(Model.)

2 Sheets—Sheet 1.

J. S. BANCROFT.

INJECTOR.

No. 322,342. Patented July 14, 1885.

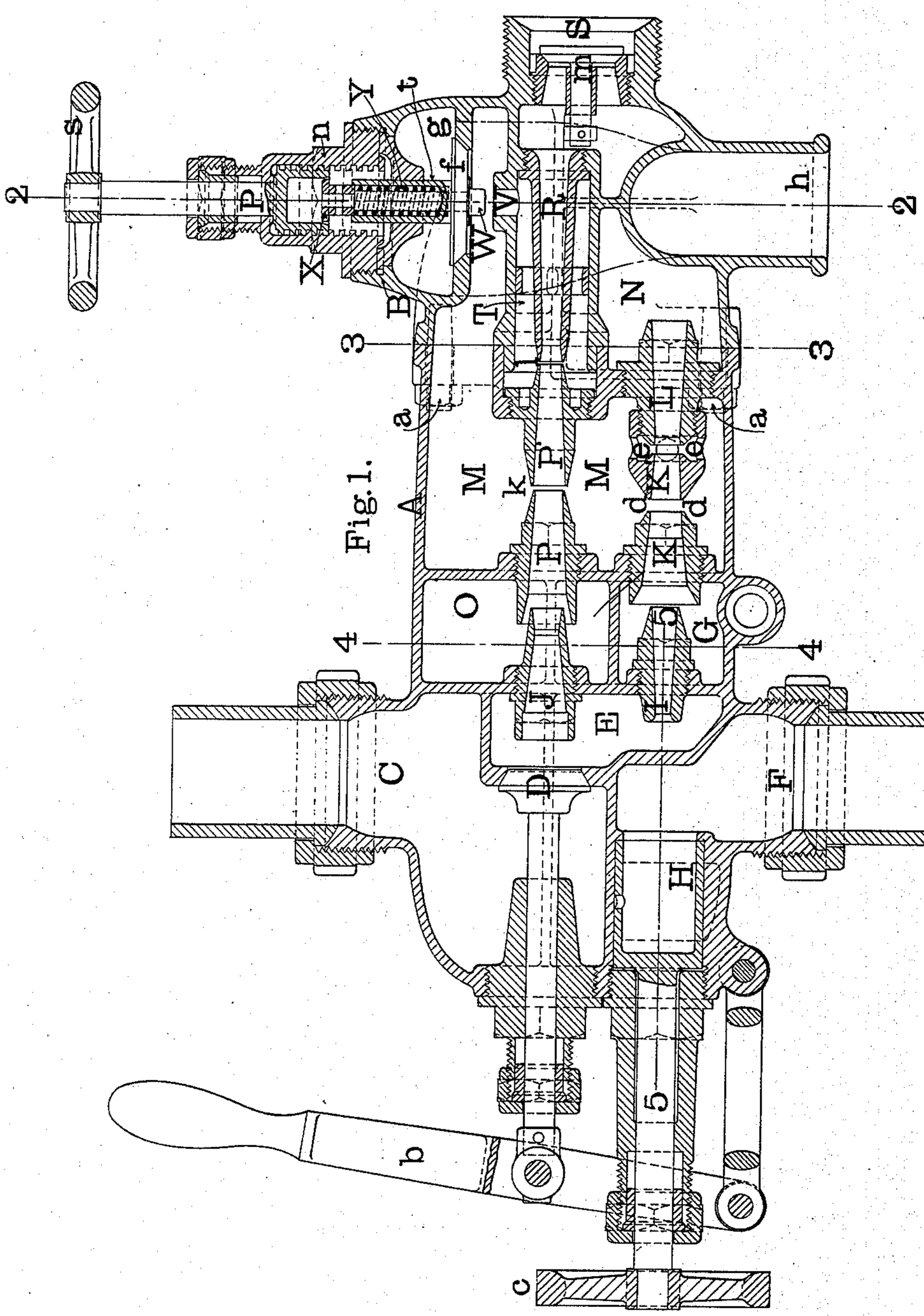

Fig. 1.

Witnesses:

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Jno. P. Schwacke

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J. Sellers Bancroft

(Model.) 2 Sheets—Sheet 2.

J. S. BANCROFT.

INJECTOR.

No. 322,342. Patented July 14, 1885.

Fig. 2.

