(Model.)

J. S. BANCROFT.

INJECTOR.

No. 331,178. Patented Nov. 24, 1885.

Fig. 1.

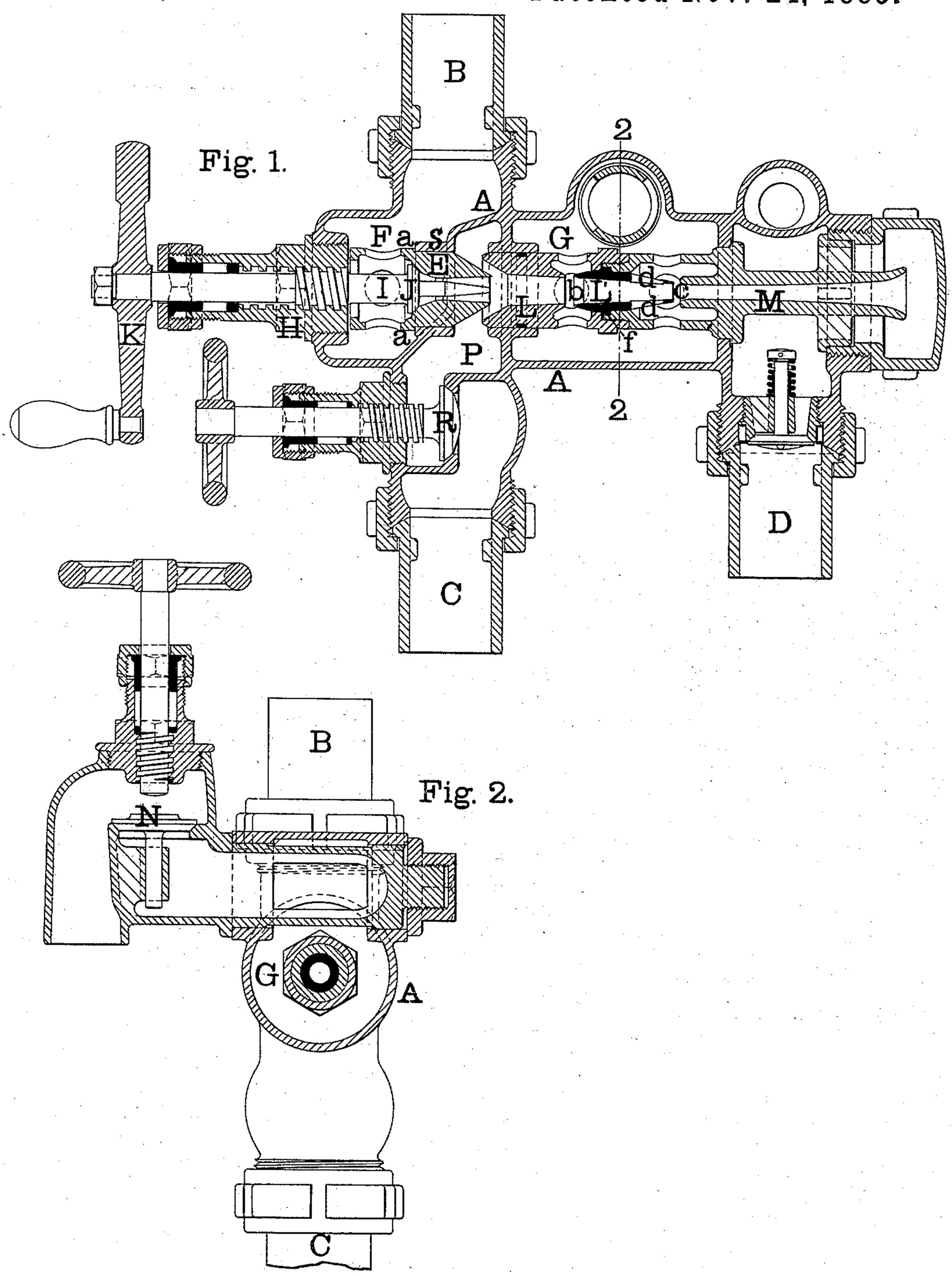

Fig. 2.

WITNESSES.

