3 Sheets—Sheet 1.

# J. H. IRWIN.

## Steam Injector and Ejector.

**No. 215,126.** **Patented May 6, 1879.**

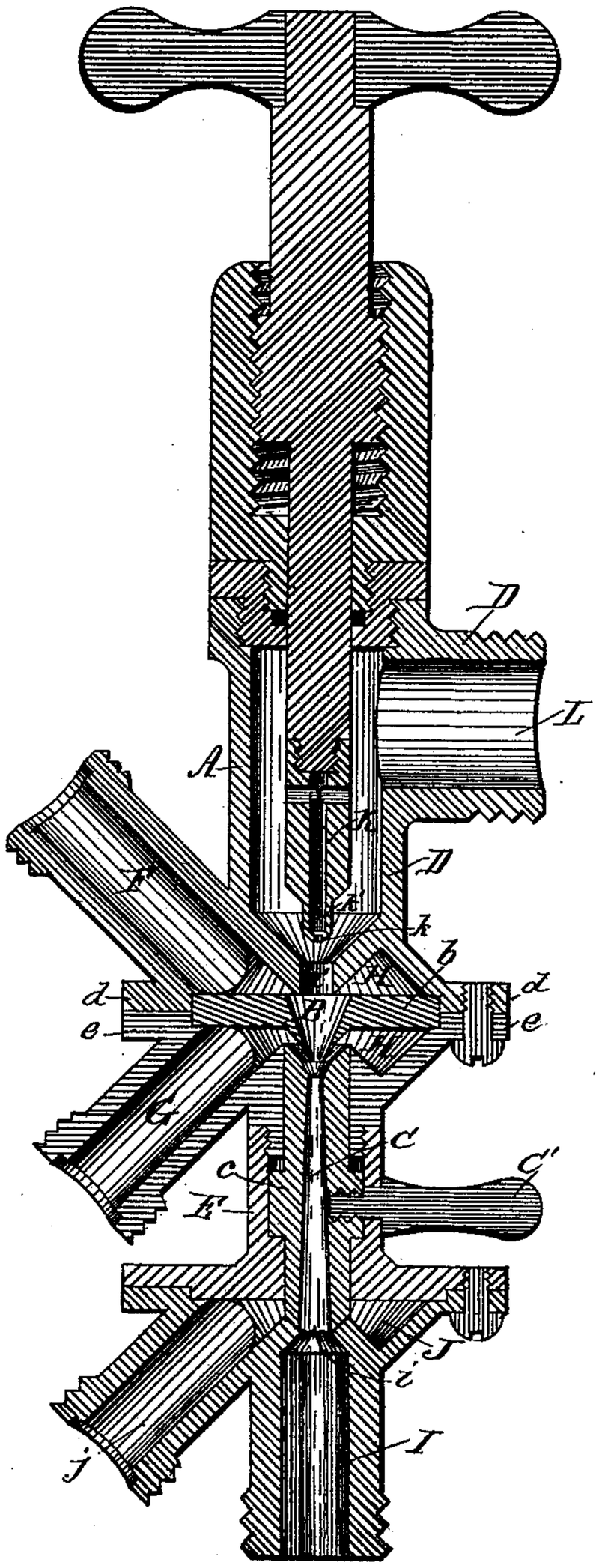


Fig. 1.

Witnesses.
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3 Sheets—Sheet 2.