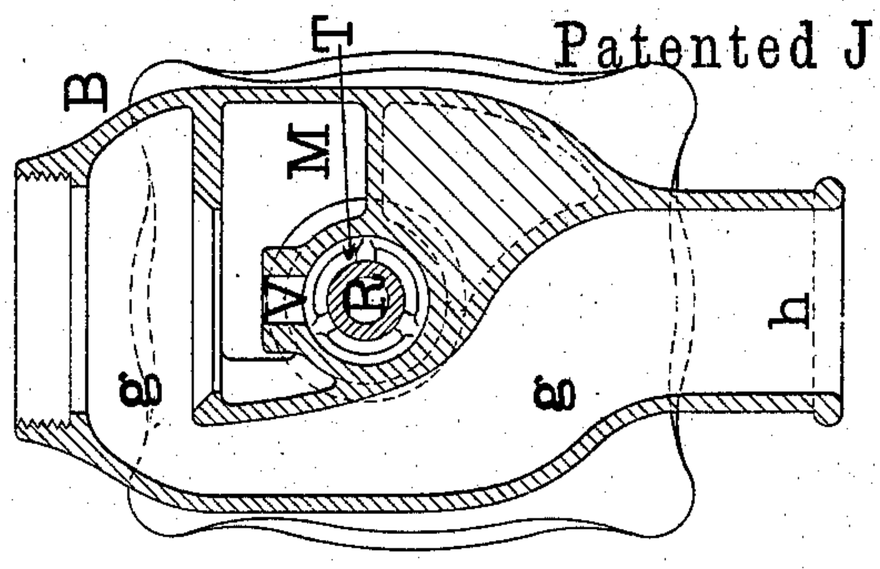


Fig. 3.

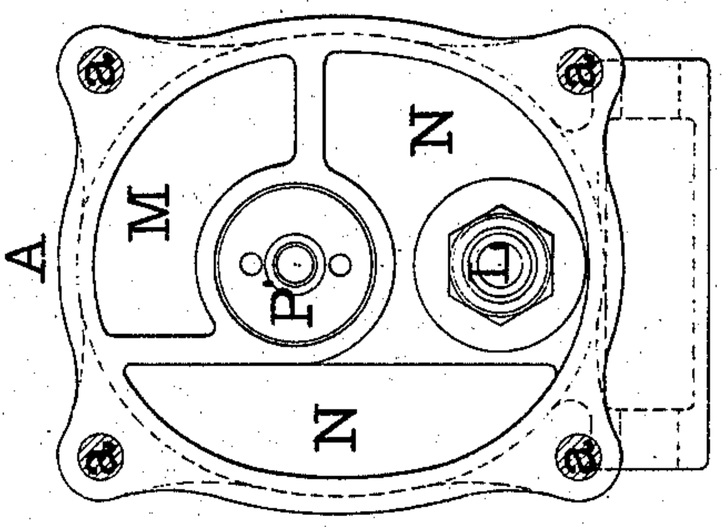


Fig. 4.

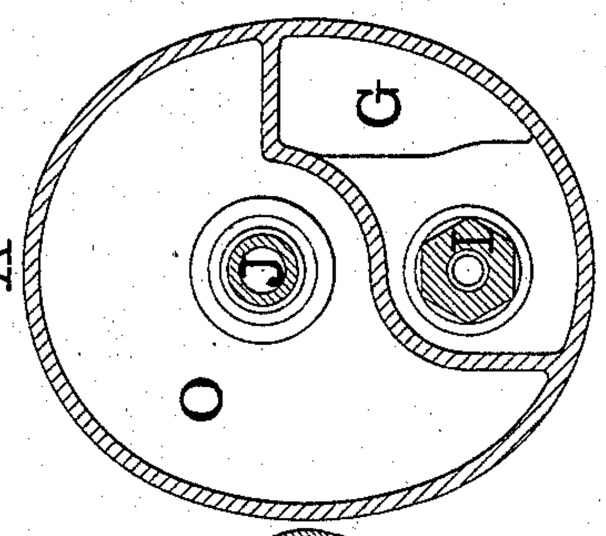
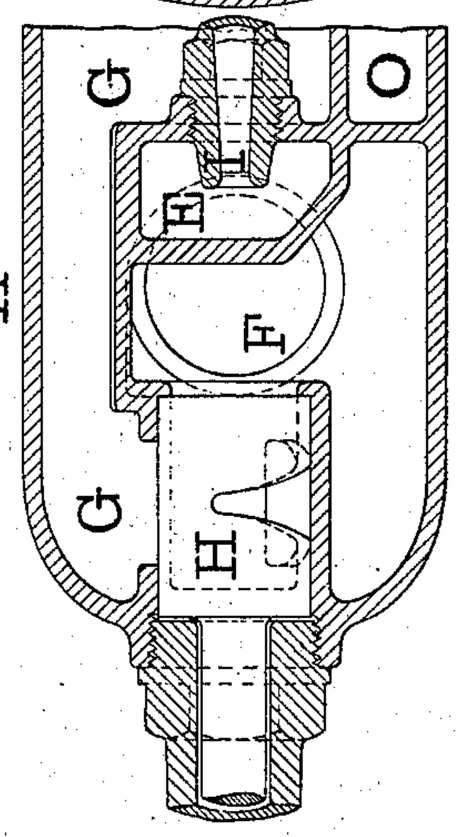


