and half-section of a valve on the same principle as that in Figs. 1 and 4, but of simpler structure, omitting the yielding valve; and Fig. 13 is a plan of this valve. Figs. 14 and 15 give, respectively, a vertical sectional elevation and plan of a still simpler form of valve on the same principle, dispensing with the adjustable sleeve and yielding stopper.

Referring to Fig. 1, *a* indicates the body or casing of the valve, having the inlet-orifice *b* and the outlet-orifice *c*, to which the pipes connect in the usual manner, as shown. These orifices are shown as at right angles to each other, the valve being thus what is known as an "angle-valve;" but it will be readily understood that the orifices may be in line with or parallel to each other, projecting from opposite sides of the casing, when desired, as in what is known as "globe-valves."

Within the casing a, around the inlet-orifice, a short neck or rim, d, rises, the top edge of which is ground true and preferably flat, and forms the valve-seat for the valve-disk or stopper e, whose face is ground to fit steam-tight thereon, as shown.

$f f' f^2$ indicate the removable top or cap of the valve-casing, having a broad-shouldered rim, f', at the middle, with an underlying threaded neck which screws into the top of the casing a, thus bringing the shoulder of the rim down steam-tight on the top edge of the casing, as shown in Fig. 1. The rim f' is preferably of circular form and overhangs the body of the valve, as shown in Figs. 1 and 2, and its upper surface forms a dial or index plate, as shown in Fig. 2, and hereinafter described, while above the said rim the cap is formed with the usual guiding neck and gland, f, through which the valve-stem projects steam-tight, while below the rim the cap is formed with the threaded sleeve or neck f^2, which projects down into the cavity of the casing in line with the seat-rim d.

Now, the valve-disk or stopper is made in two parts, e e', screwed together as shown, the upper part, e', being in the form of a shouldered thimble, which screws onto the disk e, leaving a space or play between the two. The valve-stem is also made in two parts, g g', the upper part, g, being solid and projecting through the neck and gland of the cap, while the lower part, g', is tubular and screws at the top onto a threaded tenon on the lower end of the part g, while the lower end of the tube g' fits into the thimble e', and has a shoulder to engage with the shoulder of the thimble, and is thus capable of a slight play between the thimble and the top of the disk e. Now, the solid part g of the stem is threaded near the base, and screws into a threaded part of the neck f, so that if the stem be rotated in one way or the other it will be screwed up or down, and the valve-disk e thus raised from or lowered to its seat. The projecting end of the stem is therefore provided with an operating lever, arm, or crank, h, having at the manipulating end the upwardly-projecting crank-knob h' and the downwardly-projecting index point or finger h^2, which approaches the surface of the dial-rim f', and thus sweeps over its circumference when the arm is revolved to turn the valve-stem, as will be understood. In the path of the finger h^2, however, a stop or projection, j, rises from the rim f', which stop forms a limit to the movement of the finger and the rotation of the operating arm and stem, and this stop represents the limit of opening of the valve, for when the finger h^2 contacts with said stop the valve-disk will be raised from its seat to its full extent and the full or maximum flow of steam allowed. If, however, the handle is rotated half a revolution, to the diametrically-opposite point of the rim f', at which is marked the word "closed," as seen in Fig. 2, the disk e will be brought to its seat, as seen in Fig. 1, and the flow entirely shut off, so that the point marked "closed" on the dial-rim f' is the zero of the scale through which the arm is movable, the stop J^2 forming the maximum limit, while the space between is graduated, as shown, into divisions of $\frac{1}{4}$, $\frac{1}{2}$, $\frac{3}{4}$, &c., as may be desired, so that when the arm is revolved to any of the graduations a correspondingly reduced or increased flow of steam will be obtained.

It may now be noted that when the disk e is brought to its seat, as in Fig. 1, there yet exists a play between the top of the disk and the shoulder of the stem g', and hence the steam-pressure under the disk would consequently tend to lift it and allow the steam to escape. This, however, is prevented by a spring, k, arranged within the tubular stem g', pressing at its lower end on the disk and abutting at its upper end against an adjustable screw-plug, k', so as to tend to constantly keep the disk down with a force sufficient to amply overcome the normal steam-pressure, which force can be adjusted by screwing the plug k' up or down, as will be understood; hence when the disk is forced to its seat by manually revolving the operating arm of the valve to the position of "closed," no steam can pass the valve while at its normal pressure. If, however, the engineer desires to force a circulation of steam through the valves at night, or during Sundays or holidays, when the tenants are absent, he simply will allow the steam-pressure to rise in the boiler beyond the normal point, and this increased pressure will then lift the spring-depressed disks e, and thus permit a flow of steam to pass into the radiators; and when the pressure is again allowed to fall to or below the normal the valves will automatically seat in their closed positions, as before. By this means the engineer is enabled to force sufficient steam through the heating apparatus to prevent the temperature from falling too low throughout the building and without the trouble of going to the valves to open them, and notwithstanding the fact that they had been left closed to the normal pressure. If, however, the occupant of any apartment does not desire to have the steam thus turned on, as above described, during his absence, he may readily lock the valve against the possibility of such opening, to do which it is only necessary to rotate the operating-handle one-half revolution further in its direction of closure, or from the mark "Closed" in Fig. 2 to or near to the back side of the stop j, marked "Locked," when this movement will screw the shouldered end of the stem g' down tightly onto the disk e', (against the stress of the spring k,) thus positively preventing the rise of the disk e', even though the steam-pressure be indefinitely increased.

It may now be seen that the construction described provides a valve which, after it has been closed by the tenant, will still yield to the will of the engineer through an increased pressure of steam, and enable him to open the valves and permit a flow of steam under certain necessary circumstances, and which, on the other hand, can be locked by the tenant against so yielding, when desired, which features are shown in my former patent.

In addition to these points the valve or stopper also has a graduated range of movement, with a definite stop for the maximum of opening, whereby the valve may be set to allow different graduated flows of steam, according to the quantity of heat required. This last provision, however, would be ineffective without some means of graduating or adjusting the area of the actual internal way or passage of the valve itself and proportioning it properly to the area or capacity of the radiator or other chamber to which the valve delivers its steam, so that when the stopper was fully opened, with the handles set to the maximum point or stop, no more steam could pass than could be properly condensed in the radiator without leaving any appreciable pressure from excess therein, this being one of the prime objects of my present improvement, according to the principle set forth in my pending application before referred to. Now, this adjustment of the area of the internal way may be accomplished in various obvious ways; but in the present instance, referring to Fig. 1, I prefer to effect it by means of the adjustable sleeve m, which occupies the cavity of the casing between the valve-seat and inlet-orifice, and thus controls the way of the valve. The lower end of this sleeve fits around the seat-rim d, the meeting surfaces of which are turned to a nice fit, while the upper end of the sleeve screws onto the threaded neck f^2 of the casing-cap, as fully shown in Fig. 1. This sleeve is shown removed in Fig. 3, from which, in connection with Fig. 1, it will be seen that its lower end is perforated or notched, preferably with V-shaped notches, and this notched edge fits around the seat-rim d, so that, hence, if the sleeve be rotated in one way or the other it will be screwed up or down on the neck f^2, and the notched lower edge thus raised more or less above the seat edge of the rim d, thereby affording a passage for the steam of greater or less area, according to the extent to which the notches are adjusted above the edge of the valve-seat d, and thereby adjusting the area of the internal way of the valve in a simple and effective manner.

In order to facilitate the rotation and adjustment of the sleeve m, it is formed with circumferential corrugations or teeth, as seen in Fig. 3, and its adjustment within the valve-casing is readily effected by removing the screw-plug n on the side of the casing and inserting a tool, whereby the toothed circumference of the sleeve may be engaged and turned to the desired extent, and when the screw-plug n is replaced its extremity will bear upon the sleeve, as shown in Fig. 1, and thus fasten it at the desired adjustment.

Hence by this simple means it will be seen that the way of the valve may be so adjusted to the condensing capacity or heating-surface of the radiator that, with steam at a certain pressure and the weather at a certain average condition, only such a quantity of steam can pass at the maximum—that is, when the valve-stopper is fully opened—as can be fully condensed in the radiator without leaving any appreciable pressure or excess therein which would interfere with easy regulation and the circulation in the heating system; hence when the valve-stopper is fully opened, with the handle turned around to the stop j, the full heating effect will be obtained, and when it is turned away from the stop toward the zero of the scale the flow will be more and more reduced, and the heat given out in the radiator correspondingly regulated or graduated, according to the indicated position of the valve on the dial f', thereby accomplishing a most desirable result in steam-heating.