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JOHN SELLERS BANCROFT, OF PHILADELPHIA, PENNSYLVANIA, ASSIGNOR TO WILLIAM SELLERS, OF SAME PLACE.

INJECTOR.

SPECIFICATION forming part of Letters Patent No. 331,178, dated November 24, 1885.

Application filed June 6, 1885. Serial No. 167,901. (Model.)

To all whom it may concern:

Be it known that I, JOHN SELLERS BANCROFT, of the city and county of Philadelphia, and State of Pennsylvania, have invented certain new and useful Improvements in Injectors for Feeding Boilers, of which improvements the following is a specification.

Such injectors have usually been constructed with one overflow-opening between the end of the combining-tube and the receiving end of the delivery-tube, this opening discharging into an overflow-chamber provided with a check-valve to prevent an indraft of air when the injector is working, which overflow-opening will hereinafter be called the "forward overflow." Combining-tubes have also been constructed with two overflow-openings, and such openings will be designated hereinafter in the order they occur with the movement of the jet—that is to say, that one nearest the delivery-tube is the forward overflow, and that farthest from the delivery-tube is the rear overflow—consequently the large end of the combining-tube is in the rear of the rear overflow. Now, in order to obtain the greatest efficiency as a boiler-feeder, the discharging end of the combining-tube must be but little larger than the smallest diameter of the delivery-tube, and the overflow-opening is limited thereby; but with this proportion the jet will not form, and the instrument will not operate until the supply of water is reduced very much below the maximum quantity of water the injector is capable of delivering when at full work, so that to start the water-supply must be diminished, and when in operation must be increased until the full capacity is attained. This small size of overflow-opening, moreover, necessitates great care in the admission of steam to the instrument, for, the area of the steam-nozzle being necessarily much larger than the overflow-opening, it will be evident that the full volume of steam would not be able to escape through this opening without producing considerable back-pressure in the water-supply chamber, which would prevent the water from entering; hence the steam must not be admitted faster than the gradually-forming jet is able to unite with it.

An injector constructed as described necessarily requires the adjustment of both the steam and the water supply to start it, and if the jet should break the same manipulation would be necessary to restart. Injectors have been constructed with additional overflow-openings in the converging combining-tube nearer the steam-nozzle than the forward overflow, and such additional openings have had the effect of facilitating the starting of the instrument; but in all such cases these openings have either been in an overflow-chamber separate from that of the forward overflow, or, if in the same chamber, the form of the opening has been such that they have not been able to operate effectively as an overflow. Moreover, the overflow-passage and check-valve leading from the overflow-chamber, as heretofore constructed, would permit starting the injector with low steam or with a regulated admission of high steam only. They are not large enough to vent high steam at boiler-pressure escaping from the full area of the steam-nozzle without producing a pressure in the water-chamber instead of a vacuum, which of itself would prevent the automatic operation of the injector.

To obtain the best results with the injector as a boiler-feeder, it is necessary that the overflow-opening located toward the large end of the combining-tube, hereinafter called the "rear overflow," should be as short as possible, because the jet at this point has not yet attained its full velocity. It must be located as far as possible from the steam-nozzle, to allow the combined jet time to acquire the velocity necessary to leap across it; but to obtain the maximum vacuum it must be much larger than the steam-nozzle, which would bring it near to the end of the steam-nozzle, so that to obtain the best results with these conflicting conditions it is requisite that the escape of the steam from this opening should be particularly clear and unobstructed, and therefore the end of the first part of the tube should not project into an enlarged mouth of the following tube, but the opening should be formed between the extreme ends of the two parts of the combining-tube, so as thereby to leave a clear exit for the steam in lines perpendicular to the axis of the jet, and to facilitate this discharge the outside of the second

tube should be tapered to permit steam to escape with the least possible change of direction. In place of separating the combining-tube into two parts, as shown, the necessary overflow-openings can be provided by perforations in a single tube; but in all cases the steam and water must have a direct outlet—that is, must not be reversed in direction, as is the case when the discharging end of the rear tube is inserted into the enlarged mouth of the forward tube, as hitherto. When the injector is provided with two overflow-openings, as described, and is working with a full supply of water, and its operation is stopped from any cause, it sometimes happens that it will not restart until the water-supply is diminished. Under such circumstances, of course, it ceases to be automatic. I have discovered that under such conditions it requires a third overflow-opening located between the forward and the rear overflow-openings, previously described, and this third opening is hereinafter called the "intermediate overflow."