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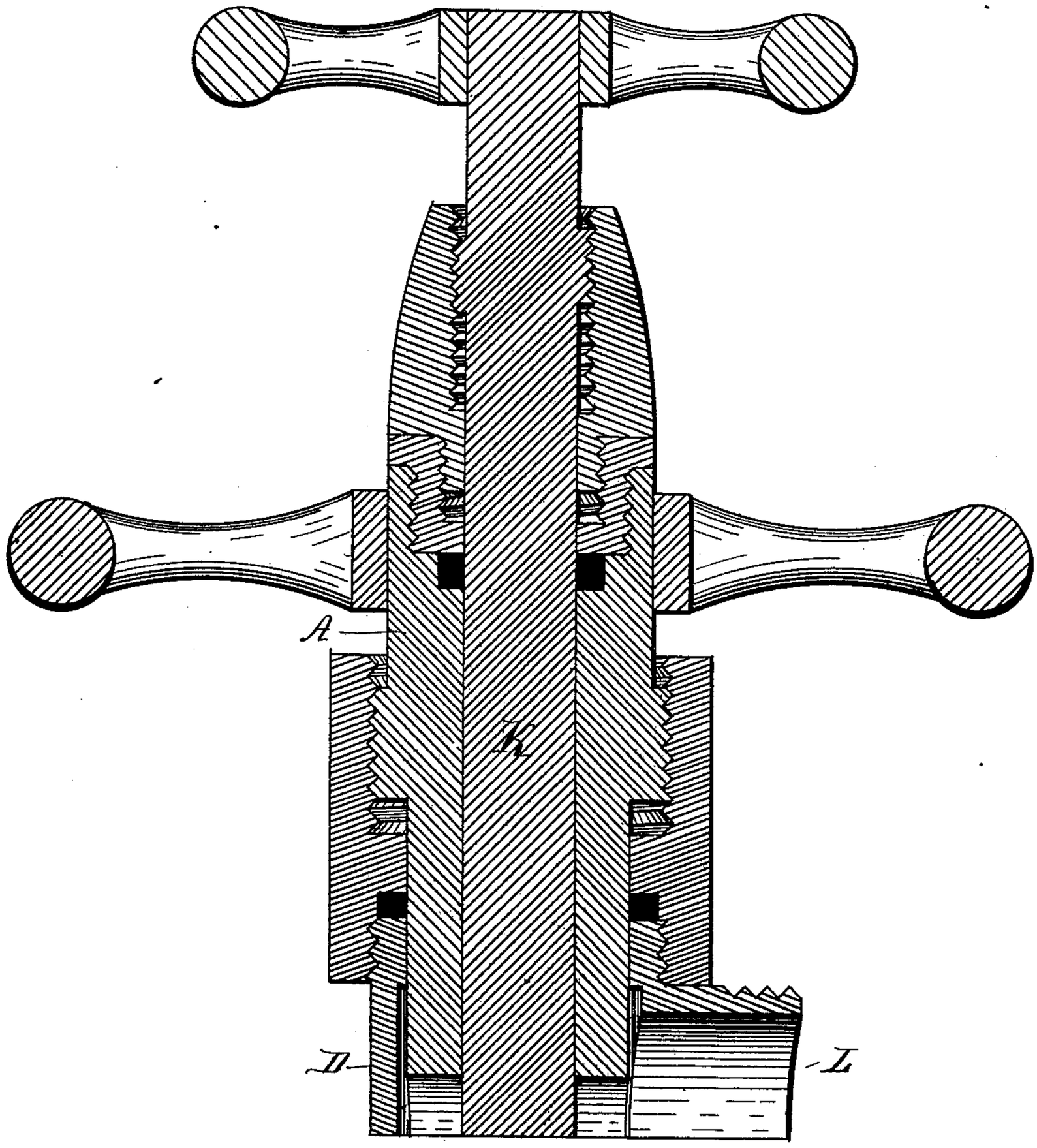


*Fig 2*

Witnesses.

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3 Sheets—Sheet 3.

