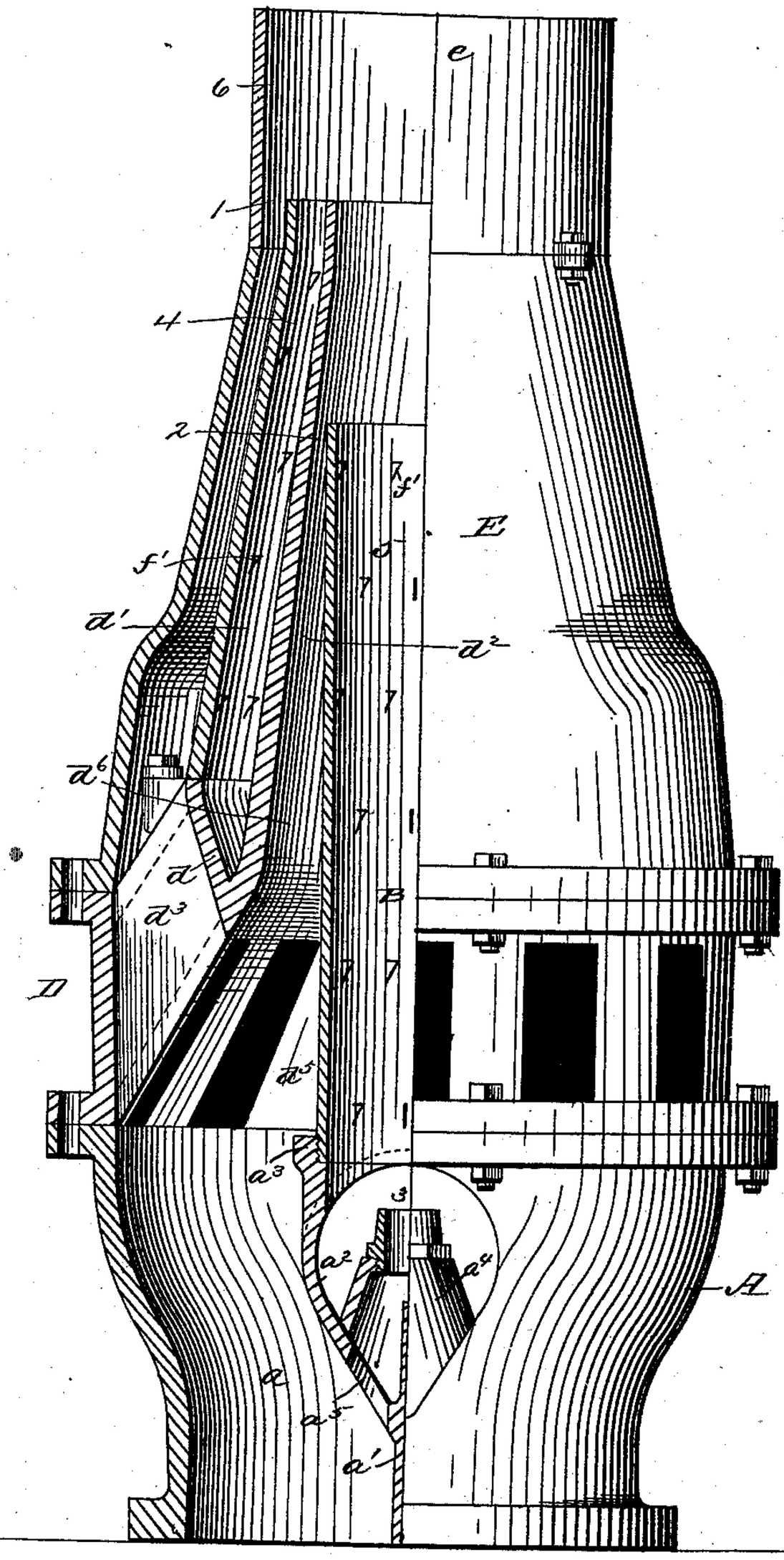
(No Model.) 4 Sheets—Sheet 1.

J. Y. SMITH.

TRIPLE EXPANSION BLAST OR EXHAUST APPARATUS FOR LOCOMOTIVES.

No. 406,483. Patented July 9, 1889.

