(No Model.)

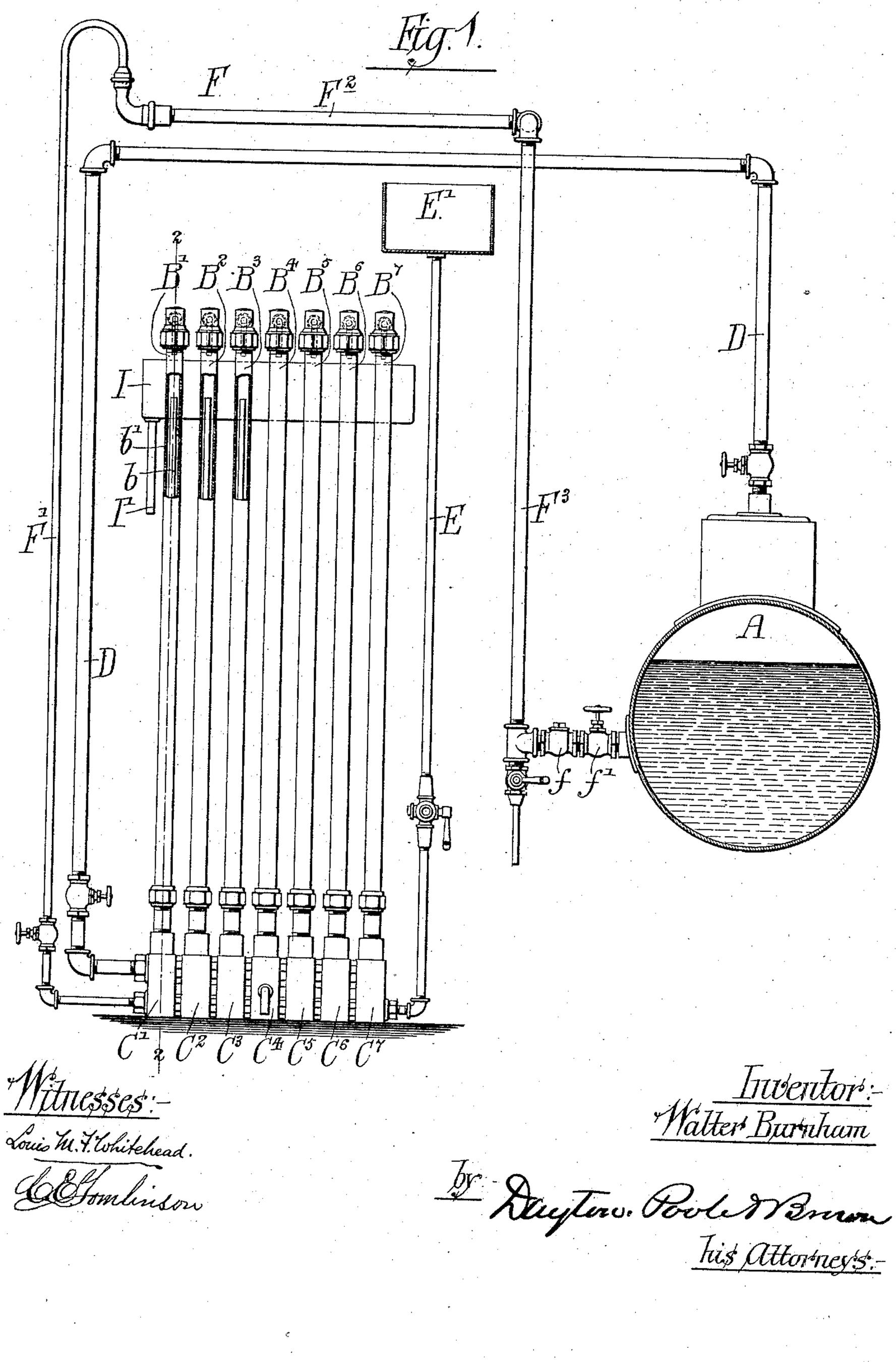
4 Sheets—Sheet 1.

W. BURNHAM.

COMBINED STEAM LOOP.

No. 474,440. Patented May 10, 1892.

Fig. 1.



Witnesses:-

Louis M. T. Whitehead.

C. E. Tomlinson

Inventor:-

Walter Burnham

by Dwyer & Poole Brown

his Attorneys.-

(No Model.)

4 Sheets—Sheet 2.

W. BURNHAM.

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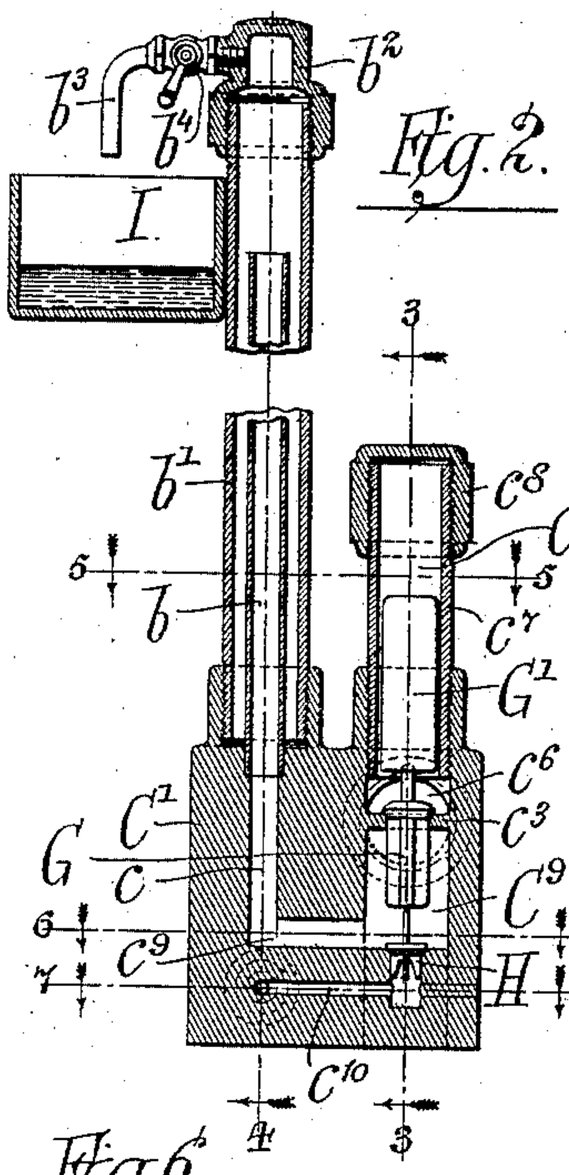


Fig. 2.

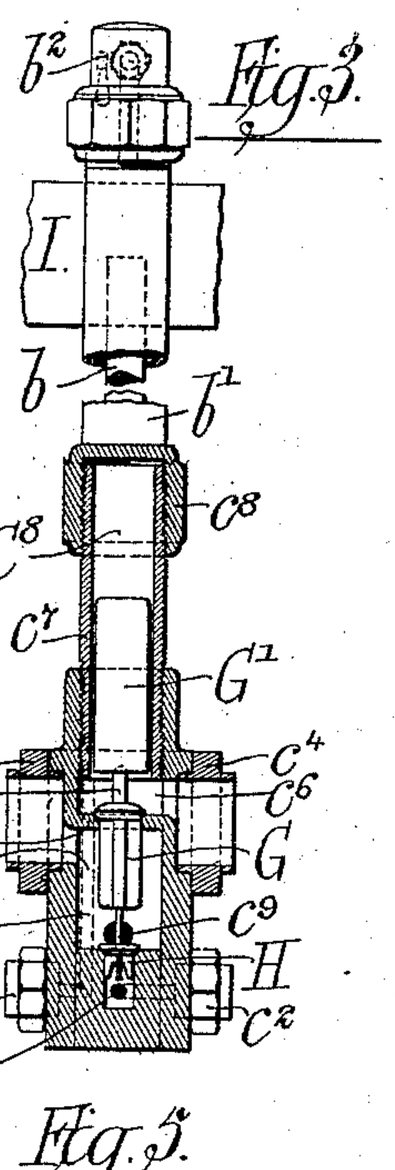


Fig. 3.