Fig. 5.



Witnesses:

Jas. L. Shanks

Jos. D. Schnacke

Inventor:

J. Sellers Bancroft

UNITED STATES PATENT OFFICE.

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

INJECTOR.

SPECIFICATION forming part of Letters Patent No. 322,342, dated July 14, 1885.

Application filed February 24, 1885. (Model.)

To all whom it may concern:

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

My invention relates to that class of injectors in which a steam-jet apparatus derives the liquid to be moved from a source of supply and delivers it to a second steam-jet apparatus, which in turn delivers the fluid to the boiler or to another similar jet apparatus, if such be found necessary to overcome the boiler-pressure, and in this specification, which describes the construction and operation of two sets of such apparatus, they are hereinafter termed the "first" and "second" sets. In case a third apparatus is used it would be simply a duplication of the arrangements shown in the first and second, and it is therefore unnecessary to describe more than the first two.

The successive actions of separate steam-jets will be found described by Giffard in his French Patent, dated May 8, 1858, and in his English Patent, No. 1,665, dated July 23, 1858; but in the instruments described and shown by Giffard, as well as in all the modifications of double jet-injectors for feeding boilers made since, previous to my invention, it has been the uniform rule for the purpose of starting the injector, when the water has to be lifted or when its temperature exceeds about 115° Fahrenheit, to admit the steam to the sets consecutively, so that the first set shall be in operation and the column of water flowing through the tubes of the second set before steam is allowed to issue from the steam-nozzle of the second set. I have discovered that with any of the proportions heretofore established between the steam-nozzles and the combining tubes of the first and second sets in such double jet-injectors, and with the provision for the escape of air and steam from these tubes, the admission of steam to the respective sets is necessarily consecutive, as already stated. For efficiency as a boiler-feeder under all conditions of steam-pressure and of water-supply, the first set must be adapted for forming a vacuum for the purpose of lifting the supply-water to the instrument, and also for delivering the water, under a pressure usually not exceeding one-third of the boiler-pressure, to the second set, and to accomplish these functions it is the recognized rule that in this set the smallest area of the steam-nozzle must be considerably less than the smallest area of the delivery-tube. On the other hand, the second set being adapted for forcing only, the smallest area of its steam-nozzle is made large enough to supplement the action of the first set, so as to deliver the jet of water into the boiler against the boiler-pressure, and if the instrument is to have any range of delivery it must be capable of delivering the water against a pressure higher than that of its boiler-pressure; and that it may meet these requirements the smallest area of the steam-nozzle of this set is made larger than the smallest area of the delivery-tube of this set; but when such injectors are used with high steam—as, for example, in locomotive service—it is impossible for the steam which issues from the steam-nozzle of the second set to pass through the delivery-tube of that set—that is, through an orifice of smaller area than the steam-nozzle itself—without establishing a back-pressure in the combining-chamber of the second set greater than the first set is capable of overcoming, and under these conditions, if there was no way provided by which the steam could be shut off from the second set, the water lifted by the first set (if it were capable of lifting against such back pressure) could not enter the combining-tube of the second set, and hence the injector could not be started. All makers of double jet-injectors have recognized these conditions and have provided valves and stop-cocks of various forms for the purpose of starting such injectors, these valves, however, being operated by hand in proper order and with sufficient intervals of time between the successive operations.