Fig. 1



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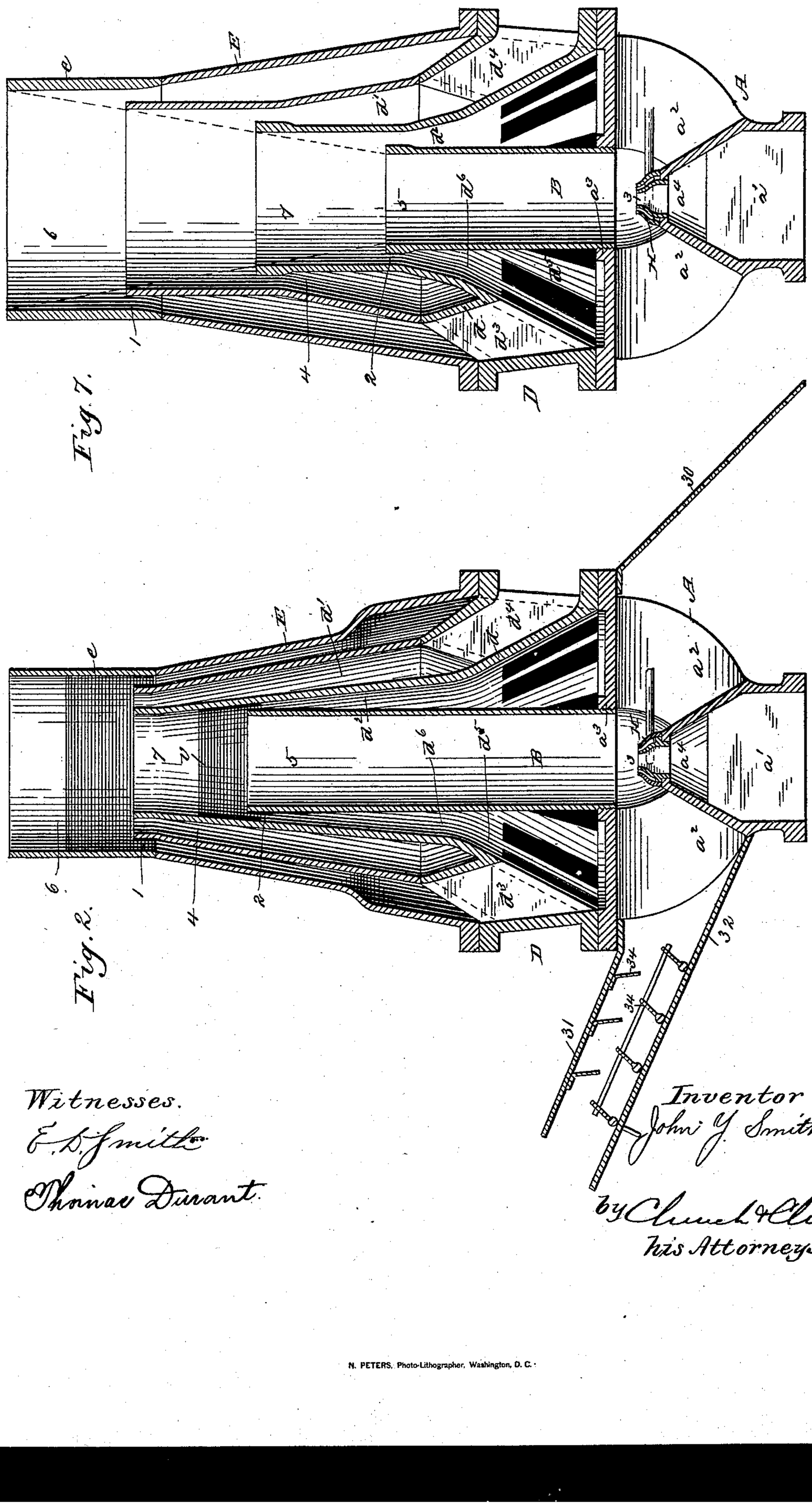

Fig. 1.

Fig. 2.

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Fig. 3.