# J. H. IRWIN.

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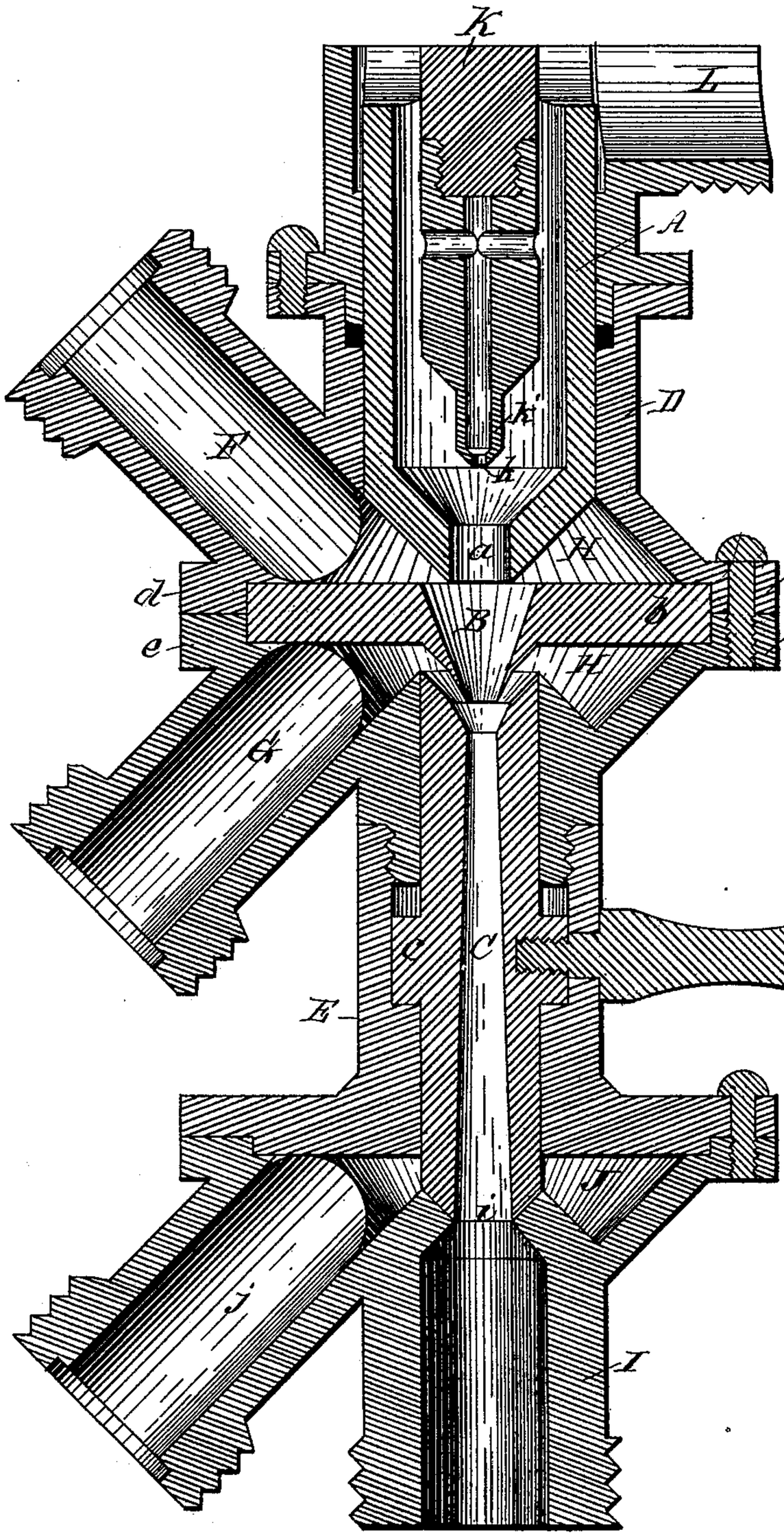


Fig. 3.

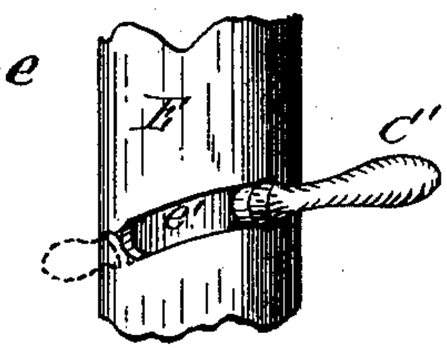


Fig 4

Witnesses,
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F. B. Groff.

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# UNITED STATES PATENT OFFICE.

JOHN H. IRWIN, OF PHILADELPHIA, PENNSYLVANIA.