In double jet-injectors, as heretofore constructed, the first set has always been arranged so as to form a vacuum by discharging the steam and entrained air—that is to say, the air that is dragged or carried along by the steam through the delivery-tube of this set or through an overflow-opening between its combining and delivery tubes, but little greater in area

than the delivery-tube, through which the water must be delivered under the required pressure to the second set. The proportions necessarily existing between the areas of the steam-nozzle and delivery-tube of the first set and the areas of the steam-nozzle, combining-tube, and delivery-tube of the second set limit the range of steam-pressures within which the first set can be used to produce a vacuum. Now, if the boiler-pressure should exceed this limitation, and such pressure should be admitted to the first set, the increased amount of steam issuing from its steam-nozzle under this higher pressure would be unable to escape freely through its overflow-space, and would therefore, produce a pressure instead of a vacuum in the water-supply pipe, so that in practice it has always been found necessary to throttle the steam-supply at ordinary boiler-pressures in order to reduce it within the required limit until the water is lifted, and the necessity for this throttling operation has precluded any automatic action of the instrument.

Now, I have discovered that the apparatus may be made automatic under any pressure of steam by increasing the proportionate overflow-space in the first set, so that it shall be large enough to permit a free escape of steam and air at the maximum boiler-pressure at which the injector may be required to operate, and thus to enable the first set to produce a vacuum in the water-supply pipe at that pressure; and I have further ascertained that I can secure the requisite increase by locating an overflow-opening toward the rear end of the converging combining-tube and comparatively close to the end of the steam-nozzle; but I have found that the velocity of jet requisite to produce the necessary pressure upon the second set could not be attained without concentrating the jet between this overflow and the smallest part of the delivery-tube; and this I have accomplished by providing the combining-tube with another overflow-opening. The first, which I call the "rear" one, is located intermediately between the ends of the combining-tube, as above set forth, gives free escape to the steam and entrained air, and enables the first set to produce a vacuum at any steam-pressure; and the second, which I call the "forward" one, is located close to the smallest diameter of the delivery-tube, permits the escape of the concentrated jet until this jet has attained sufficient velocity to enable it to pass through the delivery-tube. A first set so constructed will be capable of starting itself, when it is connected with the water-supply, upon the admission of steam to the instrument, and will continue to deliver water, under proper conditions, to the second set; or if from any cause the jet should be broken this first set will immediately re-establish the jet as soon as the disturbing cause is removed.

I have also ascertained that the opening in the second set, large enough in area to permit an escape of the steam from the steam-nozzle of this set without establishing a back-pressure in its combining-chamber too great for the first set to overcome, must be located in the combining-tube at some point where the cross-sectional area of that tube is greater than the smallest cross-sectional area of the steam-nozzle. Thus located, the opening will necessarily be at a considerable distance from the smallest diameter of the delivery-tube, and while an escape-opening of sufficient area thus located will permit a sufficiently free exit of the steam to reduce the back-pressure within the required limit, so that the water delivered by the first set can reach and condense the steam issuing from the steam-nozzle of the second set, yet with that opening alone the requisite velocity of the jet for overcoming the boiler-pressure could not be attained. It becomes necessary, therefore, as in the first set, to provide in the second set a means for concentrating the jet between such opening thus located and the smallest diameter of the delivery-tube; and I have met this requirement by providing the combining-tube with another overflow-opening, the first or rear one, located intermediately between the ends of the tube, as above set forth, permitting such free escape of steam as to prevent the establishing of a back-pressure on the first set greater than that set can overcome, and the second or forward opening, located near the smallest diameter of the delivery-tube, permitting the escape of the concentrated jet until this jet has attained sufficient velocity to enable it to pass through the delivery-tube against the boiler-pressure. This second overflow-opening also assists in discharging the steam from the steam-nozzle, and hence supplements the first overflow-opening; but in some cases—as, for example, with very high steam or very hot water—even more than two overflow-openings may be required in the combining-tubes of both sets.

It will be evident that a double jet-injector having its first and second sets constructed and arranged in the manner above described will be capable of automatically starting itself to deliver water into a boiler so soon as it is put in communication with the steam and water supplies, and consequently, if the jet should be broken by any cause, will be capable of restarting itself as soon as the disturbing cause is removed.