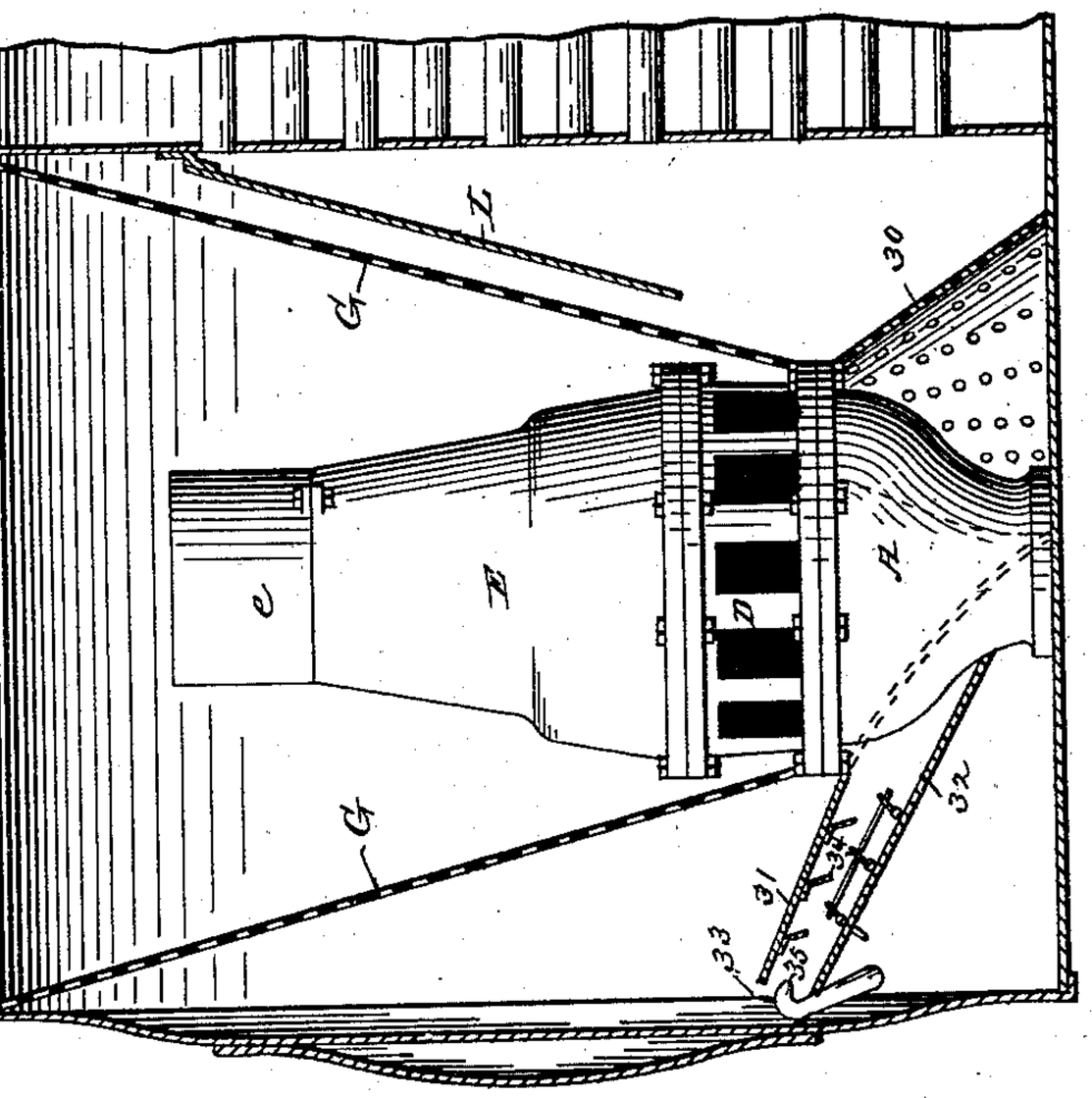
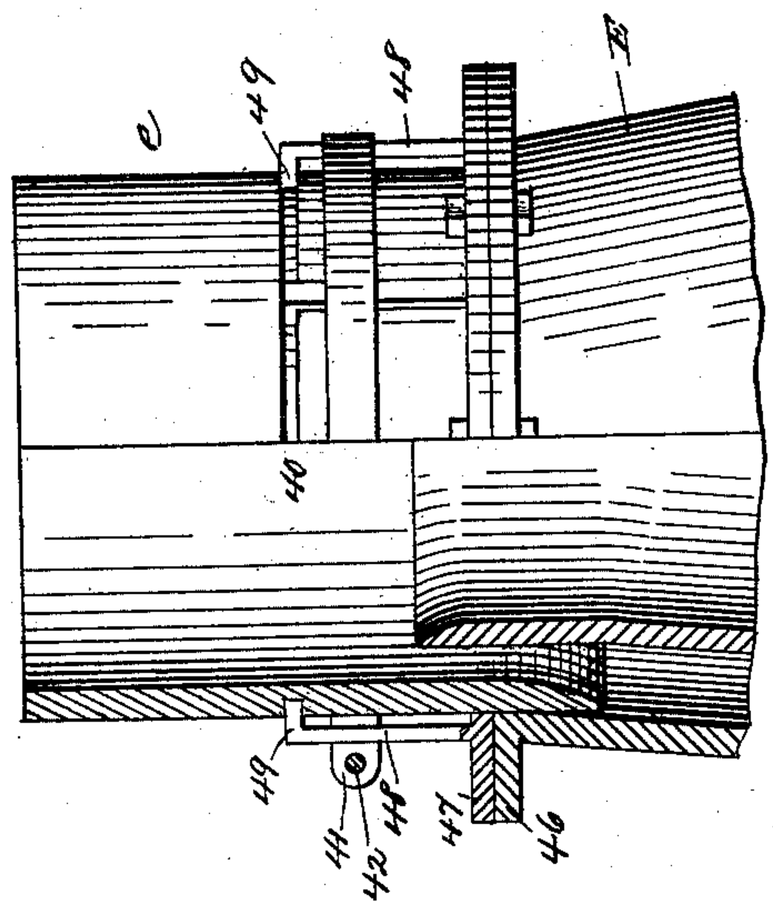


Fig. 8



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(No Model.) 4 Sheets—Sheet 4.

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TRIPLE EXPANSION BLAST OR EXHAUST APPARATUS FOR LOCOMOTIVES.

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Fig. 4.

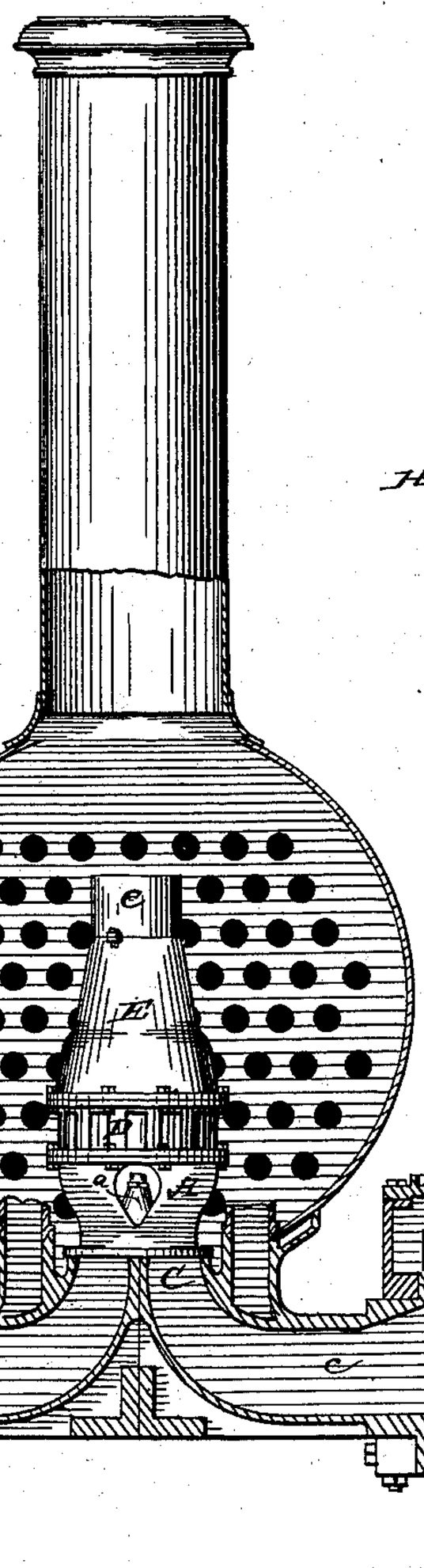


Fig. 5.