## IMPROVEMENT IN STEAM INJECTORS AND EJECTORS.

Specification forming part of Letters Patent No. **215,126**, dated May 6, 1879; application filed May 10, 1878.

*To all whom it may concern:*

Be it known that I, JOHN H. IRWIN, of Philadelphia, in the county of Philadelphia and State of Pennsylvania, have invented certain new and useful Improvements in Steam Injectors and Ejectors, which are fully described in the following specification, reference being had to the accompanying drawings, in which—

Figure 1 represents a longitudinal section of an injector embodying my improvements; Fig. 2, a similar view, on an enlarged scale, of the spindle end of the instrument; Fig. 3, a similar view of the remaining part of the instrument, which is cut transversely on the line *x x*, Fig. 1; and Fig. 4, a detail plan, showing the device for adjusting the receiving-cone.

My invention relates to that class of instruments generally known as the "Giffard injector;" and its object is to improve the construction of the instrument, whereby an operation is secured approximating perfection, and affording very nearly the full equivalent for the steam employed.

The invention consists in the construction of the essential devices composing the instrument; also, in the manner of combining these devices with each other; and, furthermore, in the novel construction of certain minor parts of the instrument, all of which will be hereinafter more fully set forth.

The general features of this class of instruments are so well known that there is no necessity here for a detailed description of the construction, arrangement, and general operation of all the parts of the instrument, and I shall therefore confine myself to a description of those parts which I have improved.

It may be stated generally that the same devices are employed which have been used heretofore—that is, the instrument is composed of a steam-cone, a spindle, a combining-cone, and a receiving-cone, in connection with suitable chambers, steam and water inlets, and overflow-pipe; but most of these parts are constructed and combined in an entirely novel manner.

In the drawings, A represents the steam-cone, which is provided with a straight nozzle, *a*, having the surrounding metal of considerable thickness, so as to give the aperture a certain definite length. The combining-cone B is formed in a disk-shaped piece of metal, *b*, arranged immediately in front of the steam-cone. The receiving-cone C, just beyond the combining-cone, is mounted in the body or case of the instrument, so as to be adjustable in a longitudinal direction.

These several devices are constructed with certain definite proportions bearing fixed relations to each other, which I have found by a long series of practical experiments to be necessary to the best working of the instrument.

Let the smaller diameter of the combining-cone B be taken as the base or starting-point for the construction of the injector. This cone is then made with its greater diameter four times the smaller diameter, and its length equal to the greater diameter, and consequently four times the smaller diameter.

The diameter of the jet-opening *a* of the steam-cone is one-half the greater diameter of the combining-cone, or twice the smaller diameter of the same, and the length of this opening is equal to its diameter.

The receiving-cone C is made with a gradually-increasing diameter—a form of this device, however, which is well known. The smaller diameter of this cone is the same as the smaller diameter of the combining-cone, the larger diameter is twice the smaller, and the length is sixteen times its smaller diameter, or the smaller diameter of the combining-cone. The smaller diameter of the combining-cone being represented by 1, its larger diameter will then be represented by 4, and its length also by 4. The diameter and length of the jet-opening in the steam-cone will be represented by 2. The smaller diameter of the receiving-cone will be represented by 1, the larger diameter by 2, and its length by 16. These are the relative proportions of these devices which I have found necessary to the best working of the instrument, and any substantial deviation therefrom will materially affect the results.

It will be readily understood by those familiar with the operation of injectors that in order to obtain the perfect working of the instrument the steam must all be condensed in the combining-cone, and to secure the best

results the water admitted to and passing through this cone should not be much in excess of the actual quantity necessary to condense all the steam.

The relative dimensions of the steam-cone and combining-cone given above are the only ones which will produce this result, and a jet-opening in the steam-cone with the relative dimensions above stated I have found will discharge the greatest amount of steam in a given time.

So far as the operation of the steam and combining cones is concerned, then, the result will be nearly as stated above when they are constructed as described.