I have also discovered that the range of delivery of the double jet-injector—that is, the difference between the maximum and minimum amount of water thrown—can be greatly increased by inclosing one or more of the overflow-openings of each set, and preferably all, in one common overflow-chamber having its outlet so located that no water can escape therefrom until after the overflow-openings of both sets have been submerged, access to the air from this chamber being provided for by a check-valve opening outward to permit free escape from the chamber, and excluding any indraft of air which would prevent the formation of a vacuum in the chamber. This ar-

rangement allows the water which may overflow from one set to come in contact with and be taken up by the jet passing across the overflow-openings of the other side, and hence no water will escape from the chamber until both sets are overflowing, or until the overflow from one set becomes too great for the other set to take up. With feed-water of ordinary temperature, the passage of the jet across the overflow-openings of the second set creates so great a vacuum that a large amount of water is drawn into the second set from the overflow-openings of the first set directly—that is to say, without passing through the delivery-tube of that set—and this in turn induces an acceleration of the supply through the combining-tube of the first set, so that the total or maximum amount of water delivered to the boiler is, by this conjoint action, very considerably increased. The amount of water delivered by this form of injector in proportion to the smallest cross-sectional area of the delivery-tube of the second set is vastly greater than that delivered through the same area by any double jet-injector heretofore constructed. When the temperature of the feed-water is high, the second set overflows slightly, and this surplus is taken up through the overflow-openings of the first set, and there will be no discharge into the air from the overflow-chamber until the temperature of the feed-water is increased, so as to cause both the first and second sets to overflow. A similar action takes place wher the water-supply is throttled for the purpose of reducing to a minimum the amount of water thrown, and the difference between the maximum and minimum amounts of water delivered by a given instrument or range of delivery is much greater than has hitherto been possible. This arrangement also makes the action of the injector much more certain and reliable under varied conditions of service, as any irregularity of action in either set is compensated by the other set, and no overflow can occur from the chamber until the variation of water-supply becomes so great as to exceed the rangeof this self-regulation.

It is frequently necessary, especially in locomotive service, to blow steam back through the water-supply pipe for the purpose of heating the feed-water, and for this purpose it is necessary to provide some means for holding the overflow check-valve on its seat to prevent the escape of steam during this heating process. If this valve be closed, as above described, after the injector is started, it is possible to use feed-water of higher temperature, and by arranging the overflow check-valve and overflow-chamber in the manner hereinafter described, so as to separate the final overflow in the second set from the common overflow-chamber when desired, the temperature of the feed-water may be still further increased; but it will be observed that when the check-valve is thus held shut the injector will not be capable of restarting itself until the check-valve is released, and hence this device would be required only under exceptional conditions.

It is one object of my invention to dispense with movable parts (in a double jet-injector) for the purpose of starting or regulating the instrument other than the valves for the admission of steam and water, and at the same time to produce an instrument of the highest efficiency and the greatest range of delivery; and it is a further object of my invention while attaining these advantages to produce an instrument that will automatically establish its own jet and automatically re-establish it in case the same shall have been broken by any accident short of the breakage or derangement of any of the parts of the instrument itself; and to these ends the nature of my improvements in double jet-injectors consists in providing the first set with overflow-space 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 four times the area of the smallest cross-section of the steam-nozzle; and it further consists in supplementing the overflow-space thus provided with an additional overflow-opening located nearer the smallest diameter of the delivery-tube.

It further consists in providing the second set with overflow-space in the combining-tube at a point in the rear of that where the cross-sectional area of this converging tube contracts to an area equal to that of the smallest cross-sectional area of the steam-nozzle; and it further consists in supplementing this overflow-space with an additional overflow-opening located nearer the smallest diameter of the delivery-tube.

It further consists in combining one or more of the overflow-openings of each set with one common overflow-chamber.

It further consists in providing this overflow-chamber with an overflow check-valve, so arranged that all of the overflow-openings which are inclosed in this chamber shall be submerged before any water can escape through the overflow check-valve.

It further consists in providing means for isolating the final overflow in the second set from the other overflows to enable the injector to take feed-water of the highest temperature.

In the accompanying drawings, which form part of this specification, Figure 1, Sheet 1, represents a vertical section through an injector embodying the above-described features of my present invention. Figs. 2, 3, and 4, Sheet 2, are vertical sections through Fig. 1 on the lines 2 2 3 3 4 4, respectively, the overflow check-valve being omitted in Fig. 2. Fig. 5 is a horizontal section on the line 5 5, showing the water-supply and water-regulating valve of the first set.

In all the figures similar letters indicate similar parts.

The case or body of the injector is made in two parts for convenience of manufacture, these parts, A and B, being fastened together

by bolts *a a*, as shown, so as to form a complete case. C is the steam-connection. D is the steam-valve, operated by the lever *b*, and so arranged that the steam-pressure tends to keep it seated. When this valve is lifted or opened, steam is admitted to the steam-chamber E, which is common to the steam-nozzles of both sets.