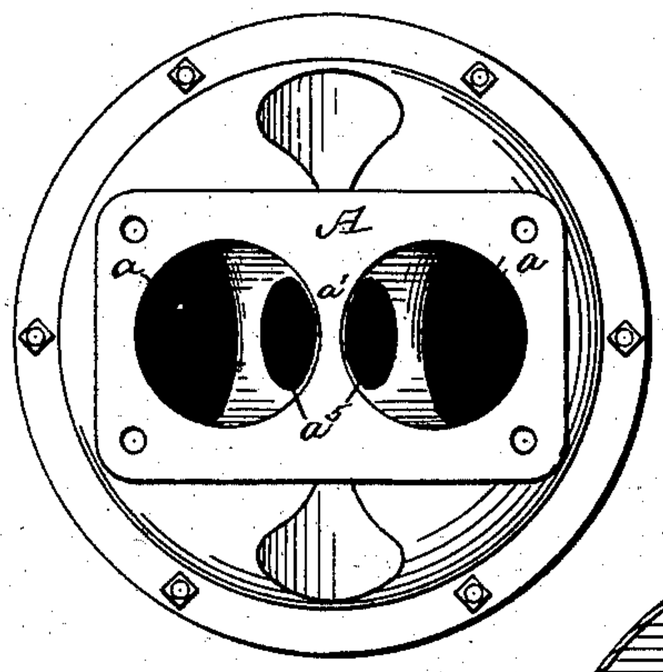
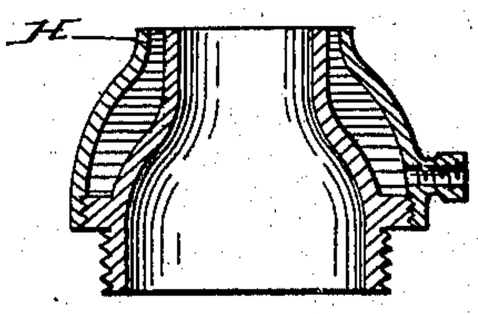


Fig. 6.



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UNITED STATES PATENT OFFICE.

JOHN Y. SMITH, OF DOYLESTOWN, PENNSYLVANIA, ASSIGNOR TO THE SMITH EXHAUST PIPE COMPANY, OF NEW JERSEY.

TRIPLE-EXPANSION BLAST OR EXHAUST APPARATUS FOR LOCOMOTIVES.

SPECIFICATION forming part of Letters Patent No. 406,483, dated July 9, 1889.

Application filed February 9, 1889. Serial No. 299,245. (No model.)

To all whom it may concern:

Be it known that I, JOHN Y. SMITH, of Doylestown, in the county of Bucks and State of Pennsylvania, have invented certain new and useful Improvements in Triple-Expansion Blast or Exhaust Apparatus for Locomotive-Boilers; and I do hereby declare the following to be a full, clear, and exact description of the same, reference being had to the accompanying drawings, forming a part of this specification, and to the figures and letters of reference marked thereon.

This invention relates to a new and improved ejector or blast apparatus designed more especially for use in connection with locomotive and similar boilers and to be operated by the exhaust-steam from the cylinders, but also capable of being operated by steam from other sources; and said invention has for its principal objects to create and maintain a practically uniform and even flow of air through the furnace and flues, to increase the volume of gaseous products discharged in proportion to the volume and pressure of the steam, to reduce back-pressure to a minimum, to diminish or suppress the noise incident to the escape of the exhaust-steam, to keep the smoke-box and flues clear from ashes and cinders by preventing their accumulation therein, to extinguish and prevent the escape of sparks, to regulate the power of the ejector and adapt the latter to special local conditions, and to provide a means whereby the draft can be started and maintained when little or no exhaust-steam is being delivered.

In the accompanying drawings, wherein the preferred form of embodiment of my several improvements is illustrated, Figure 1 is a side view, partly in section, representing the blast apparatus. Fig. 2 is a longitudinal vertical section taken in a plane at right angles to the sectional portion of Fig. 1. Fig. 3 is a sectional view of a portion of the smoke-box, showing the application of blast apparatus and inclosing-shield. Fig. 4 is a transverse vertical section through the front end or smoke-box of a locomotive-boiler with blast apparatus in position. Fig. 5 is a detail view illustrating bottom plate. Fig. 6 is a detail sectional view illustrating application of supplemental steam-nozzle to central jet-pipe. Fig. 7 is a longitudinal sectional view illustrating a modified arrangement of the nozzles. Fig. 8 is a partial sectional view showing the manner of applying the removable end or section of the blast apparatus.

Similar letters of reference in the several figures indicate the same parts.

The improved ejector or blast apparatus represented herein comprises the following principal elements, to which all the other features of improvement are more or less subordinate, viz: three steam-nozzles 1, 2, and 3 in open communication with both exhaust-pipes leading from the cylinders, two air-passages 4 and 5 in open communication with the space surrounding the ejector, and two confining-flues 6 and 7, the one surrounding the nozzle 2 and the other the nozzle 1. The outer nozzle 1 is annular in form and surrounds the eduction end of passage 4 at the base of the confining-flue 6. The inner nozzle 2 is also annular in form and surrounds the eduction end of air-passage 5 at the base of confining-flue 7. The central nozzle 3 is located at the base or induction end of the air-passage 5.

It has been customary heretofore to provide the nozzles of ejectors or blast-pipes with steam-discharge orifices the area of which was considerably less than the area of the exhaust-ports of the cylinders, the purpose being to raise the pressure of the steam at the discharge-orifice, and thereby increase the power or sharpness of the blast. The effect of such an arrangement is to check the flow of exhaust-steam, resulting in the production of more or less back-pressure in the cylinders.