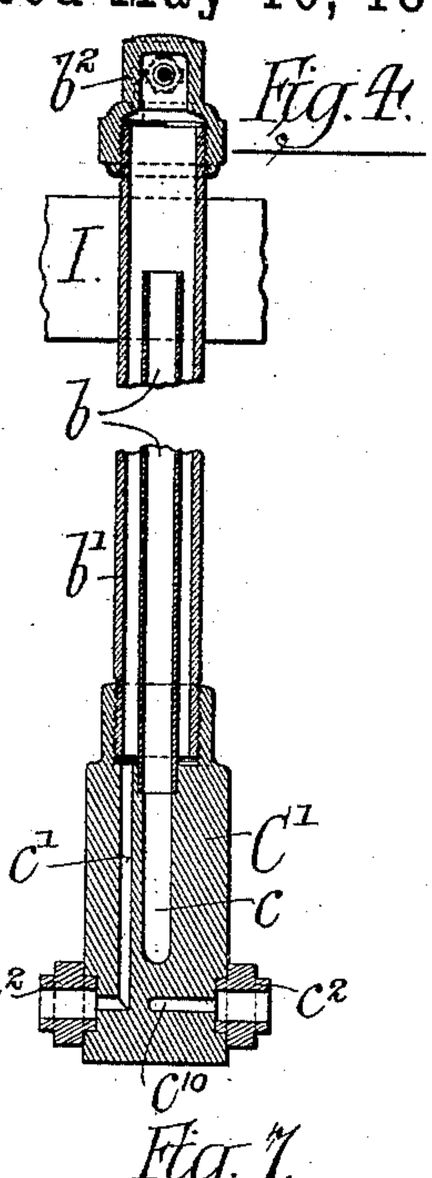


Fig. 4.

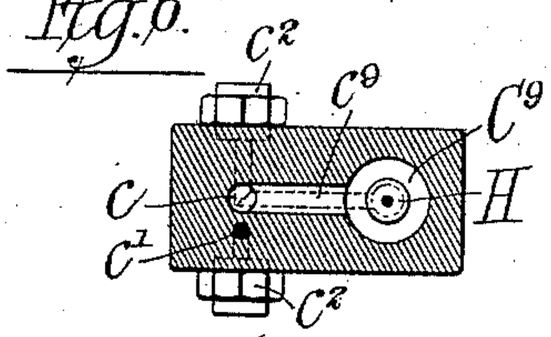


Fig. 9.

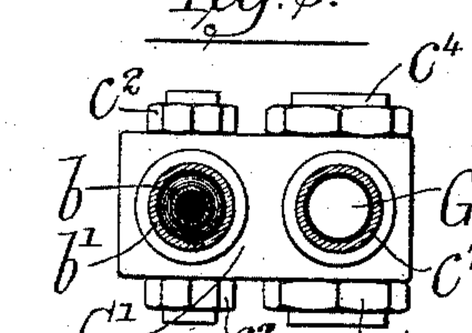


Fig. 10.

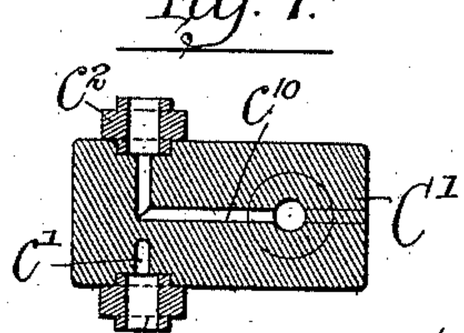
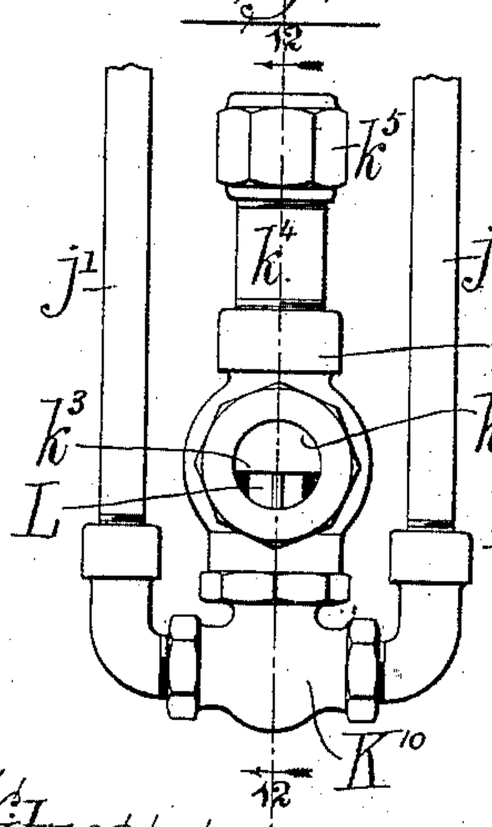
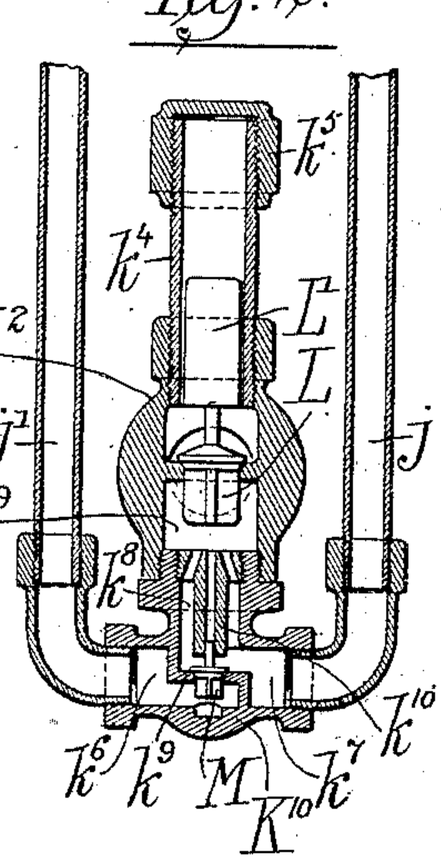
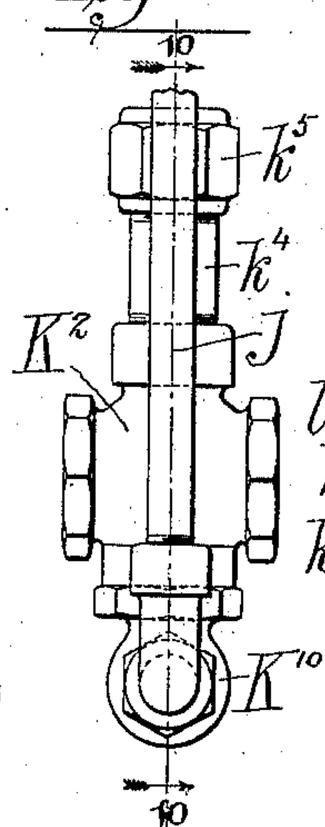


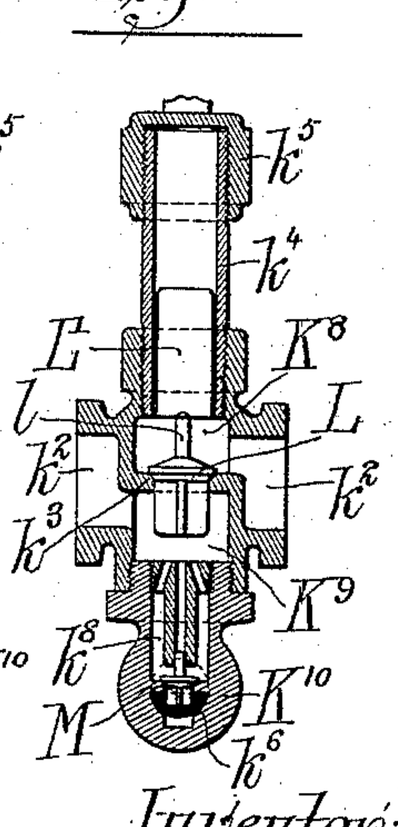
Fig. 11.

Fig. 12.









Witnesses:-

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(No Model.)

4 Sheets—Sheet 3.

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Fig. 8.