The valve shown in Figs. 4 and 5 is slightly different in structure from Fig. 1—that is, in this modification the yielding valve or stopper is omitted, and the valve-stem g is in one solid piece with the valve-disk e and solid on the end thereof. The gland-neck f is also separate from the dial-rim f', and has a ground shoulder on the lower end to seat on the ground upper edge of the casing a, as shown in Fig. 1, and also carries the threaded neck f^2, onto which the adjustable sleeve m is screwed. This sleeve is formed with key-like ears m' on each side, which fit in grooves in the sides of the casing a, as shown fully in Fig. 6, thus preventing the sleeve from turning, but permitting it to be adjusted vertically up or down. The dial-rim f serves as a cap-nut over the casing and the gland-neck, and screws down onto the casing, as shown, with a shoulder which bears on the shoulder of the gland-neck f, so as to hold said neck firmly in place and prevent leakage at the joint between the same and the casing. It will therefore be now readily seen that the sleeve m in this case may be readily adjusted by first turning the rim f' slightly, so as to release the gland-neck, and then by seizing and turning the gland-neck the sleeve m may be screwed up or down to the desired extent, and thus adjusted with the effect before described, after which the rim f' may be again screwed down tight, and will hold the parts at the desired adjustment.

As the yielding valve and the means for locking the same are in this instance omitted, the operating-arm of the valve moves between two stops, $j\ j'$, on the dial-rim, as shown in Fig. 5, which stops respectively represent the positions of fully opened and fully closed, as will be readily understood.

The valve shown in Fig. 7 embodies the same principle already set forth, but differs more in structure from Fig. 1 than does the former modification. In this form the casing a is open at top and bottom, and the dial-rim f' is formed solid on the top thereof, while the gland-neck f screws into the top in the manner of ordinary valves. The seat-rim d is in the form of a perforated nozzle, and screws into the lower end of the casing and projects up within the same, as shown, and within this nozzle is fitted the valve-stopper e, which is in the form of a perforated sleeve having perforations matching those of the seat-nozzle d, these parts being shown detached in elevation and section in Figs. 10 and 11. The valve-stem g is free to turn in the gland f, but prevented from vertical motion by a pin, g^2, which engages a groove in the stem, and on the lower end of the stem is formed a steeply-threaded screw-hub, g^3, which engages with a nut-like sleeve, o, which is attached to the stopper e. The nut-like sleeve o has keys or wings o', which are engaged in grooves on a surrounding rotary or adjustable ring, p, which is socketed in the top of the casing a, and free to revolve therein, being held, however, by the screw-plug n, as shown well in Figs. 7 and 9, in the same manner as the adjustable sleeve m in the former cases.

Now, the seat-nozzle d has two perforations, 3 3, at opposite sides, preferably about one-quarter of an inch square, and the stopper e has similar perforations, 4 4, and it will therefore be seen that when the stopper is moved so that the perforations thereof are coincident with the perforations of the nozzle the flow of steam will be allowed, and when they are moved entirely out of coincidence the flow will be shut off; hence the opening and closing movements of the valve are effected by rotating the handle as before, which will, however, through the engagement of the rotary screw g^3 with the non-rotary nut o, raise or depress the perforated stopper e in the perforated nozzle d. and thus bring the perforations into or out of register with each other by a straight, vertical, or longitudinal movement, as will be readily comprehended. Now, the adjustment of the effective area of the way of the valve is accomplished by a rotary movement of the nut and stopper o e, so as to bring the perforations of the nozzle and stopper more or less out of register with each other in a circumferential direction, and thus reduce the effective area of the perforations in the nozzle, and consequently the flow of steam which can take place through the same. This adjustment is effected by removing the screw-plug n and rotating the ring p, which will rotate the nut o and stopper e, and thus effect the desired adjustment, as will be readily seen, after which the plug is replaced to retain the parts at the desired adjustment. To facilitate the turning of the ring p, a number of holes may be made around it, as shown in dotted lines in Fig. 9.

Now, this form of my invention also embodies the yielding valve or stopper, as does Fig. 1, but in a somewhat different form—that is, the yielding valve q in this case rests on a seat in the upper part of the tubular stopper e and constantly tends to remain on its seat by the spring k, which encircles the stem of the valve with one end bearing on a cross-bar or bridge across the stopper, and the other end resting on an adjustable nut on the end of the stem. The stopper e is perforated with, say, four slots, r, just above the seat of the valve q, and in the top of the nozzle d are coincident slots, r', as shown in section and elevation in Figs. 10 and 11. The slots r' in the nozzle, it will be seen, are much wider circumferentially than those in the stopper, to allow for the circumferential adjustment of the stopper in the nozzle, as before described, so that the perforations r in the stopper will always remain open to their full extent, notwithstanding the rotary adjustment of the stopper to adjust the main way of the valve through the main perforations 3 3. Now, by referring to Fig. 7, it will be understood that when the stopper e is fully depressed to open the main way the small perforations r and r' will become shut by the solid part of the stopper e and the nozzle d covering the respective perforations; but when the stopper is raised to shut the main way 3 3, as shown in Fig. 7, then the perforations will be opened by coincidence with each other; hence if the steam-pressure be now raised beyond the normal point, the yielding valve q will lift against the stress of the spring k and allow the steam to escape through the perforations r r', and thus flow to the radiators, thereby accomplishing the same purpose described in connection with Fig. 1.

In this modification I show the operating-handle of the valve as in the form of a bent lever with a short index-finger, h^2, and an operating-knob, h', projecting radially. It will also be seen, by referring to Fig. 8, that the handle has a similar movement to that described in Fig. 1 for opening and closing the valve and locking it against the yielding flow above described—that is, when the handle is moved around to the "open" side of the stop j the valve will be opened to its maximum, and when moved around to the position "Closed," the main valve or way will be entirely closed, but the auxiliary perforations r r' will be brought into coincidence, as in Fig. 7, and therefore in a position to allow a flow of steam in case the pressure is increased to lift the yielding valve q. If, however, the handle be moved beyond the point "Closed" up to the opposite side of the stop j, marked "Locked," then the perforations r will be raised up above the perforations r', and this flow prevented, even though the steam-pressure be increased, thus locking the valve, as before described.

In the form of valve in which the yielding stopper is omitted—such as shown in Fig. 4—

I find the stuffing box or gland around the stem is actually unnecessary, and may be omitted, for it will be seen that since the main feature of this valve causes the flow of steam to be so graduated to the radiators as to supply it with only what it will condense and no more, hence there will be no appreciable pressure of steam within the casing of the valve above the seat, and therefore no tendency to cause leakage around the stem, except of course, in cases where the valve may be placed in a recumbent or inverted position, in which case condensation might trickle out; but when placed in an erect position, as shown, no leakage will occur, thus enabling stuffing-boxes to be dispensed with, and therefore greatly conducing to simplicity in the construction and operation of the valves. In Figs. 12 and 13 I have therefore shown the form in which I prefer to make the valve when the yielding stopper is omitted and the stuffing-box dispensed with. In this case the adjustable sleeve *m* also forms the guiding or gland neck of the valve-stem, and projects up out of the casing around the stem, but without any stuffing-box. The exterior of this sleeve is, however, provided with a fine screw-thread, as illustrated, which screws into the neck of the casing *a*, and the stem *g* is also provided with a similar fine screw-thread which screws into the interior of the sleeve, all the said threads being of exactly the same pitch—preferably thirty-two to the inch. The lower edge of the sleeve *m* is of course notched, as before described, and fits around the seat-rim *d* in the same manner as in Figs. 1 and 4. On the projecting end of the sleeve is screwed a jam-nut, *s*, which is screwed down upon the top of the casing *a*, to hold the sleeve *m* in whatever position it may be set. The handle, stops, and graduations of the valve are the same as already described in connection with Figs. 4 and 5; but it will be seen that the dial-rim *f′* is cast integral with the casing *a*, and that it is preferably formed with an annular groove on the top, in which is inserted an engraved or enamelled dial plate or ring, *t*, as shown in Figs. 12 and 13.