In order to obtain the requisite power and at the same time afford a free passage for the escape of the exhaust-steam, I cause the latter to be distributed through a series of blast-nozzles, the aggregate area of whose discharge-orifices nearly or quite equals the area of the exhaust port or passage, and I arrange the several nozzles so that the inner one 3 shall deliver a jet of steam through the base of the central air-passage 5, the second one 2 shall deliver an annular or tubular jet around the eduction end of passage 5 and into the confining-flue 7, and the outer one 1 shall deliver a tubular jet around the eduction end of passage 4 and into the confining-flue 6.

The nozzles 1 and 2, through which most of the exhaust-steam is discharged, are made annular in form and located outside of but in close proximity to their respective air-passages 4 and 5. This arrangement is adopted in order to increase the area of the discharge-orifices and at the same time present an extended surface of steam to the gaseous matters entering the ejector through the air-passages. By making the discharge-orifices long and narrow the steam is distributed in thin sheets, so that when brought in contact with the highly-heated products of combustion within the ejector it will be superheated and expanded during its passage through the confining-flues.

The eduction end of air-passage 4 is located between the steam-nozzle 1 and the eduction end of confining-flue 7 of the inner ejector, so that gaseous and other matters drawn through said passage will be subjected to the direct action of steam on both sides. The steam-jet from nozzle 1, surrounding the air-passage 4, is prevented from expanding outward by the walls of the confining-flue 6 in advance thereof, so that whatever lateral expansion takes place is toward the column of gaseous matter drawn through passage 4. In like manner the jet from nozzle 2 is restrained from outward expansion and directed against the inflowing column of gaseous matter in passage 5, the two columns—steam and gaseous products—being mingled in the confining-flue 7. The steam from nozzle 2 follows the wall of the confining-flue 7; hence as it emerges from the latter it is brought into contact with the inner surface of the column of gaseous matter issuing from air-passage 4 of the outer ejector. While the products drawn through the outer passage 4 are thus acted upon by steam on both faces, and a thorough incorporation or mixture of the one with the other is effected in the confining-flue 6 prior to their discharge into the smoke-stack, the same action does not always and under all circumstances take place with respect to the gaseous and other matters drawn through the central passage 5 of the inner ejector, inasmuch as the jet of steam issuing from nozzle 2 merely surrounds and envelops the gaseous and other matters flowing through the large central passage 5. Although the steam from nozzle 2 upon entering and while passing through confining-flue 7 is caused to penetrate and mingle with the gaseous and other products drawn through passage 5, nevertheless it will sometimes happen that live coals or sparks will be carried up in the central column of gaseous matter, and, being protected by the latter against the enveloping column of steam, will be permitted to escape through the smoke-stack without being extinguished during their passage through the ejector. To obviate this defective action, increase the flow through the inner ejector and the power of the central current, and assist in breaking up the larger particles, the nozzle 3 is added to the apparatus and arranged to deliver a jet of steam centrally of and within the induction end of the air-passage 5.

The steam issuing from nozzle 3 (which latter is provided with a discharge-orifice of small area as compared with the nozzles 1 and 2) occupies the central portion of the passage 5, so that the gaseous and other matters are drawn up around said jet and between it and the walls of said passage 5. As the steam traverses passage 5 it expands, forcing the gaseous and other products outward, so that as they emerge from the eduction end of said passage and are brought into direct contact with the jet issuing from nozzle 2 they will be confined between two moving currents of steam, the one from nozzle 2 on the outside and the other from nozzle 3 on the inside.

In describing the action of the currents of steam and gaseous matter within the ejector I have, for convenience, characterized them as "tubular," "columnar," &c., referring thereby to the forms given by the orifices from which they issue; but it is of course to be understood that these forms are not preserved during the entire passage through the apparatus. On the contrary, currents in various directions are set up, particularly in the confining-flues, where the various steam-jets are injected and caused to impinge against the gaseous matters flowing through the apparatus. It can readily be seen, however, that with the three steam-nozzles arranged and disposed as described whatever gaseous and other matters are drawn into and expelled from the apparatus will be completely enveloped by the steam during their entire passage through the ejector; but this is not the only action which takes place within the apparatus. The larger and heavier particles passing through the flues of the boiler are drawn toward the induction-passages leading to the central air-passage 5, and are carried into and through the latter. As these particles enter said passage and are brought within the influence of the jet issuing from nozzle 3, they are impelled with considerable force outward against the walls of the passage, and, instead of passing straight out through the ejector, they are driven in a more or less irregular path across the passage, through the steam, and against each other and the surrounding walls, so that before reaching the eduction end of the ejector they will have been pulverized or broken into smaller particles, and at the same time the ignited portions will be almost wholly extinguished.

Thus far I have merely referred to the characteristic features of my improved apparatus, broadly considered, and I will now proceed to describe the special form in which these features have been embodied, practically tested, and applied. The three steam-nozzles 1, 2, and 3 are placed in communication with the exhaust-ports of the cylinders through passages contained or formed in the base-piece

A, upon which the several tubes or partitions forming the several steam and air passages are supported. The base-piece A is formed with the steam-passages a separated at their lower ends by a bridge or division-wall a', while the upper ends of said passages are separated by the walls of a tubular bridge-piece a^2, open at both ends and provided with a central opening or socket a^3 to receive the tube B, the latter forming the walls of air-passage 5.

Within the tubular bridge-piece a^2, and beneath the opening or socket a^3, is formed a hollow projection or tube a^4, preferably conical in shape, and provided with a detachable tip, constituting the nozzle 3. The bridge or division-wall a' is extended vertically into the tube a^4, thus partially dividing the latter into two chambers, which are, however, in open communication above the bridge a', and are connected through ports or openings a^5 with the passages a.