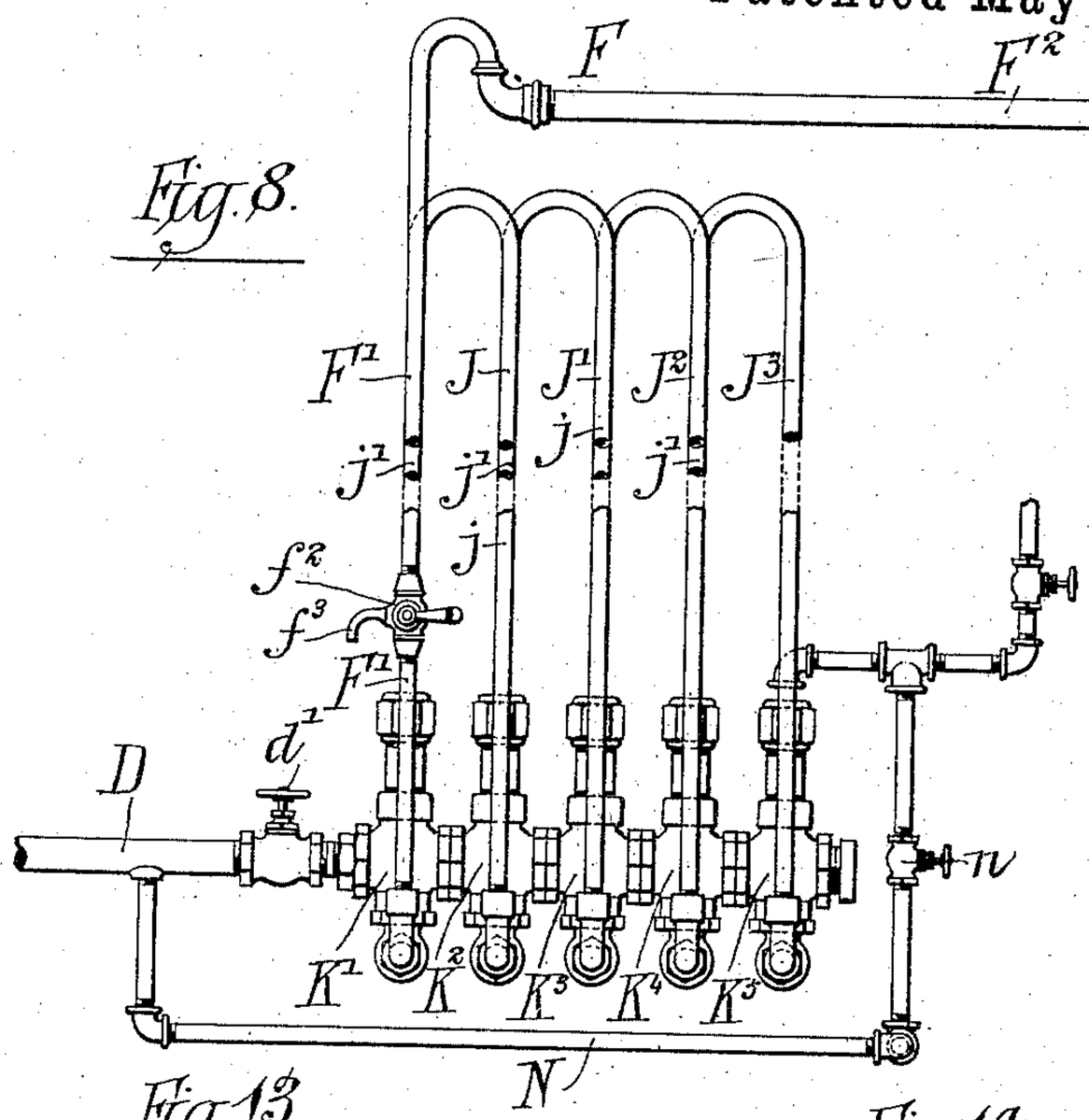


Fig. 13.

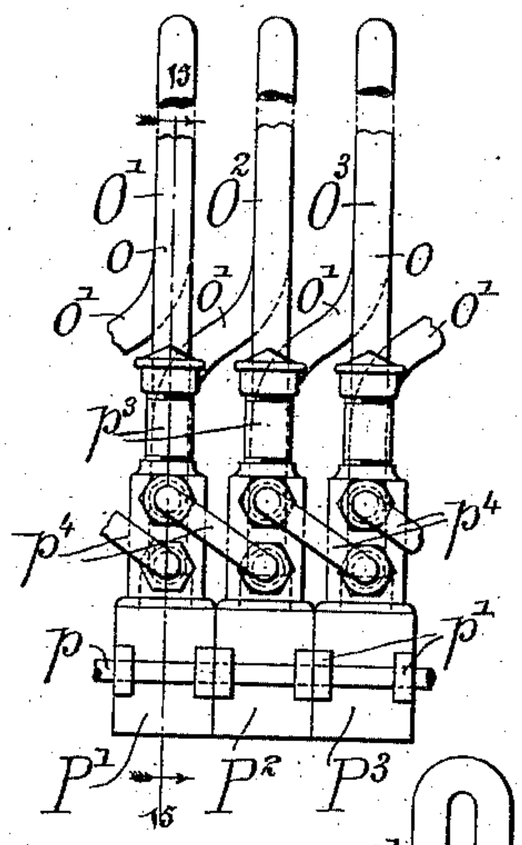


Fig. 14.

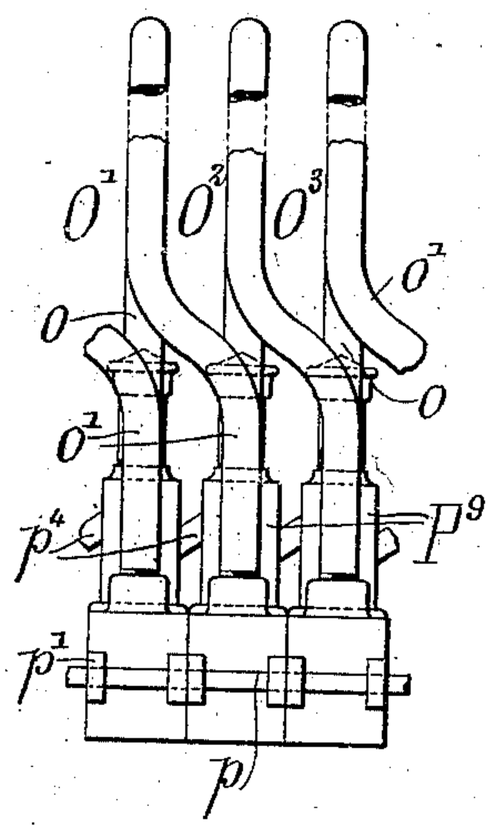
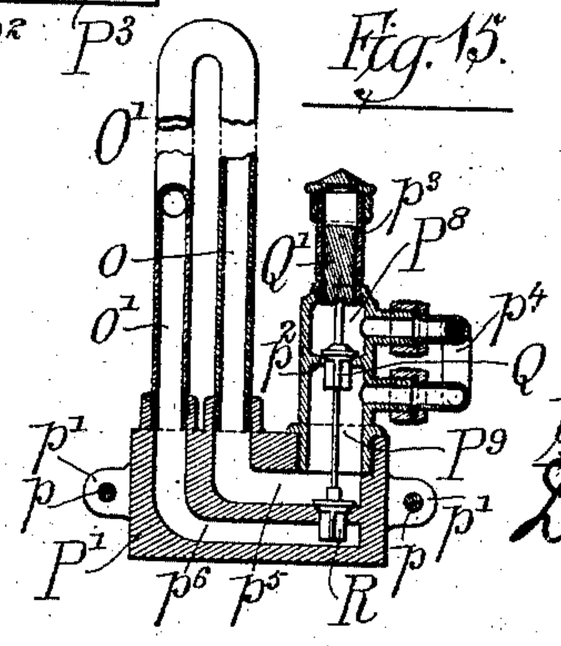


Fig. 15.



Witnesses:-

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(No Model.)

4 Sheets—Sheet 4.

W. BURNHAM.

COMBINED STEAM LOOP.

No. 474,440. Patented May 10, 1892.

Fig. 16.