It will now be seen, referring to Fig. 12, that the adjustment of the way in this valve is readily effected by first turning the stem of the valve so as to raise the valve-disk *e* to the maximum or more than the maximum distance off the seat, after which the jam-nut *s* may be loosened, and the sleeve *m* then turned or screwed up to the desired extent until a sufficient portion of the notches in the lower end of the sleeve is brought above the valve-seat to allow a sufficient flow of steam to equal the condensing capacity of the radiator, or nearly so, as will be understood, after which the jam-nut is tightened to hold the sleeve at said adjustment.

It will be noted that the sleeve has a hexagonal head at the upper end, by which it may be readily turned by the fingers or by a wrench, and it will be also seen that as the screw-threads between the casing and the sleeve are of the same pitch as the screw-threads between the sleeve and the valve-stem, hence the described adjustment of the sleeve may be made without displacing the valve-stem and its disk from any position in which it may have been left and without altering the relations of the parts with each other.

In Figs. 14 and 15 I show a still further modification of my invention, which is still further simplified in that it omits the yielding stopper and also the adjustable sleeve, the way in this case being adjusted by the greater or less distance which the valve-disk is raised from its seat when the operating-handle is moved around to the stop for the limit of opening, which stop is in this case made adjustable to allow for the adjustment of the way in the said manner. In this valve, as seen in Fig. 14, the dial-rim *f′* and seat-rim *d* are made integral with the casing *a*, as in Fig. 12. The valve-disk *e* is also solid on the stem and seats solidly on the seat-rim *d*, and above the valve-disk the stem is formed with a threaded hub, *u*, having preferably a fine thread, the same as in Fig. 12, which screws into the threaded interior of the casing *a*. The top of the stem projects through the guiding or gland neck *f*, which may or may not have a stuffing-box, but which screws into the top of the casing, as shown, and between the shoulder at the base of the said neck *f* and the top edge of the casing is interposed and clamped a ring, *v*, having a radial arm, *j*, which projects out over the dial-rim in the path of the index-finger h^2, and this arm forms the stop which limits the maximum opening of the valve, being marked "Open," as shown, while the mark "Shut" is on a fixed definite point of the dial-rim, as shown. The adjustment of the way in this case is therefore effected by loosening the neck *f*, and thereby loosening the ring *v*, with its stop *j*, and leaving it free to yield to the advance of the operating-handle and its index-finger. The handle of the valve may now be gradually revolved, so as to gradually raise the valve off its seat until the proper position is found which admits the true maximum flow to the radiator, when the stop *j* is moved up in contact with the index-finger, and the neck *f* screwed down, thus holding the stop at said position, and therefore fixing the limit for the maximum opening of the valve thereafter. It will be therefore seen that when the handle is moved to any intermediate position between "Shut" and "Open" the flow will be reduced in proportion to the approach to the minimum or shut end of the scale, thus obtaining the desired graduation or "fractional" supply or regulation of the steam, as before described, which forms the characteristic advantage of my invention.

It will be easily understood that the valve-disk in Fig. 14 may be made to yield on the stem in the same manner as in Fig. 1, so as to form the "yielding stopper" or "relief-valve" for the purpose already described, if so desired.

This improved valve I have termed the "fractional valve," as it enables a fractional control or graduation of steam-heat in radiators, which has heretofore been as impracticable as it has been desirable. Besides this primary advantage, the new valve or the system of which the valve is a part secures better circulation, with unobstructed escape of water of condensation, and consequent nonliability of freezing in the radiator. In addition to this, the fractional valve enables the entire heating apparatus to be greatly simplified, as it takes the place of three common valves to one radiator—viz., the supply, return, and air valves; also, the air-valve drippipe requires no stuffing-box and has but one moving part, so that, hence, the system of the new valve is not only much more advantageous, but much simpler than the old system.

Having now described the principal and elements of my invention and some of the various forms in which it may be embodied, what I claim as my invention is as follows:

1. A regulable valve for governing the supply of steam or other fluids combining the following elements: means for adjusting the effective area of the way or passage with a movable valve or stopper for opening or closing said way and a stop to limit the movement of said stopper and representing the maximum movement thereof, substantially as and for the purpose set forth.

2. A regulable valve for steam heaters or their equivalents, constructed with means for adjusting the effective area of the internal way or passage, in combination with a movable valve or stopper controlling said way, an external operating-handle and index-point, and a graduated scale or dial over which the same is movable, as and for the purpose set forth.

3. A regulable valve for steam-heaters or equivalent purposes combining the following features: means for adjusting the effective area of the internal way or passage, a movable valve or stopper controlling said passage, and an external operating-handle with an index point or finger, a scale or dial over which said handle or index is movable, and a stop or stops limiting the movement of said handle, substantially as and for the purpose set forth.

4. In a regulating-valve, the combination, with an adjustable way, of a movable stopper controlling the same and a yielding stopper adapted to yield and open to increased pressure with means for locking the same against so opening, an external operating-handle, and a graduated scale over which the same is movable provided with graduations representing the open, closed, and locked positions of the said valve, substantially as and for the purpose set forth.

5. The combination, in a regulating-valve, with a valve-seat in the internal way and a movable disk operating in relation therewith to open and close the way, of a notched or perforated sleeve, such as *m*, fitting around the valve or seat and adjustable thereon, for regulating the effective area of the way, substantially as set forth.

6. The combination, in a valve, with a valve-seat in the internal way and a valve-disk operating in relation therewith, of an adjustable screw-sleeve, such as *m*, having a notched or perforated edge fitting around the valve and seat and having a screw-engagement upon a sustaining part of the valve with a clamping device to hold said sleeve at the desired adjustment, substantially as set forth.

7. The combination, with a valve-casing having the seat *d*, of the valve-disk *e*, the adjustable notched screw-sleeve *m*, fitting around the valve and seat, screwing into the casing, and projecting therefrom for manipulation or adjustment, with the valve-stem *g*, screwing into the said sleeve, and means for turning the said stem and for clamping the said sleeve at desired adjustments, substantially as set forth.

8. A regulable valve combining the following features: a movable stopper for controlling the way with a yielding valve adapted to yield and open to an increased pressure, with means for locking the same against so opening when desired, substantially as set forth.

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No. 618,921. Patented Feb. 7, 1899.

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REGULATING APPARATUS FOR STEAM HEATERS.

(Application filed Apr. 7, 1897.)

(No Model.)

Fig:1.

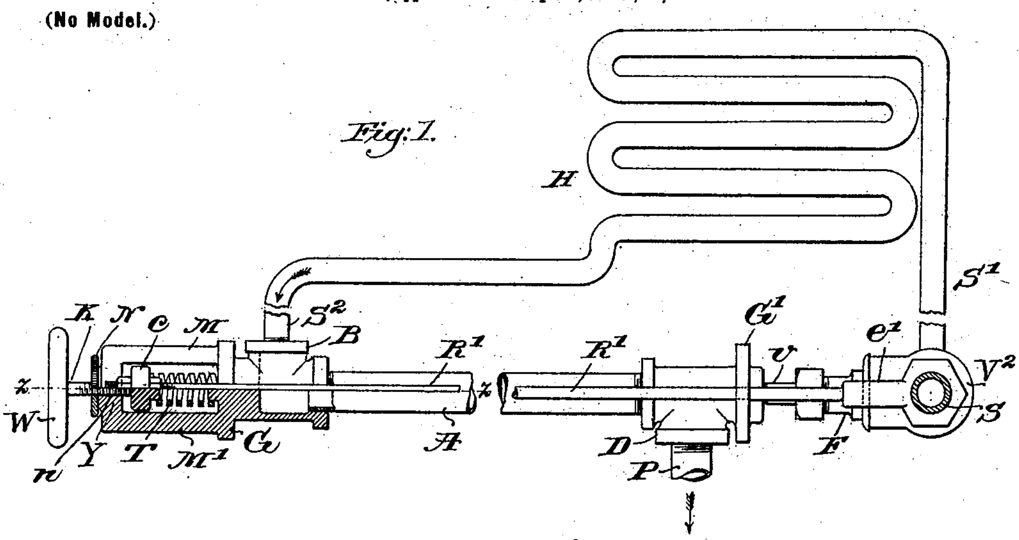


Fig:2.