Now, very good results may be obtained if with steam and combining cones thus constructed a receiving-cone is used departing somewhat from the dimensions laid down above, and therefore I do not wish to be understood as limiting my invention to any special construction of receiving-cone. A receiving-cone may be employed which will discharge all the water emitted from the combining-cone, but with comparatively little force, though sufficient for some purposes. However, to obtain the highest possible result—that is, with a given quantity of steam to discharge the greatest quantity of water with the greatest force—I have found that the dimensions of the receiving-cone must be as stated above. The receiving-cone is provided with an enlarged or flaring mouth to catch the stream from the combining-cone, which is also constructed in a peculiar manner and with definite dimensions. The length of this orifice is twice the smaller diameter of the receiving-cone, and its greatest diameter is four times the same diameter, or equal to the greater diameter of the combining-cone, its middle diameter is one-half its greatest diameter, while its smaller diameter is the same as the smaller diameter of the receiving-cone.

This construction will make the inclination of the outer section somewhat greater than the inner section, as shown in Fig. 3 of the drawings.

The case or body of the instrument is divided at the combining-cone, one section, D, containing the steam-cone, and the other section, E, the receiving-cone, the two sections being joined by a flange-connection, the flanges *d* and *e* of which are recessed or cut away to form a seat for the disk *b* of the combining-cone, which is held between the two sections when secured together, as shown in the drawings, the joint being necessarily perfectly air-tight. On the steam side of this disk is the water-pipe F, and on the discharge side is the overflow-pipe G, and of course there is an annular chamber, H, around the cone on both sides of the disk.

As stated above, the receiving-cone is mounted in the case-section E, so as to slide back and forth therein. A band or ring, *c*, is provided on the outside of the cone, which fits in a corresponding recess in the casing, elongated as shown in the drawings, to permit the ring to move back and forth therein.

The casing E is provided with an inclined or spiral slot, *e'*, as shown in Fig. 4 of the drawings, and a handle, C', is inserted in this slot and fastened to the receiving-cone, so that by reciprocating the handle or lever in the slot the receiving-cone will be adjusted longitudinally.

The construction and arrangement of the receiving-cone and its adjusting devices are such that when thrown back to its limit the discharge end of the combining-cone will just close with the opening of the receiving-cone, and when thrown forward to its limit this end of the combining-cone will project half-way into the mouth of the receiving-cone, as shown in Fig. 3 of the drawings.

A discharge-pipe, I, may be attached by a flange-connection to the end of the injector, and the opening *i* into it constructed and arranged so that the discharge end of the receiving-cone will be provided with a seat therein when thrown forward to its fullest extent, so that the receiving-cone acts as a valve at either end, according to its adjustment, one valve being opened when the other is closed. The diameter of the pipe I is somewhat larger than the outer end of the receiving-cone, and at the inner end of this pipe is an annular chamber, J, into which a pipe, *j*, opens, similar to the overflow-pipe, and for a like purpose.

The spindle K is hollow, and is adjusted back and forth within the steam-cone in any ordinary way. Its jet-opening *k* is similar in construction to the opening in the steam-cone, and is also determined in size relatively to the other parts, being made with a diameter one-half the smaller diameter of the combining-cone, so that, the latter being represented by 1, the spindle-jet will be represented by $\frac{1}{2}$.

The end or nose *k'* of the spindle is smaller than the jet-opening in the steam-cone, so that when projected into the latter there will be an annular space around the end of the spindle, inside of the opening. The diameter of this small end of the spindle is one and one-half time the smaller diameter of the combining-cone. It will therefore be three-fourths the diameter of the jet-opening in the steam-cone, and the annular space around it will represent the remaining one-fourth.

The spindle just back of the nose is cone-shaped, the angle being the same as that of the steam-cone, which consequently makes a seat for the spindle, acting as a valve to entirely close the jet-opening when projected, so that steam will pass through the spindle only. Steam is supplied to the cone and spindle by a pipe, L, in the usual way.

In operating this injector, the receiving-cone is first thrown inward, so as to close with the combining-cone, and the spindle is projected until its nose enters the jet-opening, and the latter is closed in rear, as described

above. Steam is then let on, when the air is expelled and the water is caught almost instantly.