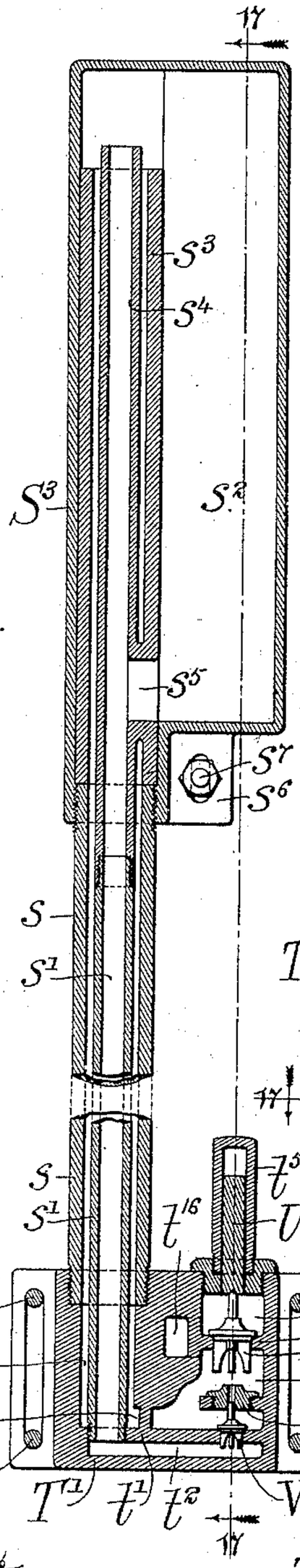

Fig. 17.

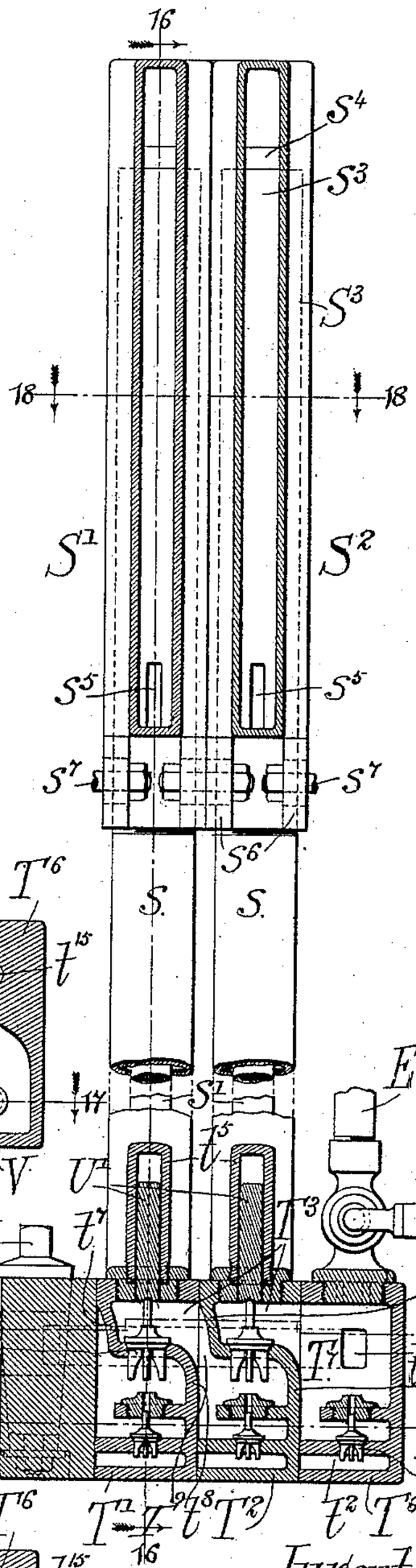

Fig. 18.

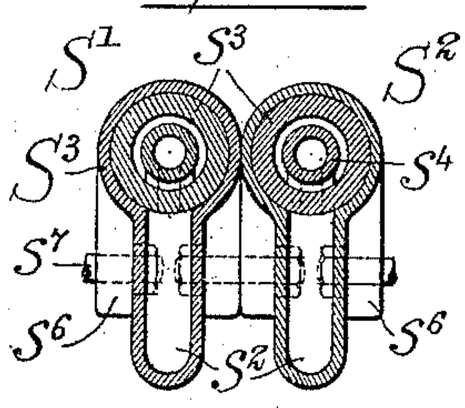

Fig. 19.

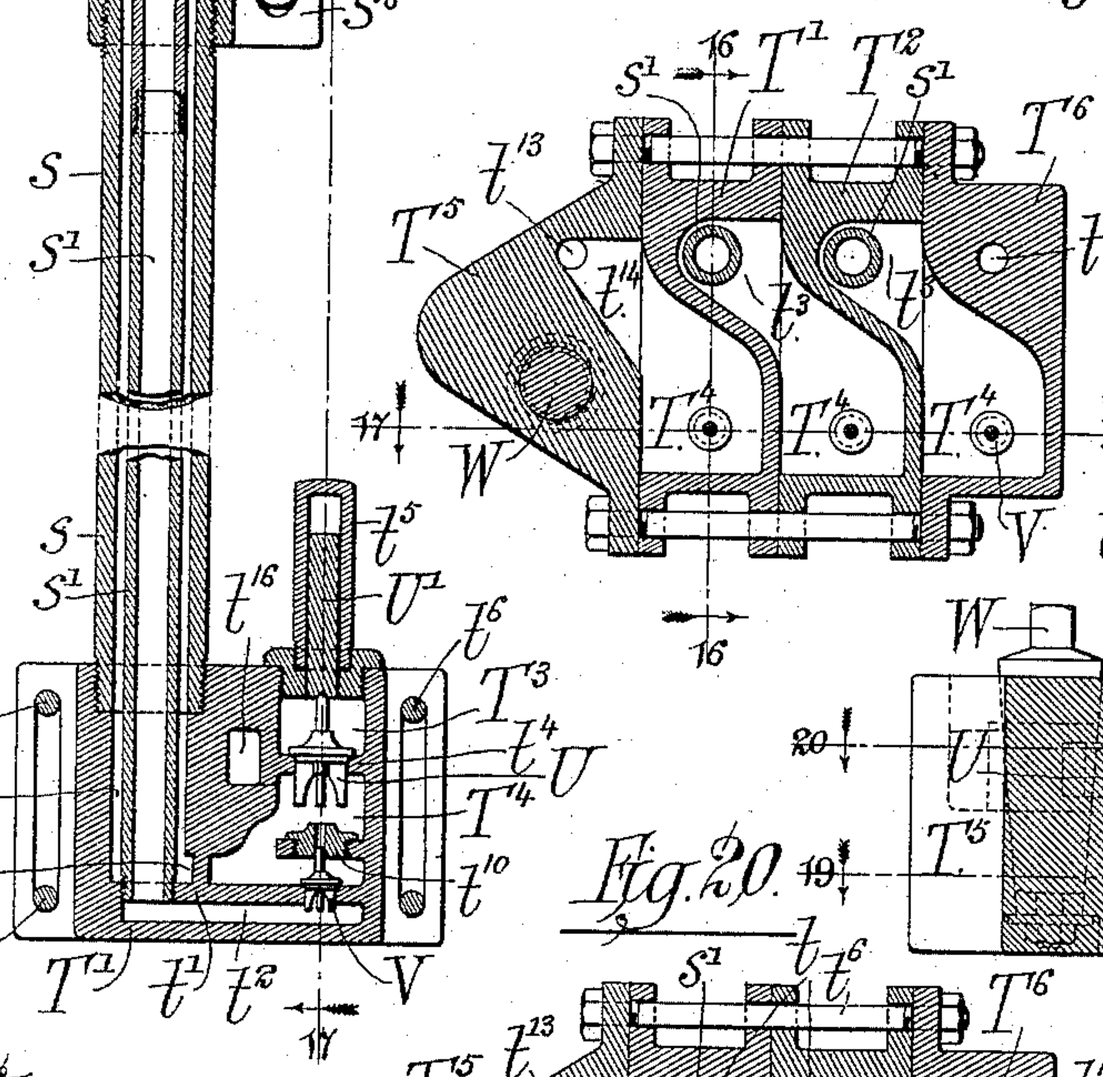

Fig. 20.

Witnesses:-

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by:-

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his Attorneys.

UNITED STATES PATENT OFFICE.

WALTER BURNHAM, OF CHICAGO, ILLINOIS.

COMBINED STEAM-LOOP.

SPECIFICATION forming part of Letters Patent No. 474,440, dated May 10, 1892.