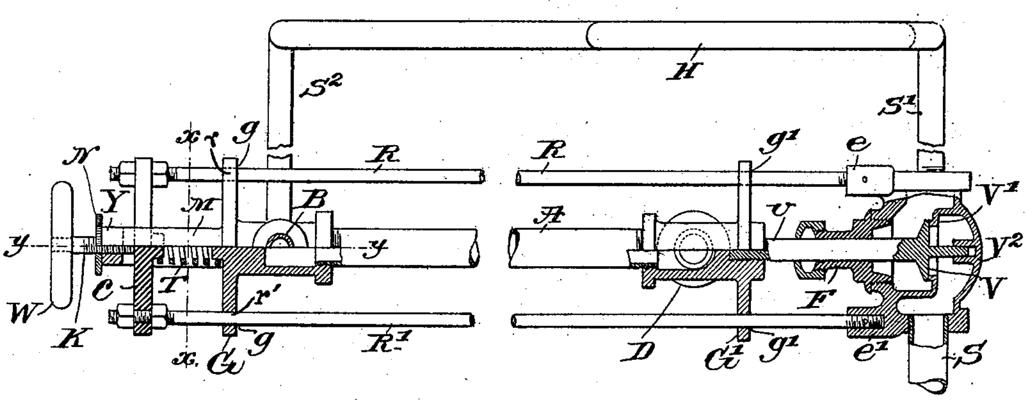
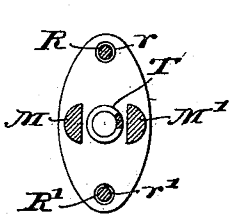


Fig:3.



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REGULATING APPARATUS FOR STEAM-HEATERS.

SPECIFICATION forming part of Letters Patent No. 618,921, dated February 7, 1899.

Application filed April 7, 1897. Serial No. 631,064. (No model.)

To all whom it may concern:

Be it known that I, FREDERIC TUDOR, a citizen of the United States, residing at Boston, in the county of Suffolk and State of Massachusetts, have invented a new and useful Improvement in Regulating Apparatus for Steam-Heaters, of which the following is a specification.

By the within-described invention a regulating apparatus is provided which when used in connection with a steam heating-coil or radiator and the valve at the intake thereof, arranged to admit steam from a main pipe or branch therefrom, serves automatically to secure a constant heat delivery from the heater or radiator and to determine the degree of service to be demanded from it.

The use of this invention will enable the user of a steam-heater to run it at high or low service, according to his changing needs, the automatic regulation of steam-supply securing constant service for any given adjustment without being disturbed by changes in the pressure at which the steam is delivered by the boiler and main pipes. A heating-coil may be used at a uniform rate of service either as a steam-heater or by adjustment of the regulator be reduced practically to the conditions of a hot-water heater for low service, although steam only is admitted to the heater feed-pipe at the valve.

The general arrangement and operation of the regulating apparatus are as follows: From the steam-valve, which may be of any desired construction, leads the pipe to the heating-coil. A discharge-pipe from the heating-coil is open and free to deliver to a hot-well or return-pipe the condensed or cooled contents of the heating-coil. Part of this discharge-pipe between the heating-coil and the final outlet passes in contact with or proximity to the mechanism which controls the action of the supply-valve, so that the heat emitted by the matter discharged from the heater is communicated to the valve mechanism. As this mechanism is warmed or cooled it expands or contracts, closing or opening the steam-valve, according to expansion or contraction.

In the drawings, wherein like letters are uniformly used to designate like parts, Figures 1 and 2 show the regulating apparatus in elevation and plan, respectively, with partial sections as follows: In Fig. 1, section at $y\ y$ of Fig. 2; in Fig. 2, section at $z\ z$ of Fig. 1 and section of the admission-valve. Fig. 3 is a detail of Figs. 1 and 2.

In Figs. 1 and 2 the heating apparatus is represented by a valve of the usual globe-valve construction, from which leads the steam-pipe S' to the heating-coil, which is shown merely in conventional form at H. The return or exhaust pipe S^2 of the heater H leads to the regulating apparatus, which operates on the valve V.

The waste-pipe S^2 delivers its contents into the pipe A, which through the union D and pipe P communicates with the hot-well or final receptacle of the condensed contents of the heater. At one end the pipe A is inserted in an elbow or union B. The other end of the pipe A carries the union D. Into the union D is screwed or otherwise firmly and tightly attached the stem v of the valve V, so that the latter will be withdrawn from its seat V' as pipe A contracts and will be pressed toward its seat as pipe A expands. The valve V, with its seat V' and casing V^2, is shown in cross-section in Fig. 2. The pipe S leads to the valve from the boiler and the pipe S' leads from the other side of the valve to the heater H.

A frame is attached to the valve-casting and consists of two stiff rods R R', which are secured to the valve-casting by being screwed into ears $e\ e'$. At the further ends of the rods R R' those rods are joined by a cross-head c, which is secured to the rods by nuts, for which the rods R R' are suitably threaded. This frame constitutes the supporting device to which the regulating apparatus is attached and from which as a base it exercises its control over the valve V.

The unions B and D have cast upon them oval flanges G G'. Onto the flange end of union D the valve-stem v is securely screwed. The casting of the union B has in addition to its flange G a bridge portion which consists of side pieces M M' and a yoke Y, joining the two. Pipe S^2 leads into union B, pipe P connects with union D, and the pipe A joins the unions B and D, Figs. 1 and 2.

The ends $g\ g\ g'\ g'$ of flanges G G', respectively, are pierced with holes $r\ r$, Fig. 3, through which pass the rods R R′, which thus support the regulating apparatus.

Between the cross-head c and flange G there is placed under compression a powerful spring T, which tends constantly to keep the valve-regulating apparatus, with valve-stem and valve connected, in proper position for valve closure. The spring T constitutes an elastic reaction member or abutment from which the valve-regulator makes its operative movement. Through the yoke Y passes a tapped hole n, which receives the threaded shaft K of the hand-wheel W. A set-nut N on shaft K serves to set the wheel W in any desired position. The end of the screw-shaft K bears upon the middle of the yoke c, which constitutes the fixed point from which the valve-regulating apparatus acts on the valve. As hand-wheel W is turned and shaft K bears upon cross-head c the effort of spring T is passively expended between the thrust-seats on cross-head c and union-casting B.

Now assume this apparatus to be manipulated by means of the wheel W. The valve V leaves its seat V′. Interference by the hand of the operator having ceased, the behavior of the apparatus is as follows: Condense-water and steam after being delivered from the heater pass through the pipe A, causing it to expand and close the valve. If the expansion of the regulator is more than sufficient to close the valve V and continues after the valve is firmly seated, further compression of the spring T relieves the regulator from any strain which would be due to the expansion of rigidly-confined members. By adjusting the valve V to a smaller opening all the steam which passes out is condensed and emerges from pipe P in the form of water, and under these conditions the operation of the heater is in effect the same as that of a hot-water heater, although the supply at the valve V is a steam-supply.

In the above-described apparatus the expansible valve-regulator constitutes a part of the return or waste passage which leads from the heater H to the hot-well, stack, or drain, as the case may be. By adopting such a construction as this the valve-regulating apparatus is made to serve several convenient functions and is adapted to receive in the best possible manner the heat of the waste products of the heater H. It is believed, therefore, that this construction is as convenient and compact as any which may be contrived, although numerous modifications to suit peculiar conditions may suggest themselves to a mechanic. In practice the valve V will be by the operation of the valve-regulator held in one position, the regulator correcting the fluctuations of service in the heater itself and automatically throttling the admission-valve V to meet changes of requirement.

The spring T constitutes an emergency relief, which in most cases will probably be necessary. It does not come into active service until the expansible regulator has completed the performance of its function by closing the valve. The combination of parts reduced to simplest form would omit this yielding member and act positively at all times. For instance, if the flange G were firmly fixed to the rods R R′ instead of being free to slide thereon, the parts M, M′, Y, W, K, N, c, n, and T being removed, the apparatus would then contain the active elementary components and would under fairly-constant conditions and with skilled handling operate properly to secure constant service from the heater. The usual conditions are such, however, that provision for relief in case of overheating or poor adjustment is believed to be desirable.

A nice adjustment of this self-regulating apparatus will enable the operator to extract the maximum duty from the steam entering the heating-coil, withdrawing from the waste-pipe P nothing except condense-water. In cases where it is desired to keep a water-tank full of water at 180° Fahrenheit, or thereabout, as for hotel water-supply purposes, &c., this self-regulating apparatus can be used to advantage, the condensation of steam in the coil being so adjusted that at no time is it possible to maintain a temperature in the tank even as high as that of steam at atmospheric pressure. This is obvious from the fact that a circuit from the valve V to the waste-pipe P is entirely open. The maximum temperature, therefore, of 212° Fahrenheit cannot in practice be reached.