The base A is adapted to be applied to the bridge-piece C of the locomotive, with each passage a in communication with one of the exhaust-pipes c leading from the cylinders, so that as steam is delivered from either cylinder it will enter one of the passages a in base-piece A, a portion of the steam being diverted through port a^5 into one of the chambers in tube a^4 and escaping through nozzle 3, while the larger volume of steam will ascend through the passage a.

The upper wall of the tubular bridge a^2 is rounded on each side of the socket a^3, and the upper ends of passages a are enlarged or widened laterally to afford a free passage for the steam.

Above the base-piece A is secured an intermediate section D, comprising a ring-section d and two vertical extensions or tubes d' d^2. The ring-section d is provided with two series of passages or ports d^3 d^4, the one d^3 extending upward and outward from the steam-space above passages a, and the other extending upward and inward from the exterior of the section to the space or chamber formed between the tubes d' d^2, those tubes being separated to form the air-passage 4. When this intermediate section is applied to the base-piece A, its lower portion forms a continuation or vertical prolongation of the outer wall of the base-piece, thus forming an annular chamber d^5 between the exterior wall and the central tube B, into which chamber the steam-passages a open. The inner tube d^2 surrounds the central tube B, and is extended beyond the eduction end of the latter, its lower end being enlarged to form a steam-passage d^6 to the annular opening between the outer wall of tube B and the inner wall of tube d^2, said annular opening constituting the nozzle 2, while that portion of the tube d^2 extending beyond the mouth of tube B and nozzle 2 forms the confining-flue 7.

The outer tube d' is for greater convenience of manufacture detachably secured to the ring-section d outside of the air-ports d^4 in the latter, and is held removed from the inner tube d^2 to form an air chamber or passage 4, through which the gaseous products are drawn.

The upper tubular section E is for convenience detachably secured to the intermediate section D outside of ports d^3, and is held removed from tube d' to form a steam-passage leading to nozzle 1, which latter is formed by the annular space between the wall of section E and the end of tube d'. The upper end e of section E is made detachable and constitutes the confining-flue 6.

The inner tube or partition d^2 may terminate opposite the end of tube d' to bring the eduction end of air-passage 4 in immediate proximity to the nozzle 1, as shown in Figs. 1 and 2, or it may terminate some distance below the end of the outer tube d', as shown in Fig. 7, and this latter construction is, under certain circumstances, preferable as affording greater clearance for the steam-jets, and at the same time increasing the action of the steam from nozzle 2 upon the air or gaseous products drawn through passage 4, so that a larger proportion of the power of the steam-jet from nozzle 1 can be utilized for propelling the gaseous matters from above and around the eduction end of the ejector into and through the smoke-stack or chimney.

It is very desirable that the steam as well as the gaseous products drawn or impelled through the ejector should have a clear and unobstructed passage through the latter, and that the openings or passages should be as wide and straight as is consistent with effective action. To this end the intermediate section of the ejector is enlarged to furnish wide passages for the steam and gaseous products, while the upper ends of the tubes d' d^2 and the outer section E are contracted to effect the necessary reduction in the area of the steam-nozzles 1 and 2 and the eduction end of passage 4. Under these circumstances and to give a greater amount of clearance to the steam-jets, the upper ends of the tubes d' d^2 and the inner face of the section E are made cylindrical and substantially parallel with the inner wall of air-passage 5 and confining-flue 6. The jet of steam from nozzle 1 and the column of mingled steam and gaseous matter from confining-flue 7 are thus caused to issue from their respective passages in lines substantially parallel with the axis of the ejector, whereby a stronger current is produced through the ejector and interfering counter-currents are prevented.

As has previously been stated, the nozzle 3 aids materially in effecting the destruction and extinguishment of such live coals and sparks as may be drawn into the ejector through the central air-passage 5, and to assist this action a series of pins or projections f' may be attached to the walls of tube B and the passage 4, (either or both,) against which the larger particles will be caused to strike,

so as to be more readily broken into smaller fragments. These pins or projecting points will operate to delay somewhat the passage of the heavier particles, and thus retain them for a longer period surrounded by and subjected to an atmosphere highly charged with steam.

The maximum pulverizing and extinguishing action is exerted upon the particles entering the induction-passages in the tubular bridge-piece a^2, and passing through the central tube B of the ejector, inasmuch as all products drawn through the central air-passage 5 are successively subjected to the action of the several steam-jets issuing from nozzles 1, 2, and 3, the last 3 expanding from the center outward, and the others 1 and 2 from the exterior inward.

The ejector is so arranged with reference to the flues and smoke-box that the induction-passages leading to the central tube B will stand opposite the lower series of flues, while the induction ports or passages d^4, through which the gaseous products enter passage 4, are disposed at a higher level.

In order that the larger particles drawn through the flues shall be compelled to pass through the central air-passage 5 before emerging from the smoke-stack, the upper portion of the ejector is inclosed by a netting or perforated plate G, extending from a point below the upper series of inlet-ports leading to passage 4 to the walls of the smoke box or chamber, so that only such particles as can pass through the meshes or perforations in the guard G will be permitted to enter the smoke-stack either through passage 4 or the space around the eduction end of the ejector, said guard being so arranged as to direct the larger particles toward the base of the ejector. The induction-passages leading to the central air-tube B are, however, open, and as the current is stronger and more concentrated at this point the larger particles are taken up and driven through the ejector.