F is the water connection or supply, from which water is admitted to the water-chamber G through the valve H, operated by the hand-wheel *c*. The form of this water-chamber G is more clearly shown in Fig. 5, where it will be seen that the chamber G extends on one side of the water-supply F and the lower part of the steam-chamber E. When the valve D is lifted, as above described, steam is admitted to the chamber E, and escapes through the steam-nozzles I and J. The steam issuing from the nozzle I blows into the tubes K and K′, which constitute the combining-tube, and escapes into the overflow-chamber M, through the rear overflow-opening, *d*, between these tubes K and K′ and the forward overflow-opening, *e*, between K′ and the delivery-tube L. The steam escapes from this overflow-chamber M under a check-valve, *f*, which allows free exit, but serves to prevent the admission of air. The discharge from this valve takes place through the passage *g*, formed in the body B, and continued down to the outlet *h*.

The check-valve *f* is held firmly on its seat, when necessary, by means of the screw *p*, operated by the hand-wheel *s*, and engaging with the screw-thread formed in the cap *n*, the screw *p* passing through a stuffing-box formed on the upper part of the cap *n*, as shown in Fig. 1, the object of the stuffing-box being to produce sufficient friction to hold the screw at the top of its stroke, which is its normal position when the injector is used as an automatic instrument. The end of the screw *p*, when at the top of its stroke, allows free lift to the valve *f* with its guiding-stem *t*, and when screwed down may be made to impinge upon the upper end of the stem *t*, and so hold the valve *f* firmly on its seat, for the purpose described. In Fig. 1 the stem *t* of the check-valve *f* is shown bored out to receive a plunger, W, and a spiral spring, Y, which rests on the lower end of the recess in the stem *t*, and its upper end presses against the cap X, secured firmly to the upper end of the plunger W, and so holds the lower enlarged end of the plunger W firmly up against the lower part of the valve *f*, and the whole device acts in the same manner as a solid check-valve, being lifted by pressure within the overflow-chamber M, and falling to its seat and closing to prevent the admission of air when a vacuum is produced in the chamber M, as hereinbefore described.

The cap X extends above the end of the hollow stem *t*, and when the screw *p* is run down to hold the valve *f* shut it first impinges on the cap X and, pushing it down, compresses the spring Y and forces the enlarged end of the plunger W down below the valve *f* until it enters the opening V, which it fills, forming a piston-valve to prevent any flow of water through this opening, for a purpose hereinafter described. The screw *p* in its downward movement pushes the cap X down until the flange on its upper end bears against the top of the hollow stem *t*, thus holding the valve *f* firmly on its seat.

The nozzle I, combining-tube K and K′, and overflow-openings *d* and *e* are so proportioned that the steam issuing from the nozzle I entrains the air from the chamber G into the tube K, from which this entrained air and steam escape through the overflow-opening *d* into the chamber M. The steam which accumulates in the chamber O, as hereinbefore described, blows back through the conduit N and delivery-tube L and escapes into the chamber M, principally through the overflow-opening *e*, which thus relieves the steam-jet issuing from the nozzle I from the counter-pressure of the jet issuing from the delivery-tube L, which would otherwise almost completely prevent the formation of a vacuum, and this combined action produces a vacuum in the water-supply chamber G, so that if the valve H is opened the water from a well or other source of supply will be drawn into the chamber G through the water-connection F. To have the proportions for insuring this operation and producing the necessary vacuum in the chamber G, it is essential that the overflow-opening *d* should be located, as shown in the drawings, at a point in the combining-tube K K′, where the cross-sectional area of this tube is at least four times the area of the smallest cross-section of the steam-nozzle I; and that the overflow-openings *d* and *e* should be large enough in area to give a free escape to the entrained air, and to the steam issuing from the nozzle I and the delivery-tube L at the highest boiler-pressure at which the injector may be required to operate, thus insuring the formation of a vacuum at such pressure. Such a vacuum will bring the water into contact with the steam-jet issuing from the nozzle I, and at this point, instead of entrained air and steam, water and steam enter the tube K, and this jet of water and steam combined discharges into the overflow-chamber M, partly through the overflow-opening *d* from the tube K, and partly through the overflow-opening *e* from the tube K′. The converging tube K′ and overflow *e* concentrate the jet and increase its velocity in the tube K until the overflow at *d* ceases, and the combined concentrated jet passes through the tube K′, overflowing at *e*, and its velocity continues to increase until the overflow at *e* ceases, when the combined concentrated jet will have acquired sufficient impetus to carry it across the overflow-opening *e* into the delivery-tube L against the steam-pressure established in the chamber O.