By the use of the above-described appliance the amount of heat delivered from the heater or steam-coil may be made entirely independent of the pressure from the main steam-pipe. The heat delivered by the heating-coil determines the temperature and quantity of the heat of waste delivered as condense-water, and therefore controls the expansion of the governing member of the steam-throttling device. Since the heat delivered by the coil or heater governs the rate of admission of live steam, the user of the heater is not affected by the increase or decrease of the pressure of steam in the main pipes.

To illustrate the adaptability of this regulating device to situations where it is desired to maintain constant and uniform heat-delivery from heaters independently of variations in pressure in the steam-supply pipe, suppose a train of railway-cars supplied in the usual manner with heating-pipes within the cars and a continuous main or train pipe extending from the locomotive-engine. With the heaters in operation, each drawing steam from the train-pipe, the pressure of the train-pipe diminishes constantly as the rear of the train is approached, and with the ordinary hand-valves now in use constant regulation of the heat throughout the train is difficult and under many conditions impossible. Now if in each car a regulating device such as described above be attached to a valve which draws steam from the train-pipe for the car these regulators may be adjusted for the delivery of the desired quantity of heat from the heaters and after such preliminary adjustment will take care of themselves. The regulator in the car nearest the engine, where the train-pipe pressure is greatest, will throttle its valve so as to admit a very small quantity of steam to the car-pipes, which, in the manner above described, deliver their waste water through the expansible valve-regulator. From this first car to the end of the train the regulators will hold the valves wider and wider open as the train-pipe pressure diminishes, each regulator automatically caring for the uniformity of heat delivered in its car. Obviously besides comfort much economy will result from the use of such an arrangement, the waste-pipe of each car delivering nothing but warm condense-water which has delivered a practical maximum of the heat which it originally contained when in the form of steam.

In practice the valve-regulating wheel may be so adjusted that the heat of the condense-water, even when cooled considerably below the temperature of condensation by loss of heat in the coil or heater at the end of the circuit which is not filled by steam, may serve to expand the regulating-tube sufficiently to keep the supply of steam below the maximum requirements of full heating. Thus the coil or heater will be only partly filled with steam and the heating effect be correspondingly reduced. Since the waste-pipe is wholly free and open, the condense-water will drain away and there never can be any jarring or trouble from the presence of water or air in the pipes.

The facility by which steam-supply may be reduced is highly desirable in steam-heating, for in such a system the return or waste pipes may be made to run nearly cold, and thus there will be secured a great gain in comfort in mild weather, as well as economy of fuel, and if the waste-pipes are open only such quantities of heat are lost as remain in or are carried off by cooled condense-water.

What I claim, and desire to secure by Letters Patent, is as follows:

1. The combination, with the admission-valve and waste-pipe pertaining to a heating-coil or equivalent apparatus, of a heat-expansible valve-regulator so located and connected as to receive heat from the waste as it passes from the heating-coil and by its expansion under heat to move the admission-valve toward a position of closure, and a direct connection between the valve and the regulator, and a yielding member so located and adapted as to absorb expansion of the valve-regulator when the valve is seated, substantially as described.

2. The combination, with the admission-valve and waste-pipe pertaining to a heating-coil or equivalent apparatus, of a heat-expansible valve-regulator so located and connected as to receive heat from the waste as it passes from the heating-coil and by its expansion under heat to move the admission-valve toward a position of closure, and a reaction member adapted to sustain the steam-pressure on the valve, and to yield to expansion of the valve-regulator when the valve is seated, substantially as described.

3. The combination, with the admission-valve and waste-pipe pertaining to a heating-coil or equivalent apparatus, of a heat-expansible valve-regulator so located and connected as to receive heat from the waste as it passes from the heating-coil and by its expansion under heat to move the admission-valve toward a position of closure, and a reaction member adapted to sustain the steam-pressure on the valve, and to yield to expansion of the valve-regulator when the valve is seated, and means whereby the position of the valve with relation to its seat may be varied at will, independently of the automatic action of the valve-regulator, substantially as described.

4. The combination with the admission-valve and waste-pipe pertaining to a heating-coil or equivalent apparatus of a heat-expansible valve-regulator, of which the expansible element is a portion or connection of the said waste-pipe, the said regulator being directly attached to the valve at one end and abutting against an elastic reaction-piece at the other, the said reaction-piece in turn having its support on a frame substantially rigid with relation to the valve-casing, and being adapted to sustain the thrust of steam-pressure from the valve and to yield when the regulator expands after the valve is seated, substantially as described.

5. In a heater, the combination with a heating-coil or equivalent apparatus, its admission-valve, and waste-pipe, of a rigid frame secured to the admission-valve chamber, a heat-expansible valve-regulator attached to the valve-stem and mounted to slide on said frame, the expansible portion of said regulator consisting of a part or connection of the waste-pipe from the heater, an adjustable connection between the valve-regulator and the rigid frame whereby the position of the valve may be operated at will, and a spring located between the supporting-frame and the valve-stem, and adjusted so as to exert its effect to keep the valve thrust toward its seat, and to take up any expansion of the valve-controller which may take place when the valve is seated.

6. In a heater, the combination with a heating-coil or radiating apparatus, its admission-valve and a waste-pipe, of a heat-expansible valve-regulator, so located and connected as to receive heat from the waste as it passes from the heating-coil and by its expansion under heat to move the admission-valve toward a position of closure, and an elastic reaction member so located and adjusted with

reference to the valve-regulator as by its yielding to absorb expansion of the regulator when the admission-valve is closed.

7. In a heater, the combination with a heating-coil or equivalent apparatus, its admission-valve and waste-pipe, of a frame, rigid with relation to the admission-valve chamber, a heat-expansible valve-regulator attached to the valve-stem and mounted to move on said frame, the expansible portion of said regulator consisting of a part or connection of the waste-pipe from the heater, an adjustable connection between the valve-regulator and the said frame whereby the position of the valve may be operated at will, and a spring located between the supporting-frame and the valve-stem and adjusted so as to exert its effect to keep the valve thrust toward its seat, and to take up any expansion of the valve-regulator which may take place when the valve is seated, substantially as described.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

FREDERIC TUDOR.

Witnesses:
ELEANOR F. GROLL,
GRACE M. SHAY.

No. 701,524. Patented June 3, 1902.

F. TUDOR.

STEAM TRAP.

(Application filed July 3, 1901.)

(No Model.) 2 Sheets—Sheet I.

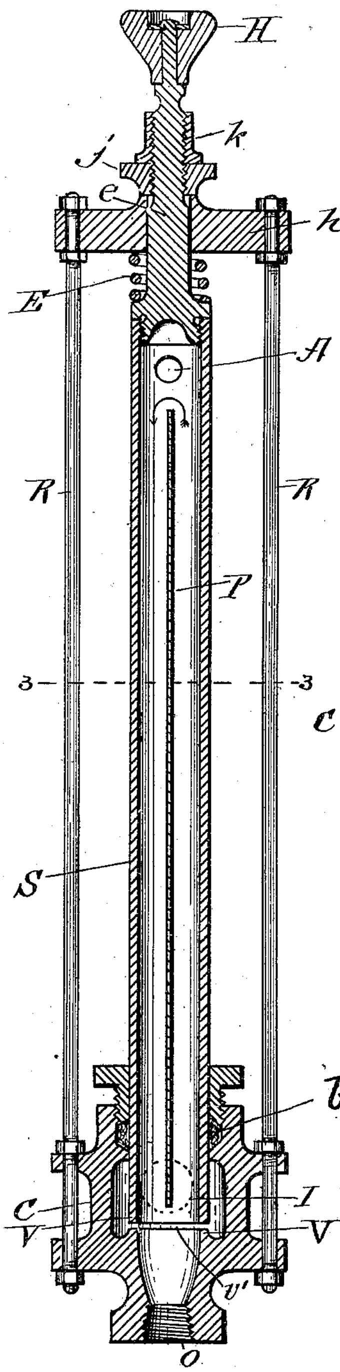

Fig. 1.

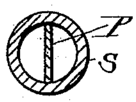

Fig. 3.