The removable end *e* of the outer wall or upper section E of the ejector is detachably secured, in order that tubes or sections of different internal dimensions may be readily substituted, and said removable section constitutes an important feature, inasmuch as it furnishes a means whereby the power of the ejector can readily be varied to suit the special conditions under which it is to be used. Thus by the substitution of a larger or smaller section *e* the size of the steam-nozzle can be adjusted so that the area of the escape-orifices will be properly proportioned to the exhaust-ports of the cylinders, and at the same time the area of the confining-flue 6 or eduction end of the ejector will be varied to correspond with the variations made in the steam-nozzle.

Another important and valuable feature of my improved ejector consists in the application within the central air-passage 5 of a supplemental blast-pipe H, preferably annular in form and surrounding the nozzle 3, (to the tip of which it is united by a screw-thread,) connected to and receiving steam direct from the boiler or other source, suitable means—such as a valve—being provided for controlling the admission of steam to said blast-pipe. This supplemental blast-pipe H, which may be of any suitable form and dimensions, is brought into use either alone or in connection with the exhaust from the cylinders and to start or maintain the draft while the locomotive is standing or running with little or no pressure in the cylinders.

When the fire is first started in the furnace, it is desirable that the cooler and heavier air and gases should be drawn from the lower portion of the smoke-box and the lower flues, in order that the whole heating-surface may be exposed to the direct action of the heated products, and the same is true when the engine has been standing for some time with the fire low or banked, as under such circumstances the lower flues and lower section of the smoke-box become charged with heavy gases, which prevent the more highly heated and lighter products of combustion from flowing therethrough. By arranging the supplemental blast-pipe H so that the steam issuing therefrom will be discharged into and caused to traverse the inner tube B of the ejector the heavier air and gases in the lower section of the boiler will be carried out and discharged through the smoke-stack, the ejector preventing too much lateral expansion of the steam and serving to conduct and direct the latter together with the gases carried thereby up through the lighter and more expanded gaseous products of combustion in the upper section of the smoke-box.

It not infrequently happens that it is desirable to increase the draft while running, but when little or no steam is being discharged from the cylinders. This is the case when getting ready to start up with a heavy load and low pressure in the boiler, or when running downgrade just before beginning a steep ascent with little or no steam being delivered to the cylinders and the injector open and forcing cooler water into the boiler. In such cases steam is admitted to the supplemental blast-pipe H, and, acting alone or in conjunction with the exhaust-steam, the steam issuing from said blast-pipe H will operate to maintain a flow of the gaseous products until the supply of the exhaust-steam has been increased sufficiently to work the ejector, when the supply to the supplemental blast-pipe is cut off.

As hereinbefore stated, it is sometimes desirable to arrange the several air and steam nozzles and confining-flues, as illustrated in Fig. 7, so that a line drawn from the inner nozzle 3 to the edge of the outer confining-flue or exit end of the ejector will nearly or just touch each of the intermediate tubes, as shown by the dotted lines in said figure. This is done to afford greater clearance for

the steam and gaseous matters. Thus the steam and gas traversing the central flue, instead of being choked or retarded by the contracted walls of said passage, are permitted a free exit into the next larger flue, the latter also provided with straight walls, and so on through the entire apparatus, the steam and gas expanding from one flue into the next, and flowing therethrough without check or retardation other than such as is incident to the friction upon the walls.

As ordinarily constructed, locomotives are provided with a diaphragm or deflecting-plate, as at L, Fig. 3, against which the solid particles drawn through the flues strike and are deflected toward the bottom of the smoke box or chamber. With a view to preventing these larger and heavier particles from entering the ejector immediately upon leaving the flues and while in a state of active combustion, as when leaving the furnaces, and at the same time to prevent an undue accumulation of coals and cinders in the front of the smoke-box and insuring their entrance into the inner ejector, the following arrangement (illustrated in Fig. 3) has been adopted:

That one of the induction-passages leading to tube B of the inner ejector, which faces the flues, is covered by a perforated hood or plate 30, curved or beveled, so as to form a deflecting-surface for directing the larger particles as drawn through the flues toward the front of the smoke-box. The front end or corner of the smoke-box is provided with an inclined wall or plate 31, joining the ejector at a point above the forward induction-opening leading to the inner ejector and extending downward and rearwardly until it joins the walls of the chamber, thus forming a covering for the induction-opening and an upwardly-inclined wall, against which the heavier particles are driven. Beneath this plate or partition 31 is arranged a second plate 32 with upturned sides or flanges, which, in connection with plate 31, forms a flue or chute, communicating at its front end through an opening 33 with the interior of the smoke-box, and at its rear end opening into the front induction-passage of the inner ejector. As thus arranged, two deflecting plates or surfaces are provided, the one covering the rear induction-passage serving to deflect the heavier particles toward the front of the smoke-box, and the other for deflecting said particles toward the mouth 33 of the chute leading to the front induction-passage, so that the larger particles will be detained for a limited space of time within the smoke-box, but will be compelled eventually to escape through the inner ejector.

In order to further delay the passage of the ignited particles, the chute may be provided with deflecting-plates 34, inclining more or less in the direction of motion of the particles through the chute, and for the purpose of regulating the motion and at the same time provide for readily clearing the chute, should particles lodge therein, one or both series of deflecting-plates 34 may be made movable or adjustable. Thus in the example illustrated the upper series of plates 34 are fixed in position, while those of the lower series, separately hinged or pivoted, are connected together to move in unison, so that they can be adjusted to change their angular position, or shaken to remove particles which may have lodged in the chute.

A jet-pipe 35, supplied with steam from the boiler or other source, may be inserted or located in the upper or front end of the chute, through which a blast of steam can be injected to clear the chute.