In the earliest forms of injectors the tapered steam-plug was adopted as the best means for admitting and regulating the supply of steam to the instrument. It was also used for the purpose of forming a vacuum to raise the supply-water; but when used for this latter purpose the outside diameter of the steam-jet was not reduced, and the issuing jet of the full size of the steam-nozzle was forced to contract in diameter to escape through the overflow-space provided, and at the same time to carry with it the air which must be removed to produce the vacuum desired, so that under these conditions the vacuum produced was very small, and could only be attained at all by skillful and careful manipulation, and numerous supplemental lifting-jets have been devised and used to overcome this serious defect. I have now discovered that with this tapered steam-plug, and with overflow-openings in the combining-tube proportioned and located as hereinafter described, I am enabled to produce as great a vacuum as has hitherto been obtained by any of the many supplemental lifting-jets in use.

It is an object of my present invention to produce an injector which shall be automatic in its action, so that when the instrument is put in communication with its steam and water supplies it will automatically start itself and deliver water into the boiler which supplies it with steam; and if, from any cause, the jet should be broken it will re-establish its jet as soon as the disturbing cause is removed and feed the water into the boiler, as before.

It is a further object of my invention to combine with this automatic action the ability to produce a vacuum at least equal to that of any supplemental lifting-jet, so as thereby to dispense with the use of such jets.

It is a further object of my invention to hold the steam-nozzle in place by the steam-pressure in snch manner that it may readily be removed without uncoupling any of the pipes for steam or water.

It is a further object to support the small end of the combining-tube between the larger end of this tube and the delivery-tube, so that its axial and longitudinal position relatively to these tubes may be fixed and maintained without disturbing the relation and connection of these tubes with each other.

To these ends my invention consists in providing the combining-tube with overflow-space through which steam and water may escape in lines perpendicular to the axis of the jet at a point in the rear of that where the cross-sectional area of this converging tube contracts to less than one and four-tenths time the smallest cross-sectional area of the steam-nozzle, supplementing this overflow-space with an additional overflow-space located near the smallest diameter of the delivery-tube, and inclosing these overflow-spaces in an overflow-chamber common to both; and it further consists in providing an intermediate overflow-space located in the converging combining-tube between these rear and forward overflow-spaces at a point forward of that where the cross-sectional area of this converging tube contracts to less than that of the steam-nozzle; and it further consists in combining all of these overflow-openings in one overflow-chamber; and it further consists in combining with a taper steam-plug in a steam-nozzle an overflow-space in the combining-tube perpendicular to the axis of the jet and located at a point in the rear of that where the cross-sectional area of this converging tube contracts to less than one and four-tenths that of the smallest cross-sectional area of the steam-nozzle; and it further consists in providing the small end of the combining-tube with a collar upon its exterior, whereby this end of the tube is properly located between the large end of the combining-tube and the delivery-tube; and it further consists in providing the steam-nozzle with a valve-rim adapted to seat against a suitable bearing in the body of the injector, whereby the pressure of the steam will keep the joint tight.

In the accompanying drawings, which form part of this specification, Figure 1 represents a vertical longitudinal section through an injector embodying my present invention; Fig. 2, a transverse section on the line 2 2 of Fig. 1.