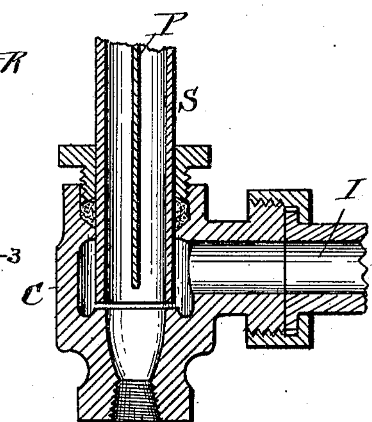

Fig. 2.

WITNESSES

[illegible]

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INVENTOR

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No. 701,524. Patented June 3, 1902.

F. TUDOR.

STEAM TRAP.

(Application filed July 3, 1901.)

(No Model.) 2 Sheets—Sheet 2.

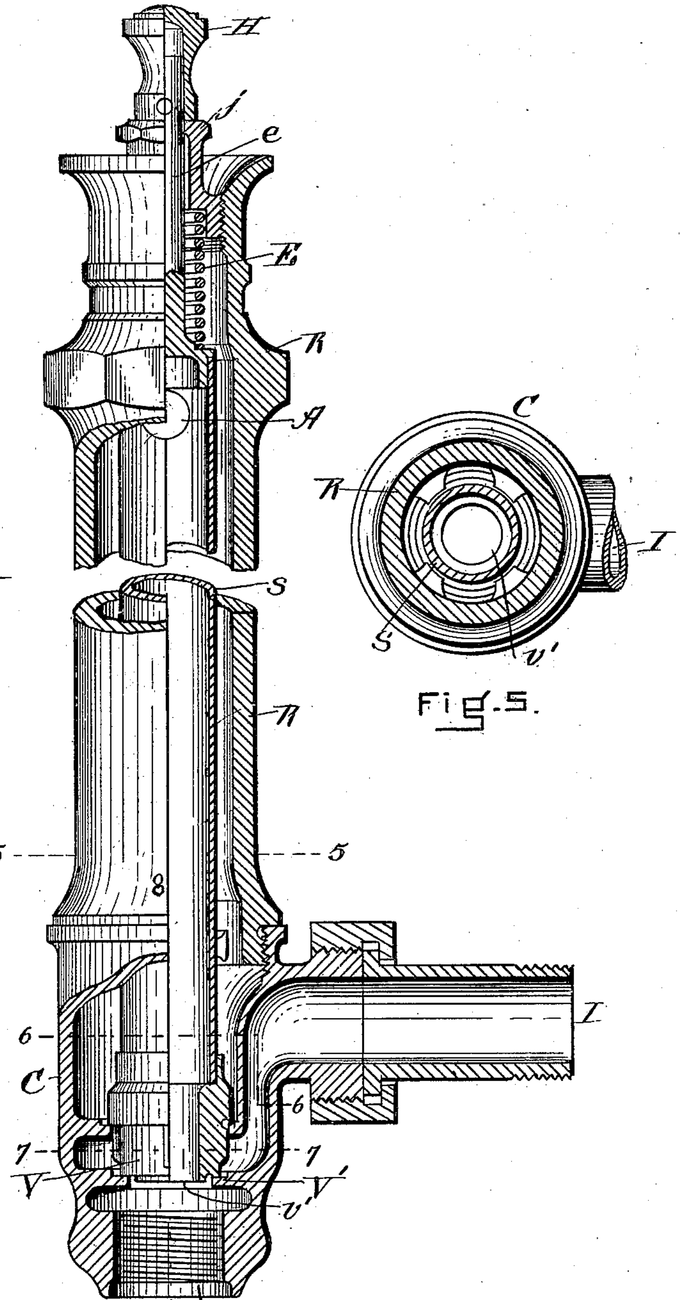

Fig. 4.

Fig. 5.

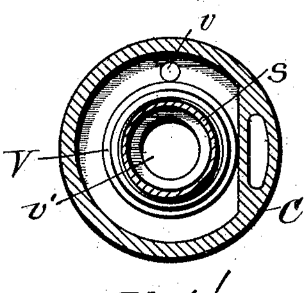

Fig. 6.

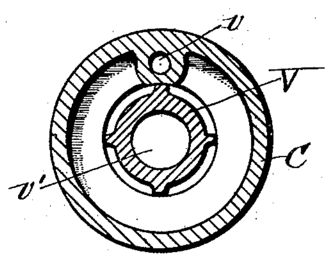

Fig. 7.

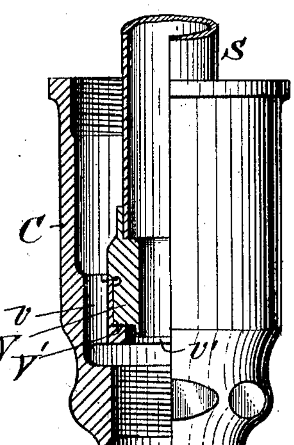

Fig. 8.

WITNESSES.

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UNITED STATES PATENT OFFICE.

FREDERIC TUDOR, OF BROOKLINE, MASSACHUSETTS.

STEAM-TRAP.

SPECIFICATION forming part of Letters Patent No. 701,524, dated June 3, 1902.

Application filed July 3, 1901. Serial No. 66,961. (No model.)

To all whom it may concern:

Be it known that I, FREDERIC TUDOR, a citizen of the United States, residing at Brookline, in the county of Norfolk and State of Massachusetts, have invented new and useful Improvements in Steam-Traps, of which the following is a specification.

The object of my invention is the production of an automatic steam-trap which shall maintain an opening sufficiently free to drain water and air from the steam apparatus with which the trap is used and which will not close until steam appears at the trap-opening.

Heretofore, so far as I am aware, steam-traps of the class to which this invention belongs—namely, expansion-traps wherein an outlet is controlled by the direct or differential expansion of parts subjected to the heat of fluids flowing through the trap—have been open to the grave defect of closing as the boiling-point of water is approached, so that in order to discharge water at or near the boiling-point the trap must be so adjusted that steam also may escape. Failing such adjustment the steam-traps heretofore known to me often close by expansion in response to the heat of the water and retain a large quantity of water in the trap and communicating apparatus. With steam-traps of the type to which I refer such behavior has been unavoidable, because water and steam occupying the same receptacle and in contact with each other have always the same temperature, and, as such an expansion steam-trap is made sensitive to fluctuation of temperature, if it is adjusted to allow water to escape at a given temperature it will also allow steam to escape at the same temperature. Thus in this important respect expansion steam-traps have failed to accomplish the object for which they are applied—namely, to draw water from steam-containing apparatus and to close or prevent the escape and waste of steam. In consequence of this fact the practical usefulness of heretofore-existing steam-traps is limited only to a partial effectiveness, so far as I am aware—that is to say, such traps cannot discharge all the water in a receptacle filled with steam or water formed from condensation or accumulation by entrainment, but can discharge only such portion of the water as may have accumulated at the lower part of the apparatus or in the pipes leading from it and which, being removed from contact with the steam and exposed to cooling influences, has so far subsided in temperature as to cause the sensitive parts of the steam-trap to contract and open the escape-valve. Inasmuch as the true function of the steam-trap is thoroughly to drain out the water as fast as it accumulates in the apparatus that it serves it is apparent that the variety of steam-traps as heretofore constructed is not adequate to accomplish this purpose.

In my improved steam-trap I provide means whereby the water accumulated in the steam or water passages is kept out of heat-conductive proximity to the sensitive portions of the trap or is so far kept out of such proximity that not enough heat is transmitted from the water to the sensitive parts of the trap to cause these parts to operate and close or choke the escape-valve. Heretofore in all practical constructions the transmission of some heat to the sensitive parts of the trap from water flowing through its passages has been inevitable; but in my improvement it is possible so to conduct water through and from the trap as to render its heat practically inoperative upon the sensitive expansible portions of the trap. On the other hand, my invention provides means whereby steam entering the trap through its inlet-pipe is induced to circulate in heat-conductive proximity to the sensitive expansible valve-controlling portions of the trap, so that the presence of steam in the trap will cause it to close instantly or at least as soon as the heat of the steam can be communicated to the expansible member. I accomplish this by providing a channel for water which conveys hot water out of the trap without passing it into conductive contact with the expansible valve-controlling portions of the trap and by providing separate side channels adapted to the induction and circulation of gaseous contents of the trap into heat-conductive contact with the expansible members of the trap.