Application filed January 12, 1892. Serial No. 417,887. (No model.)

To all whom it may concern:

Be it known that I, WALTER BURNHAM, of Chicago, in the county of Cook and State of Illinois, have invented certain new and useful Improvements in Combined Steam-Loops; and I do hereby declare that the following is a full, clear, and exact description thereof, reference being had to the accompanying drawings, and to the letters of reference marked thereon, which form a part of this specification.

This invention relates to devices acting by the direct agency of steam for delivering liquids from a space or chamber subject to one pressure into a chamber subject to a higher pressure—as, for example, the delivery of water from an open tank or from a hydrant into a steam-generator.

In a prior patent, No. 394,859, granted December 18, 1888, to William Irving, is described an apparatus for the purpose above stated, wherein a single return-pipe or "steam-loop" is employed of such height as to overcome the differences of pressure between a space subject to the higher pressure and that of less pressure.

In Letters Patent No. 394,826, granted December 18, 1888, to me, is described an apparatus embracing the general features of construction and operation contained in said Irving patent and embracing a series of chambers or vessels subject to different pressures and a plurality of steam-loops or return-pipes for transferring the liquid from the chambers subject to less pressures to those subject to greater pressures, thereby enabling the principles of construction set forth in said Irving patent to be applied to situations where it is impracticable or undesirable to employ a single return or lifting pipe to overcome the total difference in pressure between the space from which the liquid is received and that into which it is to be delivered.

The present invention embraces improvements in the apparatus described in Patent No. 394,828, by which the same is better adapted for practical use or application.

In the accompanying drawings, illustrating my invention, Figure 1 is a view in elevation, with parts in section, of an apparatus embodying the same. Fig. 2 is a sectional view through one of the steam-loops of the apparatus, taken on line 2 2 of Fig. 1. Fig. 3 is a sectional elevation taken on line 3 3 of Fig. 2. Fig. 4 is a vertical section taken on line 4 4 of Fig. 2. Fig. 5 is a plan section taken on line 5 5 of Fig. 2. Fig. 6 is a similar section taken upon line 6 6 of Fig. 2. Fig. 7 is a similar section taken on line 7 7 of Fig. 2. Fig. 8 is a view in side elevation of a plurality of connected loops, illustrating another embodiment of the main features of my invention. Fig. 9 is a view in elevation of one of the base-sections shown in Fig. 8 detached from the adjacent sections. Fig. 10 is a detail section of the same, taken on line 10 10 of Fig. 11. Fig. 11 is a side or edge view of the base-section shown in Figs. 9 and 10. Fig. 12 is a vertical section taken upon line 12 12 of Fig. 9. Fig. 13 is a view in side elevation of a plurality of connected loops, showing still another embodiment of the main features of my invention. Fig. 14 is a view of the same from the back or rear side thereof. Fig. 15 is a vertical section taken upon line 15 15 of Fig. 13. Fig. 16 is a view in central vertical section of a single loop-section, illustrating still another embodiment of the main features of my invention, taken on line 16 16 of Figs. 17 and 19. Fig. 17 is a sectional view thereof, taken on line 17 17 of Figs. 16 and 19. Fig. 18 is a horizontal section taken upon line 18 18 of Fig. 17. Fig. 19 is a plan section taken upon line 19 19 of Fig. 17. Fig. 20 is a horizontal section taken upon line 20 20 of Fig. 17.

To first describe the form of apparatus shown in Figs. 1 to 7, inclusive, A, Fig. 1, indicates a steam-generator into which water is to be delivered. B' B^2 B^3 B^4 B^5 B^6 B^7 are a plurality of return or transfer pipes or steam-loops, each for transferring water from one chamber to a chamber of higher pressure by means of a steam flow and constituting in effect one of the return-pipes or steam-loops described in the said Irving patent, said loops in this instance consisting of a pipe *b*, which constitutes the riser of the Irving steam-loops, located within another and larger pipe *b'*, which constitutes the descending part or drop-leg of the said Irving steam-loop. C' C^2 C^3 C^4 C^5 C^6 C^7 are metal castings or bases, to which the loops B' B^2 B^3, &c., are connected at their lower ends and which are connected with each other by passages affording communication between the said several loops, as hereinafter

more particularly described. D indicates a steam-supply pipe leading from the steam-generator and communicating with the several loop-bases C′ C², &c. E is a pipe by means of which the liquid which is to be transferred into the steam-generator A is admitted to the apparatus, said pipe being shown as connected with a tank E′. F indicates as a whole a steam-loop by which water carried through the several loops described is finally transferred to the generator A, said loop F being like the loop shown in said Irving patent and consisting of a riser F′, a horizontal F², and a drop-leg F³, which latter communicates with the generator, below the water-level thereof, through a check-valve *f* and a globe-valve *f′*. The several loops B′ B², &c., and bases C′ C², &c., to which they are connected, are alike, and each connected loop and base will be herein denominated a "loop-section." One of said loop-sections—to wit, the one marked B′ C′ of Fig. 1—is shown in detail in Figs. 2 to 7, inclusive, and is constructed as follows: Said base C′ is made of considerable depth or thickness from front to rear, and contains in its rear part a vertical passage *c*, forming a downward continuation of the inner pipe or riser *b*, and a second vertical passage *c′*, forming a downward continuation of the annular space or passage between the said riser *b* and the outer pipe *b′*. Said passage *c′* at its lower end is turned directly outward toward the side face of the base and communicates with a short coupling pipe or nipple *c*², which affords connection or communication between the bases of the several loop-sections, but which in the case of the end loop C′ communicates directly with the riser F′ of the steam-loop F, as clearly shown in Fig. 1. In the forward part of the base C′ are located upper and lower steam-chambers C⁸ C⁹, which are separated by a horizontal diaphragm *c*³, in which is located an upwardly-opening check-valve G, giving admission of steam from the lower chamber C⁹ to the upper chamber C⁸, but preventing the movement of steam in the opposite direction. *c*⁴ *c*⁴ are short steam pipes or couplings connecting each base with the adjacent bases at the opposite sides of the same, and communicating at one side of each base with the lower steam-chamber C⁹ by means of a passage *c*⁵ and at the opposite side of said base with the upper steam-chamber C⁸ by means of a passage *c*⁶. Within the upper chamber C⁸ is located a weight G′, which rests upon the valve G and tends to hold the same closed against the passage of steam, and which acts, therefore, to maintain a less pressure of steam in the upper chamber C⁸ than in the lower chamber C⁹. In the particular construction shown the valve G is provided with an upwardly-extending stem *g*, upon which the weight G′ rests, said weight G′ being of cylindric form and being held and guided in the upper part of the chamber C⁸, which for convenience of construction is formed by means of a tube *c*⁷, secured in the upper part of the base-casting C′ and provided with a cap *c*⁸ for closing its upper end. The removal of said cap *c*⁸ or the detachment of the tube *c*⁷ from the base obviously enables access to be readily had to the weight G′ and valve G. *c*⁹ is a horizontal passage connecting the passage *c*, which leads from the riser *b*, with the bottom of the lower chamber C⁹. *c*¹⁰ is a passage communicating at one end with the bottom of the lower chamber C⁹ through a check-valve H, which is adapted to open inwardly, or toward said chamber, and at its opposite end with the pipe or coupling *c*² at the side of the base opposite to that at which the passage *c′* terminates, as clearly seen in Fig. 4. The couplings *c*² *c*² are shown as arranged in alignment with each other at opposite sides of the base and the passage *c*¹⁰ as extending rearwardly from the bottom of the chamber C to a point beneath the passage *c* and then laterally outward to the side of the base, as clearly seen in Fig. 7. The inner pipe or riser *b* of the loop terminates at its upper end somewhat below the top of the outer pipe *b′*, and the latter pipe is provided with a cap *b*², having a blow-off pipe *b*³, controlled by a valve *b*⁴. The blow-off pipes *b*³ *b*³, belonging to the several loops, are shown as turned downwardly and arranged to discharge into a receptacle or trough I, extending across the loops and provided with a discharge or drainage pipe I′. It is obvious that when the several loop-sections are connected with each other by the couplings described the upper chamber C⁸ of each section will be connected with the lower chamber C⁹ of an adjacent section, and there will be free passage of steam from said upper to the lower chamber, and an equilibrium or pressure will exist in the said two chambers, so that the same pressure will be maintained in the upper chamber of one base as in the lower chamber of the next adjacent one, and the upper and lower chambers thus connected will constitute in effect a single steam-chamber, which is in communication with similarly-constituted steam-chambers at each side of it through the medium of the weighted check-valves G G. Furthermore, the said several steam-chambers thus formed by the connected upper and lower chambers of adjacent loop-sections are subject to different steam-pressures, which decrease between any two chambers to an extent depending on the weight applied to the check-valve between them, that chamber with which the steam-pipe D directly communicates being subject to nearly-full boiler-pressure, while that chamber remote from said steam-pipe is subject to a relatively small pressure. The said steam chambers or spaces so formed by connecting the upper and lower chambers C⁸ and C⁹ of adjacent loop-sections therefore correspond with the several tanks or chambers described in my said prior patent, while the pipes *b b′* constitute the risers and drop-legs of the steam-loops shown in said prior patent for transferring