A is the body or case of the injector, B the steam-connection, C the water-supply connection, and D the delivery-connection leading to the boiler. E is the steam-nozzle, which fits easily in a cylindrical bearing, S, formed in the partition that separates the steam-chamber F from the water-supply chamber P. The back end of the nozzle E is enlarged, as shown, and the projection or rim *a* forms a valve which fits against the finished end of the bearing S, forming a steam-tight joint, which is held firmly seated by the steam-pressure within the chamber F. The back end of the steam-nozzle is a hollow cylinder pierced with holes, as shown,

for the admission of steam, and carried back so as merely to clear the face of the nut H when this nut is screwed firmly into the end of the body A. By this means the steam-nozzle cannot get out of place in handling the injector when disconnected from the pipes, and there is nothing to prevent the nut H from being screwed firmly home to form a steam-tight joint on its collar, as shown, and when the nut H is unscrewed the steam-nozzle may readily be removed by hand. The delivery and combining tubes are retained in place, as shown and described in United States Patent No. 224,762, dated February 24, 1880, granted to me and assigned to Wm. Sellers. As thus arranged, the steam-nozzle is placed in position through one end of the injector case or body, and the combining and delivery tubes through the other end. The valve-seats determine their relative distance, and the steam and water pressure, respectively, maintain them in this position. By removing the two end caps, as now arranged, all of the injector-tubes may readily be removed for examination without disturbing the pipe-connections. The steam-plug I, having a thread engaging with the nut H, is provided with a valve, J, which seats steam-tight on a seat at the rear of the steam-nozzle, as shown. The handle K serves to move the steam-plug I to admit steam to the nozzle or cut it off, as required.

The forward end of the steam-plug is made short and of quick taper, for a purpose to be described. When the steam-valve J is opened wide, the steam from the chamber F, issuing from the nozzle E, blows into the rear tube, L, and forward tube, L′, which constitute the combining-tube, and escapes into the overflow-chamber G through the rear overflow-opening, *b*, between these tubes L and L′, the intermediate overflow-opening, *d*, located in the tube L′, and the forward overflow-opening, *c*, between the forward tube, L′, and the delivery-tube M. The steam escapes from the overflow-chamber G under a check-valve, N, which must have an area of discharge at least two and one-half times the smallest area of the steam-nozzle with low steam-pressure, in order that the pressure in the overflow-chamber may be sufficiently reduced to permit automatic starting and restarting when the water merely flows to the injector; but with low or high steam, when the water requires to be lifted from any considerable depth, the area of this check-valve must be at least nine times the smallest area of the steam-nozzle, so that the pressure in the overflow-chamber may exceed that of the atmosphere as little as possible, whereby the resistance to the discharge of steam through the overflow-openings *b d c* will be reduced to a minimum, and to adapt the injector to all uses I prefer to make the area of all such conduits and check-valves nine times that of the steam-nozzle. This check-valve N serves to prevent the admission of air when the injector is working, and may be held firmly on its seat, when required, by the screw and hand-wheel shown. The body O, containing this valve, is shown as secured to the case A, as shown and described in my hereinbefore-mentioned former patent, and, as the method of attaching the valve forms no part of this present invention, further description of this part is unnecessary.

The nozzle E, combining-tubes L and L′, and overflow-openings *b*, *d*, and *c*, are so proportioned that the steam issuing from the nozzle E entrains the air from the water-supply chamber P into the tubes L and L′, from which this entrained air and steam escape through the overflow-openings *b*, *d*, and *c*. This action produces a vacuum in the water-supply chamber P, so that if the water-valve R is opened the water from a well or other source of supply will be drawn into the chamber P through the water-connection C. The proportions for insuring this operation and producing the greatest vacuum in the chamber P are affected by the shape of the discharging end of the steam-nozzle, the rate of contraction of the tube L, and the location of the rear overflow-opening, *b*. I have found that when the discharging end of the steam-nozzle enlarges at the rate of one part in ten from its smallest diameter, and the converging rear tube, L, contracts at nearly the same rate, which are the proportions shown in the drawings, the rear overflow-opening, *b*, for ordinary steam-pressures should be located, as shown, at a point in the combining-tube L L′, where the cross-sectional area of this tube is at least one and one-half time the area of the smallest cross-section of the steam-nozzle E, while for high pressures—such as are usual in locomotive service—the combining-tube must be enlarged and the proportional area of this overflow-opening must be twice that of the smallest cross-section of the steam-nozzle. Thus if the taper of the discharging end of the steam-nozzle or that of the rear tube, L, is made quicker—say one part in six—the combining-tube must be enlarged and the proportional area of the overflow-opening must be increased; but this proportion for the end of the steam-nozzle or of the combining-tube would be no more efficient in an injector for simply feeding a boiler, while it would not be as efficient for an automatic injector. In all cases the area of the overflow-opening *b* should be larger than that of the end of the steam-nozzle. It is essential, in order that this overflow-opening may be reduced within the limits required for efficiency as an injector, that the discharge of steam and entrained air should be unimpeded; and therefore I make this opening between the extreme ends of the tubes L and L′, and also taper the outside of the tube L′, as shown, in order that the steam may have a perfectly free path of escape. The overflow-openings *b*, *d*, and *c* must be large enough in area to give a free escape to the entrained air and steam at the highest boiler-pressure for which the injector is designed to operate, to insure a vacuum at that pressure. Such a vacuum will bring the wa-