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 entrained air and steam without cutting off the combining-tube to such extent as to deprive it of the power of concentrating the jet sufficiently to enter the delivery-tube. 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 entrained air and the steam issuing from the nozzle I, (which I secure by the opening *d*, located as already described,) so as to permit the formation of a vacuum at the maximum boiler-pressure, would not give the necessary concentration and velocity to the jet of combined steam and water to enable it to pass through the delivery-tube; nor would it afford a sufficiently free escape for the steam issuing in the opposite direction from the delivery-tube L, the conjoint operation of the two overflows *d* and *e*, therefore, could not be accomplished by one single overflow however located, for it will be seen that while the two overflows have severally distinct functions to perform, each overflow co-operates with and supplements the other.

From the delivery-tube L the jet passes through the conduit N to the combining or water chamber O of the second set. The steam issuing from the nozzle J of the second set passes through the tubes P and P′, which constitute the combining-tube, and escapes through the rear overflow-opening, *k*, between the tubes P and P′, and the forward overflow-opening, *l*, between P′ and the delivery-tube R into the chamber M, which is common to the overflows from both the first and second sets. The steam from the nozzle J also fills the water-chamber O and establishes a certain pressure there and produces a discharge of steam back through the conduit N and delivery-tube L of the first set, as before described, and the combining-tube P P′ and overflow-openings *k* and *l* of the second set are so portioned to the steam-nozzle I and to the combining-tube K K′ and delivery-tube L of the first set that this pressure in the chamber O will never be too great with any steam-pressure to prevent the water delivered by the first set from reaching the steam issuing from the nozzle J. To have the proportions for insuring this operation and preventing the pressure in chamber O from exceeding this limitation, it is essential that the overflow-opening *k* should be located, as shown in the drawings, at a point in the combining-tube P P′ where the cross-sectional area of this tube is larger than the area of the smallest cross-section of the steam-nozzle J, and that the discharging ends of the converging tubes P and P′ should be large enough in area to permit the escape of steam from the nozzle J with such freedom that any back-pressure which may be produced in chamber O will always be less than the first set is capable of overcoming. The water delivered by the first set will reach and combine with the steam issuing from the nozzle J and pass through the tube P, and this jet of steam and water combined discharges into the overflow-chamber M, partly through the overflow-opening *k* from the tube P, and partly through the overflow-opening *l* from the tube P′. The converging tube P′ and overflow *l* concentrate the jet and increase its velocity in the tube P until the overflow at *k* ceases, and the combined concentrated jet passes through the tube P′ overflowing at *l*, and its velocity continues to increase until the overflow at *l* ceases, when the combined concentrated jet will have acquired sufficient impetus to carry it across the overflow-opening *l*, through the delivery-tube R, and into the boiler through the connection S. 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 in this set 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 in this set, (which I secure by the opening *k*, located as already described,) so as to reduce the back pressure within the required limit, would not give the necessary concentration and velocity to the jet to enable it to pass through the delivery-tube R, and the conjoint operations of the two overflows *k* and *l*, therefore, could not be accomplished by one single overflow however located, for it will be seen that in the second set, as in the first set, while these two overflows have severally distinct functions to perform, each co-operates with and supplements the other, and that they conjointly co-operate with the openings in the first set, so that by their combined action the instrument will automatically establish and re-establish its own jet, as presently described.

A check-valve, *m*, is placed at the end of the injector near the connection S, as shown, to prevent escape of water from the boiler when the injector is not working.

The check-valve *f* is placed at the top of the overflow-chamber M, so that any water which may overflow from either the first or second sets will be retained in the chamber M until after the overflow-openings from both sets have been submerged. This arrangement allows the water which may overflow from one set to be taken up through the overflow-openings of the other set, and hence no water will escape through the check-valve *f* until both sets are overflowing, or the overflow from one set becomes too great for the other set to take up.

When the temperature of the admitted water rises to too high a point, water will escape from the overflow-chamber through the valve *f* as soon as the pressure in the overflow cham-