water from the chambers subjected to less pressure to those subject to greater—that is to say, each one of the loops b' b^2, &c., constitutes a steam-loop operating on the same principle as that of the said Irving patent, the said steam-loops having in their descending portion or drop-leg, formed by the annular space between the pipes b and b', a water column of height due to the difference in pressure to which the opposite ends of said water column are subjected, and above the water column a space of less pressure than that of the chamber from which the riser leads and which may result either from radiation and condensation alone or of condensation assisted by the escape through the valved blow-off pipe b^3. By reason of such relatively low pressure in the pipe above the water column steam is caused to flow upwardly within the riser b with greater or less rapidity, and in its flow carries along with it small bodies of water admitted to the lower end of said riser from the chamber with which it communicates. The water so carried upward within the riser is not lifted in a solid column, but consists of one or of several relatively small masses in the form of short pistons filling or closing the bore of the riser, or of waves on the sides of the riser, or of drops or globules suspended in the steam. The water so lifted through the riser is deposited in the descending part of the loop, or, in other words, in the annular passage between the pipes b and b', and when a column of sufficient height is formed to overcome the difference in pressure between the two adjacent steam-chambers connected by the loops finally enters the chamber subject to the higher pressure, and the transfer of the water from the chamber subject to less pressure to the next chamber subject to a greater pressure is thereby accomplished. In the operation of the apparatus constructed as described, therefore, steam passing from the generator through the supply-pipe D enters the base of loop-section B′, and, overcoming the resistance of the reducing-valve of that section, a part of it escapes into the upper chamber C^8 of said base and passes thence to the lower chamber C^9 of the loop-section B^2 C^2, while part of the steam passes through the risers b' b of said loop B′ to the low-pressure space at the top of said loop, carrying upwardly with it water contained in the lower part of the chamber C^9, and thereby securing the delivery of such water to the return-loop F, by which the same is transferred to the generator in the same manner as set forth in said Irving patent. It may be noted at this point that the difference in steam-pressure between the generator and the lower chamber C^9 of the loop B′ C′ (which is that nearest the generator) is that due merely to condensation in the steam-pipe, so that the height of the water column in said loop F need be only sufficient to overcome such difference in pressure produced by condensation, together with the pressure required to lift the water vertically and overcome the friction in the pipes. Of the steam entering the lower chamber of the loop-section B^2 C^2 a part passes through the reducing-valve of that section to the next section B^3 B^3, while a part passes upwardly through the riser b of said loop-section B^2 C^2 to the low-pressure space of said loop-section B^2 C^2, and thereby effects the transfer of water contained in the lower chamber C^9 of the base C^2 to the corresponding chamber of base C′, it being obvious that water will accumulate in the space between the pipes b b' of loop B^2 until the pressure produced by the water column thus formed against the under side of the check-valve H will be sufficient to lift said check-valve against the steam-pressure in the lower chamber of the base-section C′, when the water will pass from the passage c^{10} through said valve into said chamber. In a similar manner a part of the steam delivered to the base of loop B^3 sweeps up the riser of said loop, carrying with it water from the base C^3, which accumulates in the descending part of loop B^3 and finally escapes through the check-valve of base C^2 into the lower steam-chamber of said base. In a similar manner part of the steam delivered to the several loop-sections at gradually-decreasing pressures serves to transfer the water from the lower chamber of one section to the lower chamber of the next section which is under greater steam-pressure. The several regulating-valves are so weighted or the loops are made of such number that the loop-section B^7 C^7, to the base of which water is delivered through the delivery-pipe E, is subject to a steam-pressure sufficiently small to be overcome by the column of water in said pipe E or in the tank or source of supply from which said pipe leads—as, for instance, if the water-supply were taken from the city mains or hydrant the steam-pressure in the lower chamber C^9 of the loop-section B^7 C^7 would be less than that within the water-supply pipe or main, so that water may enter said chamber C^9 through the check-valve H thereof against the pressure in said chamber. It will of course be understood, however, that the quantity of water admitted through the supply-pipe E must be controlled or regulated so as not to exceed that which can be delivered by the action of the steam through the several loops to the generator. Manifestly any number of loops and connected steam-chambers may be employed in the series by variation in the height of the loops, and the difference of pressure between two adjacent or connected loops may be so small that comparatively low loops may be employed, and any total difference of pressure between the source of supply and the generator may be overcome, no matter how high the pressure to which the generator may be subjected. Thus, assuming the difference of pressure between the steam-chambers of any two adjacent loop-sections to be five pounds, while each water

column in the descending part of the loop is not much higher than is due to a difference of pressure of five pounds, the several water-columns of the seven loops shown give an aggregate pressure of thirty-five pounds, with a corresponding lifting capacity, so that by the aggregate energies of the several loops water is delivered to the loop F against thirty-five pounds greater pressure than that of the pipe E, from which it is taken. It will of course be understood that in first starting the apparatus it is necessary to discharge the air from the several loops, and this is accomplished by turning on the steam-pressure and opening the several blow-off pipes b^3 b^3. After the air is thus discharged from the several loops the same will remain filled with steam, but no transfer of water will take place from one loop to another until sufficient water has accumulated in the descending portions of the loops to overcome the difference in pressure between the same—that is to say, assuming the boiler-pressure to be thirty-five pounds, steam admitted to the base of loop B′ will hold down the check-valve thereof with thirty-five pounds pressure. Some of this steam will pass back to the generator through the loop F and some of it will lift and pass through the reducing-valve of loop B′, by which it will lose five pounds pressure, and will therefore only give thirty-five pounds pressure in the lower chamber of loop B^2. This steam at thirty-five pounds pressure passes through loop B^2 and acts upon the under side of the check-valve in the base of loop B′ with thirty pounds pressure, but is unable to lift it, because it is held down by thirty-five pounds pressure. Water gathering in the descending part of loop B^2 finally produces a water column of sufficient weight to overcome the five pounds difference between the pressures in the two loops, and the pressure on opposite sides of the said check-valve at the base of loop B′ will then be equalized. Any water now admitted to the column in loop B^2 will then lift and flow through said check-valve in loop B′, and as soon as it does so the water passing into the lower chamber of said loop B′ is caught in the sweep of the steam passing up the riser of loop B′ and is transferred back to the boiler. When the apparatus is first placed in operation, therefore, water similarly accumulates in the descending part of the loops until they are all in operation, and the transfer of water from the source of supply to the generator will then be continuous and uninterrupted. The base C^7 of loop B^7 has, of course, no pressure-reducing valve, the pressure in the chamber of said base C^7, to which the water is delivered, being reduced by the valve in the base of loop B^6. The base of loop B^7 is, however, provided with a check-valve, through which water enters from the pipe E and which is subject to the downward pressure of steam in the said chamber and which can only be lifted for admission of water to the said chamber when the pressure of the supply-pipe exceeds that within the said chamber. As shown in my said prior patent, the several loops connecting the steam-chambers were provided with "horizontals" connecting the risers with the descending parts or drop-legs of the loops and giving increased radiating-surface, tending to maintain an area of low pressure above the water columns. Such horizontals are not, however, in all cases needed, the conductivity of the metal risers in a construction such as is above described being so great as to secure such amount of radiation at the upper ends of the loops as is usually needed in practice. If necessary, however, the loops may be provided with condensing spaces or chambers at their upper ends, or horizontals may be employed where desirable. A construction embracing condensing-chambers at the upper ends of the loops is illustrated in connection with another embodiment of my invention herein shown.