By employing a steam-trap constructed according to my invention the outlet-valve of a low-pressure steam-heater can be arranged so as to drain away the water condensed in the heater at a substantially constant rate, corresponding to the rate of condensation in the heater. If the conditions under which the heater operates are changed—as, for instance, by changes in the outside temperature—so that the condensation in the heater is less rapid than before, the steam-trap guards against waste of steam by closing automatically as soon as the condense-water is drained away and steam appears at the outlet.

In the drawings hereto annexed there are shown two embodiments of my invention, one operating by direct expansion of a single member, the other operating by differential expansion of two members. Both of these forms of apparatus are characterized by the same principle of operation.

Figure 1 shows one form of my steam-trap in vertical section. Fig. 2 shows in vertical section the lower part of the steam-trap of Fig. 1 viewed from the right hand. Fig. 3 is a cross-section of Fig. 1 at the line 3 3. Fig. 4 shows another form of my steam-trap, partly in vertical section, partly broken away. Fig. 5 is a cross-section of Fig. 4 at the line 5 5. Fig. 6 is a cross-section of Fig. 4 at the line 6 6. Fig. 7 is a cross-section of Fig. 4 at the line 7 7. Fig. 8 shows the lower portion of the steam-trap of Fig. 4, partly in vertical section, viewed from the left hand.

The inlet-pipe I is connected with the apparatus with which the steam-trap is in service, and the outlet-pipe O delivers the contents of the trap to such receptacle as may be provided. The inlet-pipe I and outlet O constitute a discharge-passage for fluids from the apparatus with which the trap is used and are shown as formed in the casting C, wherein also the valve-seat V′ is formed and adapted to coöperation with the valve V.

In Fig. 1 a tubular steam-chamber S passes through the top of the casting C and makes a steam-tight joint therewith by means of the packing *b*. At its outer end the steam-chamber S, which is tubular in form, is attached to a stem *e*, which passes through the cross-head *h*, sliding freely therein. The cross-head *h* is rigidly connected with the casting C by means of side rods R. The inner end of the steam-chamber S is ground to the valve-surface at V and coöperates with the valve-seat V′, which is formed on the casting C. The outlet O is placed below the opening of the valve V, so that liquids which pass through the discharge-passage and valve-opening immediately flow downward and away from the steam-trap and steam-chamber S.

The walls of the steam-chamber S are composed of material sensitive to heat and readily expanding under the influence of heat—brass tubing, for instance. The chamber S is further provided with means whereby the circulation of steam and air through the chamber is induced. By providing a central partition P the circulation of steam issuing from the inlet-pipe I is more readily initiated than will be the case where no special means for inducing circulation are presented.

Where there would be no objection to the escape of air from the trap into the place or room where the trap is used, an opening A may be provided and may be employed either with or without a circulation-partition P. Between the outer end of the steam-chamber S and cross-head *h* I provide a spring E, which serves as an elastic cushion, which when the valve S is seated by the expansion of the steam-chamber S absorbs any surplus expansion of the steam-chamber and prevents straining of the apparatus.

To provide for blowing out the trap without disturbing the adjustment, the rod *e* is threaded to receive a nut *j*, resting on the cross-head and held firmly against the latter by the spring E. The instrument is adjusted by means of this nut *j*, and the latter is prevented from turning on the thread after adjustment by the lock-nut *k*. By pulling up the handle H, attached to the rod *e*, the valve may be lifted a quarter of an inch or more from its seat and be thoroughly cleared of all kinds of sediment, dirt, and scale, and when released will return to its normal position.

In Fig. 4 I show a different specific arrangement of parts of a steam-trap adapted to perform the functions peculiar to my invention. Here the rods of Fig. 1 are replaced by a tube R, surrounding an inner tube S, which has a coefficient of expansion different from that of the supporting-tube R. The outer tube R may be of cast-iron, the inner tube S of zinc. The valve V is attached to the zinc tube S and is urged to its seat by the spring D under compression between tubes R and S through the rod *e*, handle H, and adjusting-nut *j*. The valve V is double-seated and when slightly open offers a passage downward for water and a passage upward for air and steam. At the side of the valve is a small passage *v*, connecting the upper outlet and chamber with the main outlet and passing through or by the inlet-chamber. This is to drain away any water escaping into the upper chamber of the trap. It will be seen that air first and subsequently steam which escapes into the upper chamber find their easiest way out through openings A at the top of the inner tube S, water going directly out by the side passage *v*; but the expansion produced by the heat of the steam acting differentially upon the tubes R and S will have closed the valve before steam can escape from the main outlet at O. If the expansive movement is more than sufficient to close the valve or if sediment should be lodged between either face of the valve and its seat, the surplus movement will be taken up by the spring E and injury to the instrument will be prevented. In the case of Fig. 4 the adjusting-nut *j* is screwed to the outer tube R instead of to the rod *e*, and there is no lock-nut. Any thick paint made with a non-drying oil applied to the joint between R and *j* will bind the parts together. The adjustment and the mode of blowing out sediment are, however, substantially the same in Fig. 3 as in Fig. 1.

The operation of the apparatus shown in

these drawings is as follows: If the water is accumulated in the apparatus to which the trap is attached, it enters the discharge-passage in the casting C, issuing from the apparatus to which the trap is attached by the inlet-opening I, the trap is adjusted so that when no steam is actually present in the steam-chamber S the valve V is open. When, therefore, hot water issues from the inlet I, it flows through the valve-opening at v' and directly out of the apparatus through the outlet O, passing by the entrance of the expansible steam-chamber S, so that substantially no heat is communicated to the sensitive expansible parts from the hot water. The location of the outlet O below the valve V insures this result. When the water has been drained from the apparatus, steam proceeding therefrom flows or circulates freely upward as well as outward, and its circulation through the tubular chamber S is encouraged by the presence of the partition P or by the air-aperture A, Fig. 1, if the latter is provided, or by both, and straightway heat is communicated to the expansible parts of the apparatus, which operate immediately to close the valve V, and so long as steam remains in the trap the valve V will by closure prevent its escape. It will be observed that steam being prevented from escaping by the outlet O and from it into any pipe thereto connected can only act upon the trap by escaping past the open valve. Hence when the valve becomes closed it cannot remain closed, because its members gradually parting with their heat begin to contract and again cause the valve to open. The slightest opening gives passage to water, which escapes more and more freely until it is all drained away and steam again enters the upper chamber. The effect of these actions is to keep the steam side of the trap quite free from water, the expansive members taking a permanent temperature and position, which is that allowing only enough steam to pass to maintain its temperature at the critical point, only the lower half or thereabout of the instrument being as hot as steam. The trap is also an efficient automatic air-valve, suitable for use in steam-heating systems as such, or combining the functions of both steam-trap and automatic air-valve.

In all expansion-traps where the opening for the escape of water is necessarily limited there is a tendency to accumulate sediment, which finally completely chokes the outlet and renders the trap inoperative. Fine-wire nettings or screens designed to intercept this sediment become themselves choked and are of little or no advantage. The most effective remedy for this defect in such trap is to provide means for loosening and blowing out the sediment; but to do this it has been heretofore necessary to disturb the adjustment of the trap, which ought to be permanent. Consequently whenever the trap is blown out adjustment has to be made over again, as at first, and demands the attention and care of a person skilled in this kind of work. To obviate this disadvantage, I have contrived means for opening the valve manually without disturbing the adjustment, giving free passage to comparatively large objects as well as sediment should such happen to have been carried into the trap. The trap can thus be cleared in an instant by any person without disarranging the adjustment.

What I claim, and desire to secure by Letters Patent, is—

1. In a steam-trap or analogous apparatus, the combination of a discharge-passage, a steam-chamber communicating therewith, a valve, controlling the discharge-passage and the entrance to the steam-chamber, a heat-expansible valve-controller in heat-conductive proximity to the steam-chamber, the discharge-passage and steam-chamber being so disposed with relation to each other that liquids flow through the discharge-passage without entering the steam-chamber, substantially as described.

2. In a steam-trap or analogous apparatus, the combination of a discharge-passage, a steam-chamber communicating therewith, a valve, controlling the discharge-passage and the entrance to the steam-chamber, a heat-expansible valve-controller in heat-conductive proximity to the steam-chamber, an elastic cushion, whereon the valve-controller is abutted, the discharge-passage and steam-chamber being so disposed with relation to each other that liquids flow through the discharge-passage without entering the steam-chamber, substantially as described.