ter into contact with the steam-jet issuing from the nozzle E and at this point, instead of entrained air and steam, water and steam enter the tube L, and this jet of water and steam combined discharges into the overflow-chamber G, partly through the overflow-opening *b* from the tube L, and partly through the overflow-openings *d* and *c* from the tube L′. The converging tube L′ and overflows *d* and *c* concentrate the jet and increase its velocity in the tube L until the overflow at *b* ceases and the combined concentrated jet passes through the tube L′, overflowing at *d* and *c*, and its velocity continues to increase until the overflow at *d* and *c* ceases, when the combined concentrated jet will have acquired sufficient impetus to carry it across the overflow-opening *c*, through the delivery-tube M, and into the boiler through the connection D.

An overflow-opening near the small part of the delivery-tube could not alone be made large enough in area to give a sufficiently-free discharge for the steam without cutting off the combining-tube to such an extent as to deprive it of the power of concentrating the combined jet of water and steam sufficiently to enable it to enter the delivery-tube, and, on the other hand, an extension of the converging part of the delivery-tube toward the steam-nozzle with an opening located nearer to the steam-nozzle and large enough in area to permit a free discharge of steam, so as to permit the formation of a vacuum at the maximum boiler-pressure for which the injector is designed to operate, would not give the necessary concentration and velocity to the jet to enable it to pass through the delivery-tube M, and the conjoint operation of the several overflows *b*, *d*, and *c*, therefore, could not be accomplished by one single overflow, however located, for it will be seen that while these overflows have severally distinct functions to perform, each overflow co-operates with and supplements the other.

When the overflow-openings are inclosed in one common overflow-chamber, as shown and described, the injector will be automatic with a much higher temperature of supply-water, and the range of delivery will be considerably increased over what is possible when these overflows are in separate chambers, so that by combining them in one chamber I not only save the cost of the extra overflow check-valve hitherto employed, but I materially increase the efficiency of the injector.

The combining-tube L is secured to the delivery-tube M by a screw-thread, as shown, and these tubes may be supported in the case of the injector in any manner found convenient. I prefer, however, the method shown, which is more fully described in my hereinbefore-mentioned former patent. The forward tube, L′, is cylindrical, and is formed with a collar, *f*, on its outside, and is supported in a cylindrical bearing on the end of the delivery-tube M, by which it is centered. The rear tube, L, is provided with a shoulder which just clears the collar in the forward tube, L′, so that when the tubes L and M are firmly coupled together the tube L′ will merely be secured easily in place without being clamped, and in this way there is no danger of disturbing the alignment or relative position of the tubes L and M.

An injector constructed as described will be automatic—that is to say, adapted to establish and re-establish its own jet without manipulation—capable of starting itself as soon as steam and water are admitted to the instrument, and if, from any cause, the jet should be broken, as soon as the disturbing cause ceases to operate the injector will re-establish its jet and again feed water into the boiler. This automatic action will be complete if the water flows under a head to the injector and also up to about sixteen feet lift with ordinary pressure of steam, the amount of water delivered being regulated in either case by the water-regulating valve R, operated by the screw and hand-wheel shown, or by the adjustment of the water-valve and steam-plug combined, as may be preferred. This adjustment is exceedingly simple, and to obtain the minimum discharge no special care need be observed, for if the water-supply is too much reduced steam will escape at the overflow, but the jet will not break, as it will do under similar circumstances with all other forms of injectors, so that if such escape of steam is observed the admission of a little more water will correct it without interfering with the action of the instrument.