In order to raise and eject the water with increased velocity more steam is now required; but it is important that it should be added in precisely the proper quantities and gradually; otherwise, if steam is added too rapidly, the water will be heated before its movement will be accelerated and imperfect condensation will result, and if not added with sufficient rapidity when the spindle is being retracted, then the vacuum will be lost and the water will retreat. Hence the importance of the relative proportions and forms of the steam cone and jet. The spindle should then be retracted slowly and steam admitted through the annular space surrounding it to re-enforce the spindle-jet, which loses power as the spindle is retracted. The vacuum is thereby preserved without the addition of steam with rapidity sufficient to heat the water before increasing its velocity. The receiving-cone is also thrown forward to its fullest extent, thereby closing the opening into the pipe I, and opening the valve at the inner end of the cone, when the instrument will work up to its fullest capacity.

In order to regulate the volume of water fed into the boiler, the steam-cone may be made adjustable longitudinally, as shown in Figs. 2 and 3 of the drawings, which, in connection with the adjustable spindle, enables the quantity of feed-water to be regulated with great nicety. This is not a necessary feature of construction, however, as the steam-cone may be made stationary, as shown in Fig. 1 of the drawings, the instrument being adjusted to a certain amount of pressure. The arrangement of the steam-cone is then as shown in Fig. 1 of the drawings, with the steam-jet projecting up to but not entering the combining-cone, this adjustment securing the highest results.

The inclination of the steam-cone is forty-five degrees, which enables the volume of water entering the combining-cone to be regulated rapidly and with slight movement of the steam-cone, which movement is always just that necessary to give the proper distance of the jet from the small end of the combining-cone to suit the volume of water admitted and the required quantity of steam. At the same time the jet of steam is also regulated easily and with nicety.

With the dimensions given above, mathematical calculation will show that the quantity supplied by the opening in the spindle will be one-sixteenth the whole quantity, which will pass through the steam-cone opening, and that the annular space about the spindle-nozzle, when in the cone-opening, will pass seven-sixteenths more when fully opened, or, together with the spindle-jet, one-half the full jet of the steam-cone with variations all the way between these points.

The water-pipe F is set at an angle of forty-five degrees to the axis of the instrument, and the sides of the chamber H are inclined at the same angle. This arrangement affords the least resistance to the water and the surface of the steam-cone being also on the same inclination, the water will be directed into the combining-cone with the least possible friction. The plane surface of the disk also assists in this action, as, in accordance with a well-known law, the liquid clings, as it were, to this face, against which it is directed.

With the instrument constructed as above described I have obtained highly satisfactory results, and by exhaustive experiment have demonstrated that its operation is close to perfection, or, in other words, very nearly the full theoretical equivalent of steam is obtained, taking into account the volume, velocity, and temperature of the feed.

The instrument will operate under a steam-pressure below the atmosphere, producing an augmented pressure considerably above the atmosphere, and at the same time lifting the water a considerable distance. In this operation, however, it is evident that the instrument must be started with steam above the pressure of the atmosphere, or the air will not be blown out of the injector and suction-pipe.

In working with steam above the pressure of the atmosphere a greatly-augmented pressure is obtained. For illustration, in actual practice with steam at ninety pounds, I have obtained a pressure of three hundred and fifty pounds, and with steam at forty pounds at least two hundred pounds, the injector being fed without head of water. In obtaining these augmented pressures I have found the free admission of air through the overflow-pipe of considerable importance, making a difference of at least one atmosphere in the amount of pressure gained.

This operation may be utilized at low pressures or small quantities of steam for pumping air and forcing it into a receiver, the air being supplied through the overflow. For illustration, with steam at five pounds an air-pressure of at least fifteen pounds may be obtained, and a vacuum at the overflow-inlet of from twenty to twenty-seven inches. The air will of course enter the receiver with a small quantity of water; but the volume of the latter will be so much smaller than the former as to be of little consequence.