ber M becomes greater than the atmospheric pressure. The proportions of the tubes are such, however, that the injector will feed water into the boiler with considerable pressure in chamber M when the valve *f* is held shut by the screw *p*, as before described, and hence the temperature of the feed-water may be thus considerably increased; but under these circumstances the injector will not be automatic, and should the jet be broken will be unable to re-establish its jet until the check-valve *f* is released. The delivery-tube R and the discharging end of the combining-tube P′ are inclosed in a chamber or case, T, formed in the body B. This case T communicates freely with the overflow-chamber M through the opening V when the screw P is at the top of its stroke, as shown in Fig. 1, and the relative action of the overflow-openings will be as hereinbefore described. When, however, it becomes desirable for any purpose to feed water of a higher temperature than the injector is capable of operating with automatically, and the valve *f* is closed by means of the screw *p*, the piston W fills the opening V and separates the case T from the chamber M, so that the water which would otherwise overflow from the final overflow-opening *l* is prevented from entering the chamber M, and consequently from reaching the overflow-openings of the first set and producing a pressure there which would break the jet. This device is only required when the temperature of the feed-water is exceptionally high, and for all ordinary purposes of boiler feeding the plunger W may be omitted and the stem *t* be made solid.

The proportion of the steam-nozzles and combining-tubes relative to the overflow-spaces of the respective sets is such that the first set is always capable of producing a vacuum, and hence of lifting the water, and that the second set cannot establish a back-pressure in chamber O sufficient to prevent the first set from delivering water to the second steam-jet issuing from the nozzle J. These proportions of the combining-tubes and overflows further facilitate the rapid and certain formation of the jet as soon as steam and water are admitted to the injector.

If desired, the steam-valve D may be arranged with a supplemental valve closing the steam-nozzle J, or with a cylindrical extension entering a cylindrical seat in the nozzle J, so that when the valve D is raised a short distance from its seat steam may be admitted to the first nozzle, I, only. This arrangement is designed to avoid the waste of steam issuing from the nozzle J, and is only desirable when the injector has to lift its water a great height. As soon as water appears at the overflow *h* the steam-valve D is further opened, so as to lift the supplemental valve or withdraw the cylindrical plug from the nozzle J, as the case may be, and the steam issuing from J will instantly unite with the water, and the injector will go to work, and everything will also be in proper condition for the automatic re-establishment of the injector, if the jet should be broken from any cause.

It is not essential that the overflow-openings of either set should be made annular, as shown in the drawings, between the ends of separate tubes, for the combining and delivery tubes of either set may be formed in one piece, and the necessary overflow-space provided by perforating them with a series of holes of sufficient aggregate area located in the converging tube at any point where its cross-section is sufficiently large, as hereinbefore described, for the purpose of the first overflow, and an additional series of corresponding holes located just before the smallest part of the delivery-tube for the purpose of starting the concentrated jet, as above described, or the annular overflow-openings may be supplemented by a series of holes, if desired.

Having now described the nature and objects of my invention, what I claim therein as new, and desire to secure by Letters Patent, is—

1. In a double jet-injector, a first set of jet apparatus provided with overflow-space 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 four times the area of the smallest cross-section of the steam-nozzle, substantially as and for the purposes set forth.

2. In combination with overflow-space in the first set of jet apparatus, 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 four times the area of the smallest cross-section of the steam-nozzle, an additional overflow-opening in this combining-tube nearer the smallest diameter of the delivery-tube, the combination being and operating substantially as described.

3. In a double jet-injector, a second set of jet apparatus provided with overflow-space in the combining-tube at a point in the rear of that where the cross-sectional area of this converging tube contracts to an area equal to that of the smallest cross-sectional area of the steam-nozzle, substantially as and for the purposes set forth.

4. In combination with overflow-space in the second set of jet apparatus, located in the combining-tube at a point in the rear of that where the cross-sectional area of this converging tube contracts to an area equal to that of the smallest cross-sectional area of the steam-nozzle, an additional overflow-opening in this combining-tube nearer the smallest diameter of the delivery-tube, the combination being and operating substantially as described.

5. In combination with the first set, constructed and operating substantially as described, the second set correspondingly provided with two overflow-openings respectively located and arranged therein, as set forth, the two sets being combined and oper-

ating in combination, substantially as described, so that the instrument will automatically establish and re-establish its own jet, as set forth.

6. An overflow-chamber common to one or more of the overflow-openings located in each set of jet apparatus, substantially as described, and for the purposes set forth.

7. In combination with an overflow-chamber common to one or more of the overflow-openings of each set of jet apparatus, an overflow-check valve so arranged that all of the overflow-openings which are connected with the overflow-chamber shall be submerged before any water can escape through the overflow-check valve, the combination being and operating substantially as described.

8. An overflow-chamber common to one or more of the overflow-openings of each set of jet apparatus and an overflow-chamber which receives the final overflow of the second set, in combination with a valve which controls the communication between the two overflow-chambers, substantially as and for the purpose described.

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Witnesses:
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