If it is desired to use the injector to lift its water from a greater depth, the necessary vacuum may be obtained by inserting the tapering end of the steam-plug I into the steam-nozzle E, so as to diminish its area and reduce the amount of steam flowing through the nozzle, thus converting the solid jet into an annular one having great surface proportionally to cross-sectional area, while the quick taper of the steam-plug allows this annular jet to expand internally, or toward the center. The overflows *b*, *d*, and *c* allow free escape for this steam and entrained air, and I have discovered that by properly proportioning the respective tapers of the steam-nozzle and steam-plug, in conjunction with the location and proportion of the rear overflow-opening, as hereinbefore described, I can obtain as great a vacuum as is obtained by any of the ordinary supplemental lifting-jets, and this without adding any parts to the injector as best adapted for automatic action, so that I am enabled to construct a lifting-injector at no more expense than a non-lifting.

I am aware that injectors have been constructed with two or more overflow-spaces and with more than one overflow-chamber, and that two or more overflow-spaces have been inclosed

in one overflow-chamber. I therefore do not claim, broadly, two or more spaces in one overflow-chamber; but

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

1. In an injector, the combination, in one single overflow-chamber, of a forward overflow-space located near the smallest diameter of the delivery-tube, and a rear overflow-space located in the combining-tube at a point in the rear of that where the cross-sectional area of this converging tube contracts to less than one and four-tenths that of the smallest cross-sectional area of the steam-nozzle, substantially as and for the purposes set forth.

2. In an injector, the combination, in one single overflow-chamber, of a forward overflow-space located near the smallest diameter of the delivery-tube, and a rear overflow-space perpendicular to the axis of the jet located in the combining-tube at a point in the rear of that where the cross-sectional area of this converging tube contracts to less than one and four-tenths that of the smallest cross-sectional area of the steam-nozzle, substantially as and for the purposes set forth.

3. In an injector, a steam-nozzle, a combining-tube, and a delivery-tube, the steam-nozzle provided with a divergent discharging end, the combining-tube provided with a rear overflow-space perpendicular to the axis of the jet at a point where the cross-sectional area of this tube is greater than that of the largest cross-sectional area in the discharging end of the steam-nozzle, the delivery-tube provided with an overflow-space in the rear of its smallest cross-section, and an overflow-chamber common to both of the overflow-spaces, the combination being and operating substantially as and for the purposes set forth.

4. In an injector, the combination of a forward overflow-space with a rear overflow-space perpendicular to the axis of the jet and located in the combining-tube at a point where the cross-sectional area of this tube is greater than that of the largest cross-sectional area in the discharging end of the steam-nozzle, and an intermediate overflow-space, substantially as described, and for the purposes set forth.

5. In an injector, the combination of a forward overflow-space and a rear overflow-space perpendicular to the axis of the jet and located in the combining-tube at a point where the cross-sectional area of this tube is greater than that of the largest cross-sectional area in the discharging end of the steam-nozzle, with an intermediate overflow-space located in the converging combining-tube at a point forward of that where the cross-sectional area of this converging tube contracts to less than that of the steam-nozzle, for the purposes set forth.

6. In an injector, the combination of a forward overflow-space, a rear overflow-space, and an intermediate overflow-space, substantially as described, with an overflow-chamber common to all of these overflow-spaces, for the purposes set forth.

7. In an injector, a taper steam-plug and a steam-nozzle, in combination with a rear overflow-space perpendicular to the axis of the jet located in the combining-tube at a point in the rear of that where the cross-sectional area of this converging tube contracts to less than one and four-tenths that of the smallest cross-sectional area of the steam-nozzle, for the purposes set forth.

8. The collar *f* on the forward tube, L′, in combination with the coupled ends of the tubes L and M, substantially as and for the purposes set forth.

9. In an injector, a steam-nozzle and a delivery-tube which are pressed toward each other by the steam and the water pressure, respectively, and are maintained in their proper relative positions against such pressure by valves and valve-seats, substantially as and for the purposes set forth.

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Witnesses:

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