Inasmuch as in the manufacture of the instrument it will be next to impossible to construct the parts with absolute mathematical precision, it may be desirable in practice to make the diameter of the steam-jet a trifle less than twice the smaller diameter of the combining-cone, or, what would be the same in effect, make the combining-cone with its smaller diameter a trifle greater than one-half the diameter of the steam-jet; otherwise a little more steam might be projected into the combining-cone than would be condensed, and the mass would not pass through the cone, and

the operation would be interrupted when the spindle is entirely withdrawn from the jet-opening in the steam-cone.

No substantial departure from these relative proportions can be made, however, as it is an essential feature of my improvement that the ratio between the small diameter of the combining-cone and the diameter of the steam-jet shall be substantially as 1 to 2.

The length of the combining-cone may be varied somewhat to suit different pressures of steam, as is evident from the adjustment of the steam-cone in the instrument described to suit low pressures, which is effected by setting the cone forward slightly into the combining-cone, according to the pressure of steam. Its large opening may also vary some. The relation between the small opening in the combining-cone and the steam-jet, however, remains the same, and must remain substantially the same under all pressures.

I do not limit myself to a steam cone with an elongated jet-opening precisely as described, for approximate results may be obtained even if this opening is not as long as the diameter thereof; but the latter dimension should always have substantially the same relation to the dimensions of the combining-cone which have been herein specified.

This instrument is also a very efficient ejector for water or air, and may be used very economically for simply lifting water. For this purpose pressure is not the ultimate end, but the movement of volume with a comparatively very small quantity of steam; hence in operating the instrument as an ejector, the spindle is projected into the nozzle of the steam-cone until the latter is closed by the valve, in which adjustment it is held. It is evident, then, that the jet of steam is only through the small opening in the spindle, which is very small as compared with the dimensions of the combining and receiving cones, but supplies sufficient steam to produce the necessary vacuum in the instrument to raise water at least twenty feet.

In this operation it is also necessary to adjust the receiving-cone so as to close the valve at its inner end, and make it practically one piece with the combining-cone.

Having thus described my invention, what I claim as new, and desire to secure by Letters Patent, is—

1. In an injector, a combining-cone constructed with dimensions substantially as set forth—that is, the greater diameter four times the smaller, and the length equal to the greater diameter.

2. A short combining-cone of substantially these dimensions—viz., the greater diameter and length equal, and the smaller diameter one fourth the greater, in combination with a steam-cone the jet-opening of which is twice the smaller diameter of the combining-cone, substantially as described.

3. A steam-cone, A, in combination with a combining-cone, B′, and a receiving-cone, C, all constructed with substantially the relative proportions specified, and arranged and operating substantially as set forth.

4. The casing-sections D E, recessed as specified, in combination with the combining-cone disk *b*, fitted to the recesses and held between the section, substantially as described.

5. The inlet-chamber H, with its sides arranged at an angle of forty-five degrees to the axis of the instrument, in combination with the disk *b* and water-pipe F, arranged at the same angle, substantially as described.

6. An adjustable steam-cone, with the face at its jet end inclined at an angle of forty-five degrees, in combination with the combining-cone, having the proportions specified, substantially as described.

7. A steam-cone, A, in combination with a hollow spindle, K, the two having discharge-openings, the relative proportions of which are substantially as set forth, that is—the diameters of the jet-opening of said cone and spindle are as 1 to $\frac{1}{4}$.

8. A steam-cone, A, having its inner face at the jet end inclined at an angle of forty-five degrees, in combination with a spindle, K, provided with a nose, *k′*, of about three-fourths the diameter of the jet-opening in the steam-cone, and a conical enlargement just back of the nozzle, inclined also at an angle of forty-five degrees, substantially as described.

9. A combining-cone, B, in combination with an adjustable receiving-cone, C, and a discharge-pipe, I, the receiving-cone being provided with a seat, and forming a valve at either end with one of the other parts, according to adjustment, substantially as described.

10. The disk *b*, carrying the combining-cone B, in combination with the water-pipe F and overflow-pipe G, arranged adjacent to each other on opposite sides of the disk, and inclined in opposite directions, substantially as described.

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J. M. THACHER.