In Figs. 8 to 12 is shown another form of construction in connected or combined loops, wherein the risers and descending parts of the loops are separated from each other instead of being one within the other, as in the construction hereinbefore described. In this instance J J′ J^2, &c., indicate the loops, which are connected with base castings or sections K′ K^2, &c., and the risers *j* and drop-legs *j′* of each loop are continuous with each other or formed from a single piece of pipe bent into U shape, the lower end of the riser *j* of each loop being connected with one base-section, as K^2, while the drop-leg *j′* of the same loop is connected with the next adjacent section, as K′. Each base-casting is provided with an upper chamber K^8 and a lower chamber K^9, said chambers being in communication with inlet and outlet passages k^2 k^2 and being separated by a partition or diaphragm k^3, in which is located a pressure-reducing valve L, opening upwardly from the lower chamber K^9 into the upper chamber K^8. A weight L′ engages a stem *l* of the valve L and is located in a tube k^4, which forms an upward extension of the upper chamber K^8 and which is closed by a cap k^5. Attached to the bottom of each base-casting is a T-shaped valve-casing K^{10}, having an inlet-opening k^6, with which the drop-leg *j′* is connected, and outlet-opening k^7, with which the riser *j* is connected, and a passage k^8, leading into the lower chamber K^9 of the main base-casting. The inlet-opening k^6 is separated from the outlet-opening k^7 and the passage k^8, leading to the chamber K^9, by means of a diaphragm or partition k^9, containing a check-valve M. The said valve M is shown as provided with a valve-stem arranged to slide in a tubular guide k^{10}, supported in the passage k^8 in the manner illustrated. In the operation of this form of loop the water column in the drop-leg *j′*, when of sufficient height, lifts the check-valve M, and a portion thereof escapes into the lower portion of the riser *j′*, through

which it is swept by steam passing from the lower chamber K^9, through the opening K^8, upwardly into said riser to the low-pressure space at the upper part of the loop of which that riser forms a part, in the same manner as hereinbefore described in connection with the form of apparatus illustrated in Figs. 1 to 7. The loops shown in Figs. 8 to 12 are not provided with blow-off pipes or openings at their upper parts, and to provide means for discharging the air therefrom when the apparatus is first put into operation a branch steam-pipe N, Fig. 8, is led from the main supply-pipe D to the base of the end loop at that end of the apparatus subject to the smallest steam-pressure, or that at which the water is delivered. A valve d' is placed in the main steam-pipe D between the point at which the said branch N is connected therewith and the loop J, and a valve n is also placed in the branch pipe N. Under ordinary working conditions the valve d' is open and the valve n closed. When it is desired to start the apparatus in operation, said valve d' is closed and the valve n opened, when steam which enters the steam-chamber of the loop J^3, being unable to pass backwardly through the pressure-reducing valves, will traverse all the loops, thereby driving from them air contained therein, which will be discharged through an outlet-opening f^3, connected with a three-way cock f^2, located near the lower end of the riser F′ of the return-loop F.

In Figs. 13, 14, and 15 is shown a form of the connected or combined loops differing in mechanical details only from that shown in Figs. 8 to 12. In this instance the several loops O′ O^2 O^3, &c., consist of pipes of inverted-U shape, (forming risers o and drop-legs o' o',) the lower ends of which are connected with rectangular base-castings P′ P^2, &c., which are secured or clamped together side by side by means of horizontal tie-rods p p, extending through projections or lugs p' p' at the front and rear surfaces of the said castings. In this instance upper and lower steam-chambers P^8 P^9 are formed by means of tubular casings secured to the bases P′ P^2 P^3, said chambers being separated by diaphragms p^2, formed in said casings and containing check-valves Q Q. Weights Q′ Q′ for the check-valves are located in cylindric extensions p^3 of the upper chambers P^8 P^8, and each of said chambers P^8 is connected with the lower chamber P^9 of the adjacent loop by an oblique pipe p^4. Passages p^5 lead from the bottom of the chambers P^9 to the risers o, while other passages p^6 lead from the drop-legs o' to points beneath the said chambers P^9, with which they are connected through openings provided with upwardly-opening check-valves R, said passages p^5 p^6 being cast in the base-castings P′ in the manner clearly shown in the drawings. The operation of the loops thus constructed is the same as those forms hereinbefore set forth and need not here be stated in detail.

In Figs. 16 to 20 is shown a form of the connected or combined loops wherein the drop-leg of each loop is contained within the riser, and enlarged spaces or condensing-chambers are provided at the upper ends of the loops to afford additional condensing-surface, by which the maintenance of a space subject to low pressure is facilitated or made more certain. In this instance S′ S^2 indicate steam-loops, and T′ T^2 base castings to which the same are connected. Each loop comprises an exterior pipe s and an interior pipe s', the inner pipe constituting the drop-leg of the loop, while the space between the inner and outer pipes constitutes the riser of the loop. The outer pipe s is connected at its upper end with a tubular casting S^3, having an integral lateral extension s^2 at one side thereof, the main part of the said casting S^3 being preferably made cylindric and somewhat larger in diameter than the pipe s, which is connected with said main part of the casting by a screw-threaded joint at its upper end, while the lateral extension s^2 is made narrower than said main part of the casting, as clearly shown in the sectional view, Fig. 18. Inside the main port of the casting S^3 is another casting, consisting of connected inner and outer tubes s^3 s^4, the outer tube s^3 forming an extension of the pipe s, while the inner tube s^4 is connected at its lower end with and forms an upward extension of the inner pipe s'. The said tubes s^3 s^4 extend to a point near the top of the chamber S^3, so that the annular space between them forms part of the riser and opens into the upper part of the said chamber. A lateral passage s^5 passes through the said tubes s^3 s^4, near the lower ends of the same and form an opening leading from the bottom of said chamber S^3 into the inner pipe or drop-leg s'. The object of the construction described is to afford a large condensing-surface at the top of the loop, while allowing water of condensation which accumulates in said chamber to readily escape to the drop-leg through the opening s^5. The said chambers S^3 are shown as provided at their lower ends with flanges s^6, adapted for contact with each other when the loops are placed together and through which are inserted bolts s^7 for clamping the adjacent castings together. T′ T^2 are base-castings to which the lower ends of the pipes S S′ of the loops are secured. Said castings are each provided in its rear part with a vertical passage t of larger size than the inner pipe s' and through which said pipe passes to a point near the bottom of the casting, where it is secured in a horizontal partition-wall t', between which and the bottom of the casting is formed a horizontal passage t^2, with which said pipe s' communicates. The space between the said pipe s' and the wall of the casting t forms a continuation of the annular space between the inner and outer pipes s s', and said space terminates at its lower end in a space or opening t^3, located above the partition t' and extending laterally outward