3. In a steam-trap or analogous apparatus, the combination of a discharge-passage, a steam-chamber communicating therewith, a valve, controlling the discharge-passage and the entrance to the steam-chamber, a heat-expansible valve-controller in heat-conductive proximity to the steam-chamber, the discharge-passage and steam-chamber being so disposed with relation to each other that liquids flow through the discharge-passage without entering the steam-chamber, and means whereby the valve-controller may be manually operated to lift the valve from its seat substantially as described.

4. In a steam-trap or analogous apparatus, the combination of a discharge-passage, a steam-chamber communicating therewith, a valve controlling the discharge-passage and the entrance to the steam-chamber, a heat-expansible valve-controller in heat-conductive proximity to the steam-chamber and means whereby the valve-controller may be manually operated to lift the valve from its seat against the stress of the elastic cushion, the discharge-passage and steam-chamber being so disposed with relation to each other that liquids flow through the discharge-passage without entering the steam-chamber, substantially as described.

5. In a steam-trap or analogous apparatus the combination of a discharge-passage, a

steam-tube of heat-expansible material, a valve connected therewith controlling the discharge-passage and the entrance to the steam-tube, the steam-tube adapted to receive steam issuing from the discharge-passage, connections between the expansible steam-tube and the valve whereby expansion of the tube is accompanied by closure of the valve, the discharge-passage being so located that liquids passing therethrough flow away from effective heat-conductive proximity to the steam-tube.

6. In a steam-trap or analogous apparatus the combination of a discharge-passage, a steam-tube of heat-expansible material, a valve connected therewith controlling the discharge-passage and the entrance to the steam-tube, the steam-tube provided with devices whereby circulation of steam issuing from the inlet-pipe is induced through the steam-tube, connections between the expansible steam-tube and the valve whereby expansion of the tube is accompanied by closure of the valve, the discharge-passage being so located that liquids passing therethrough flow away from effective heat-conductive proximity to the steam-tube.

7. In a steam-trap or analogous apparatus, the combination of a discharge-passage, a steam-chamber communicating therewith, a valve, controlling the discharge-passage and the entrance to the steam-chamber, a heat-expansible valve-controller in heat-conductive proximity to the steam-chamber, the discharge-passage and steam-chamber being so disposed with relation to each other that liquids flow through the discharge-passage without entering the steam-chamber, and connections with the valve whereby the valve may be opened at will independently of the normal operation of the valve-controller, substantially as described.

8. In a steam-trap or analogous apparatus, the combination of a discharge-passage, a steam-chamber communicating therewith, a valve, controlling the discharge-passage and the entrance to the steam-chamber, a heat-expansible valve-controller in heat-conductive proximity to the steam-chamber, an elastic cushion, whereon the valve-controller is abutted, the discharge-passage and steam-chamber being so disposed with relation to each other that liquids flow through the discharge-passage without entering the steam-chamber, and connections with the valve whereby the valve may be opened at will independently of the normal operation of the valve-controller, substantially as described.

9. In a steam-trap or analogous apparatus, the combination of a discharge-passage, a steam-chamber communicating therewith, a valve, controlling the discharge-passage and the entrance to the steam-chamber, a heat-expansible valve-controller in heat-conductive proximity to the steam-chamber, the discharge-passage and steam-chamber being so disposed with relation to each other that liquids flow through the discharge-passage without entering the steam-chamber, and means whereby the valve-controller may be manually operated to lift the valve from its seat and connections with the valve whereby the valve may be opened at will independently of the normal operation of the valve-controller, substantially as described.

10. In a steam-trap or analogous apparatus, the combination of a discharge-passage, a steam-chamber communicating therewith, a valve, controlling the discharge-passage and the entrance to the steam-chamber, a heat-expansible valve-controller in heat-conductive proximity to the steam-chamber and means whereby the valve-controller may be manually operated to lift the valve from its seat against the stress of the elastic cushion, the discharge-passage and steam-chamber being so disposed with relation to each other that liquids flow through the discharge-passage without entering the steam-chamber, and connections with the valve whereby the valve may be opened at will independently of the normal operation of the valve-controller, substantially as described.

11. In a steam-trap or analogous apparatus the combination of a discharge-passage, a steam-tube of heat-expansible material connected therewith, controlling the discharge-passage and the entrance to the steam-tube, the steam-tube adapted to receive steam issuing from the discharge-passage, connections between the expansible steam-pipe and the valve whereby expansion of the tube is accompanied by closure of the valve, the discharge-passage being so located that liquids passing therethrough flow away from effective heat-conductive proximity to the steam-tube, and connections with the valve whereby the valve may be opened at will independently of the normal operation of the valve-controller.

12. In a steam-trap or analogous apparatus, the combination of a fluid-discharge pipe, a valve in the same, the said valve controlled by a heat-expansible valve-controller, and so located that liquids passing through the discharge-pipe past the valve flow away from the valve-controller, a steam-opening leading to the controller from the outlet side of the valve, so that steam, to approach the controller must first pass the valve, substantially as described.

13. In a steam-trap or analogous apparatus, the combination of a fluid-discharge pipe, a valve in the same, a tubular valve-controller secured to the valve, an aperture from the outlet side of the valve leading to the interior of the tubular controller, a casing surrounding the controller, an aperture in the controller communicating with the interior of the said casing, and drain-apertures from the casing to the discharge-pipe, substantially as described.

14. In a steam-trap or analogous apparatus, the combination of a discharge-passage, a steam-chamber branching from and commu-

nicating therewith, a valve, controlling the discharge-passage and the entrance to the steam-chamber, a heat-expansible valve-controller in heat-conductive proximity to the steam-chamber, the discharge-passage and steam-chamber being so disposed with relation to each other that liquids flow through the discharge-passage without entering the steam-chamber, substantially as described.

15. In a steam-trap or analogous apparatus, the combination of a discharge-passage, a steam-chamber branching from and communicating therewith, a valve, controlling the discharge-passage and the entrance of the steam-chamber, a heat-expansible valve-controller in heat conductive proximity to the steam-chamber, an elastic cushion, whereon the valve-controller is abutted, the discharge-passage and steam-chamber being so disposed with relation to each other that liquids flow through the discharge-passage without entering the steam-chamber, substantially as described.

16. In a steam-trap or analogous apparatus, the combination of a discharge-passage, a steam-chamber branching from and communicating therewith, a valve, controlling the discharge-passage and the entrance to the steam-chamber, a heat-expansible valve-controller in heat-conductive proximity to the steam-chamber, the discharge-passage and steam-chamber being so disposed with relation to each other that liquid flows through the discharge-passage without entering the steam-chamber, and means whereby the valve-controller may be manually operated to lift the valve from its seat substantially as described.

17. In a steam-trap or analogous apparatus the combination of a discharge-passage, a steam-tube of heat-expansible material branching therefrom, a valve connected therewith controlling the discharge-passage and the entrance to the steam-tube, the steam-tube adapted to receive steam issuing from the discharge-passage, connections between the expansible steam-tube and the valve whereby expansion of the tube is accompanied by closure of the valve, the discharge-passage being so located that liquids passing therethrough flow away from effective heat-conductive proximity to the steam-tube.

18. In a steam-trap or analogous apparatus the combination of a discharge-passage, a steam-tube of heat-expansible material branching therefrom, a valve connected therewith controlling the discharge-passage and the entrance to the steam-tube, the steam-tube provided with devices whereby circulation of steam issuing from the inlet-pipe is induced through the steam-tube, connections between the expansible steam-tube and the valve whereby expansion of the tube is accompanied by closure of the valve, the discharge-passage being so located that liquids passing therethrough flow away from effective heat-conductive proximity to the steam-tube.

19. In a steam-trap or analogous apparatus, the combination of a discharge-passage, a steam-chamber branching therefrom and communicating therewith, a valve, controlling the discharge-passage and the entrance to the steam-chamber a heat-expansible valve-controller in heat-conductive proximity to the steam-chamber, the discharge-passage and steam-chamber being so disposed with relation to each other that liquids flow through the discharge-passage without entering the steam-chamber, and connections with the valve whereby the valve may be opened at will independently of the normal operation of the valve-controller, substantially as described.

Signed by me at Boston, Massachusetts, this 24th day of June, 1901.

FREDERIC TUDOR.

Witnesses:
REUBEN L. ROBERTS,
ODIN B. ROBERTS.