through the side of the casting. In the outer or forward part of the casting above the horizontal partition t' are formed two chambers T^3 and T^4, separated from each other by a horizontal partition t^4, within which is located an upwardly-opening check-valve U, to allow the passage of steam from the lower chamber T^4 to the upper chamber T^3. In a tubular extension t^5 of the upper chamber T^3 is located a weight U', which acts upon the check-valve U to hold the same upon its seat. The said chamber T^3, above the partition t^4, extends outwardly through the side of the base-casting at the same side thereof as that at which the recess t^3 is located, while the lower chamber T^4 extends through the casting at the opposite side thereof, these chambers being so constructed that when the castings are secured together side by side by means of bolts t^6, as shown, or otherwise, the chamber T^3 of one casting will open into or be continuous with the lower chamber T^4 of the adjacent casting, and the recess t^3 will also open into the annular part of said chamber T^4, the side wall t^7 of said upper chamber T^3 and the side wall t^8 of the lower chamber T^4 being so shaped or curved, as clearly seen in Figs. 17 and 20, as to afford a space or opening t^9 between the chambers T^3 and T^4 of adjacent castings. A check-valve V allows the passage of water from the lower passage t^2 of the casting upwardly into the lower chamber T^4 thereof, the stem of said valve being herein shown as being supported in a guide t^{10}, held in an arm or bracket cast on the side of the chamber, in the manner clearly shown in the drawings. T^5 is a casting secured to the base of that loop at which live steam is received, said casting being provided with a vertical passage t^{11}, with which the steam pipe is connected, and with a horizontal passage t^{12}, leading from the passage t^{11} to the lower chamber T^4 of the base of the casting T' of the first loop. Said casting T^5 is also provided with a vertical passage t^{13}, communicating with the said lower chamber T^4 by means of a recess t^{14}, extending laterally through the side face of said casting T^5 and opening into the lower part of said chamber T^4 when the parts are secured together, as seen in Fig. 19. Said passages t^{13} and t^{14} are for the exit of water from the combined loops in its passage to the generator. At the opposite end of the group of combined or connected loops is secured a casting T^6, which is provided with a vertical passage t^{15}, with which the supply-pipe E communicates and which opens at its lower end into a horizontal passage t^2, corresponding with the similar passages t^2 of the castings T' T^2, &c., and communicating with the chamber T^7, formed in the upper part of said casting, by means of a check-valve V, corresponding in function with check-valves V, hereinbefore referred to. The chamber T^3 opens at the inner side of the casting T^6 into the upper chamber T^3 of the adjacent casting T^2 and also into the recess t^3 of said adjacent casting. In the operation of this form of the connected or combined loops steam is supplied through the passage t^{11}, and, passing through the several pressure-reducing valves, affords lessened steam-pressures in the several steam spaces or chambers formed by the communicating upper and lower chambers T^3 and T^4 of adjacent loop-sections. Water supplied by the pipe E and acting on the check-valve in the casting T^6 with sufficient force to lift said valve against the steam-pressure in the chamber T^7 enters the lower part of said chamber and, passing through the recess t^3 of the base-casting T^2 to the bottom of the passage t, is swept upwardly between the pipes S and S' into the chamber S^3. Water accumulating in said chamber fills the pipe or drop-leg s' until a liquid column is formed therein of sufficient height to overcome the steam-pressure in the lower chamber T^4 of the loop-section S^2, when it will lift the valve V, belonging to said section, and find its way to the riser of loop S', through which it will be swept upwardly to the low-pressure space within casting S in the same manner as before described. The water reaching the lower chamber T^4 of the loop S', or that subjected to the highest pressure, passes through the passage t^{13} of the casting T^5 and is carried through the same back to the generator. As shown in said Figs. 16 to 20, a steam-passage t^{16} extends from the casting T^5 through the several base-castings T' T^2 into the casting T^6, where it opens into the chamber T^7. In the steam-passage t^{12} of said casting T^5 is placed a three-way cock W, by which communication may be established between the steam-passage t^{11} and either the passage t^{12} or t^{16}. In the ordinary operation of the device the three-way cock W is turned, as shown in Fig. 20, so as to close the passage t^{16}, and thus direct the flow of steam to the steam-chambers of the several loops. When, however, at the time of starting the apparatus it is desired to blow out the air from the several loops, the three-way cock W will be turned so as to deliver steam into the passage t^{16} and shut it off from the several steam-chambers. Steam will then enter the chamber T^7 under full pressure and inasmuch as it will be prevented from passing backwardly through the pressure-regulating valves the steam will pass through the several loops and out through the passage t^{13}. The air thus discharged is delivered through a discharge-opening in the return-pipe controlled by a three-way cock, as hereinbefore stated, or otherwise. The said passage t^{16}, arranged as above described, obviously performs the same function as the pipe N. (Shown in Fig. 8.) The connected or combined loops, arranged as described, will perform their work no matter what the boiler-pressure may be or whether it is high or low. Furthermore, the loops will work perfectly when there is a vacuum, instead of pressure,

in one or more of the same—as, for instance, there may be a vacuum in loop B^7, produced by the action of the water column in the other loops. By placing the valve-chambers and connecting-passages in the base-sections in the manner described I am enabled to greatly cheapen the cost of manufacture of the loops and decrease the space occupied by the loops required to do a certain work. This construction, furthermore, greatly facilitates the construction and repair of the loops, inasmuch as any loop-section is complete in itself and any number of them may be combined, as required, to fulfill the duty required.

An important advantage is gained by forming each loop of one pipe arranged within the other, not only by reason of the greater cheapness of construction thereby obtained, but by reason of the saving of loss of heat by radiation, which takes place where both the riser and drop-leg are exposed to the atmosphere.

I claim as my invention—

1. An apparatus for delivering liquid from a space subject to one pressure into a space subject to a higher pressure, comprising a plurality of similar base-castings adapted for connection with each other and containing a pressure-reducing valve or valves, and pipes connected with the base-castings, said base-castings forming a plurality of chambers, in which different pressures are maintained by the action of the reducing valve or valves, and the pipes forming steam-loops by which water may be transferred from one to the other of said chambers, substantially as described.

2. An apparatus for delivering liquid from a space subject to one pressure into a space subject to a higher pressure, comprising a plurality of similar base-castings adapted for connection with each other and containing a pressure-reducing and check valve or valves, and pipes connected with the base-castings, said base-castings forming a plurality of chambers, in which different pressures are maintained by the action of the reducing valve or valves and the pipes forming steam-loops by which water may be transmitted from one to the other of saidchambers through said check valve or valves, substantially as described.

3. An apparatus for delivering liquid from a space subject to one pressure into a space subject to a higher pressure, comprising a plurality of pipes forming steam-loops and base-castings, each of which is provided with upper and lower steam-chambers, an upwardly-opening pressure-regulating valve, a passage leading from the descending part of a steam-loop connected therewith to the lower chamber provided with a check-valve, and a passage leading from the said lower chamber to the riser of another steam-loop, the upper steam-chamber of each section being adapted for communication with the lower chamber of an adjacent section when the sections are secured together, substantially as described.

4. A loop-section comprising two pipes, one within the other and forming the riser and drop-leg of a steam-loop, and a base-casting provided with a pressure-reducing valve, substantially as described.

5. A loop-section comprising two pipes, one within the other and forming the riser and drop-leg of a steam-loop, and a base-casting provided with a pressure-reducing valve and a check-valve, substantially as described.

6. A loop-section comprising two pipes arranged one within the other and forming the riser and drop-leg of a steam-loop, and a base-casting containing upper and lower steam-chambers and in which the upper steam-chamber is adapted for connection with the lower chamber of a similar base-casting at one side of it and the lower chamber is adapted for connection with the upper steam-chamber of a similar base-casting at the other side of it, a pressure-reducing valve between said chambers, and passages in the said base-casting for connecting the riser and drop-leg of said loop-section with the lower steam-chamber of that and adjacent loop sections, substantially as described.

7. A loop-section comprising two pipes arranged one within the other and forming the riser and drop-leg of a steam-loop, and a base part or casting containing upper and lower chambers, of which the upper chamber is adapted for connection with the lower chamber of an adjacent loop upon one side of it and the lower chamber is adapted for connection with the upper chamber of an adjacent loop at the other side of it when the castings are secured together, a pressure-regulating valve between said chambers and containing, also, passages for connecting the riser and drop-leg of said loop-section with the lower steam-chambers of that and adjacent loop-sections, and a weight located in the upper chamber and acting upon the said regulating-valve, substantially as described.

8. The combination, with a steam-generator, means for delivering water to the same, comprising a plurality of chambers subject to different degrees of steam-pressure, steam-loops connecting said chambers with each other, and a water-return pipe having a valved outlet, of a steam pipe or passage leading to the chamber subject to greatest pressure, another steam pipe or passage leading to the chamber subject to the smallest pressure, and valves in said pipes, whereby steam may be allowed to flow through the several loops and outwardly through the said outlet, substantially as described.

9. The combination, with a steam-generator, means for delivering water to said generator, comprising a plurality of steam-chambers and a pipe supplying the steam to said chambers from the generator, pressure-reducing valves located between the said steam-chambers, steam-loops connecting the steam-chambers and provided with check-valves,

and a water-return pipe provided with a valved outlet, of a separate or branch steam pipe or passage leading to the chamber subject to the lowest steam-pressure, and valves in the said steam-pipes, whereby steam may be allowed to flow through all of the said steam-loops and outwardly through said outlet, substantially as described.

In testimony that I claim the foregoing as my invention I affix my signature in presence of two witnesses.

WALTER BURNHAM.

Witnesses:
H. H. NEWMAN,
S. F. CHAMBERLAIN.