To provide for the ready removal and insertion of the outer section *e* the following arrangement may be adopted:

Referring to Fig. 8, *e* represents the detachable section fitted to enter snugly within the mouth of section E, the lower edge being beveled, as shown. Upon section E a flange 46 is formed, to which is bolted or otherwise secured a ring 47, provided with several arms 48, having inwardly-projecting shoulders 49. A groove 40 (or shoulder) is formed on the exterior of the section *e* to receive the shoulder 49 on arms 48, the latter being sprung or forced inward to clasp the removable section *e* by means of a split ring 41, embracing the arms, and provided with a clamping-bolt 42. Other known means may be employed for securing and holding the tip or removable section *e* in position above or within the mouth of section E; but the arrangement of parts shown in Fig. 8 possesses obvious advantages, in that it furnishes a means whereby the section can be quickly removed and replaced.

I do not claim herein the employment of the pins or deflecting-surfaces for solid particles within the ejector, said subject-matter being comprehended in my prior application, Serial No. 285,866, filed September 20, 1888.

Having thus described my invention, what I claim as new is—

1. In a blast or exhaust apparatus such as described, the combination, with an inner and an outer steam-nozzle, of an air-passage adjacent the outer nozzle, an air-passage centrally of the inner nozzle, and a jet pipe or nozzle discharging into the induction end of the central air-passage, substantially as described.

2. In a blast or exhaust apparatus such as described, the combination, with steam-nozzles 1 and 2, air-passages 4 and 5, and a steam-chamber common to the said nozzles and communicating through separate passages with the cylinders, of a steam-nozzle or jet-pipe 3 in open communication with both passages leading to the cylinders, as and for the purpose set forth.

3. In a blast or exhaust apparatus such as described, the combination, with the outer annular steam-nozzle, its confining-flue and air-passage, the inner annular steam-nozzle, its confining-flue and central air-passage, and

the jet-pipe or steam-nozzle located at or near the induction end of the said central air-passage, of a chamber or passage communicating with the three steam-nozzles and the cylinders, substantially as described.

4. The combination, in a blast or exhaust apparatus such as described, comprising inner and outer ejectors having separate air-passages and inlet-ports located at different levels, and a perforated screen inclosing or covering the upper series of air-inlets, substantially as described.

5. The combination, with the smoke-box flues and smoke-stack, of an exhaust or blast apparatus such as described provided with inner and outer steam-nozzles and separate air-passages opening into the smoke-box at different levels, a jet-pipe or steam-nozzle delivering into the induction end of the lower air-passage, and a screen inclosing the upper air-inlets and the inlet to the smoke-stack, as and for the purpose set forth.

6. In a blast or exhaust apparatus such as described, comprising inner and outer ejectors, the combination, with the walls or tubes forming the steam and air passages, of the removable tubular section forming the confining-chamber and outer wall of the outer steam-nozzle, and the eduction-orifice of the apparatus, substantially as described.

7. In a blast or exhaust apparatus such as described, the combination, with the central air-passage communicating through a transverse tubular bridge with the lower portion of the smoke-box, of a supplemental steam-nozzle discharging into the induction end of said central passage and connected with the boiler, substantially as and for the purpose set forth.

8. In combination with a blast or exhaust apparatus such as described, containing a central air-passage, an annular steam-nozzle surrounding said passage, and a central jet-pipe or steam-nozzle discharging into said air-passage, and passages connecting said annular and central nozzles with the exhaust-ports of the cylinders, a supplemental blast pipe or nozzle surrounding the central nozzle and discharging into the central air-passage, said supplemental blast-pipe being in communication with a constant steam-supply, as and for the purpose set forth.

9. In a blast or exhaust apparatus such as described, the combination, with the central air-passage and annular steam-nozzle surrounding said air-passage, of a confining-flue located in advance of the steam-nozzle and provided with parallel walls at its eduction end, substantially as and for the purpose set forth.

10. The combination, in a blast or exhaust apparatus such as described, and with an inner ejector consisting of a steam-nozzle, air-passage, and confining-flue, of an outer ejector, including air-passage, steam-nozzle, and confining-flue, the walls of said nozzle and flue being formed parallel, substantially as and for the purpose set forth.

11. In a blast or exhaust apparatus such as described, the combination, with the inner ejector whose confining-flue is provided at its eduction end with cylindrical walls, of an outer ejector provided with cylindrical steam and air nozzles located in advance of the confining-flue of the inner ejector, and a cylindrical confining-flue common to the two ejectors, as and for the purpose set forth.

12. In a blast apparatus such as described, the combination, with the hollow base-piece provided with a partition and a transverse tubular bridge-piece containing the induction-passages and a port or opening into the air-passage of the ejector, a hollow projection or tube located within said tubular bridge and provided with a steam-nozzle or escape-orifice discharging into the ejector, said hollow projection containing a division-wall, separating it into two chambers, each of the latter communicating with one of the steam-passages in the base-piece and with the steam-nozzle, as and for the purpose set forth.

13. In a blast or exhaust apparatus such as described, the combination, with the hollow piece containing steam-passages and a tubular bridge, a tube forming an air-passage mounted upon and communicating with the interior of the tubular bridge, an intermediate section containing a steam-chamber surrounding the central air passage or tube and communicating with the steam-passages in the base-piece, and two series of reversely-inclined ports, the one for air and the other for steam, of two tubular walls separated from each other and the inner air-tube to form air and steam passages, and an outer tube arranged above the intermediate section and provided with a detachable eduction end, substantially as and for the purpose set forth.

14. The combination, to form a blast or exhaust apparatus such as described, of the base A, formed or provided with steam-passages a, a tubular bridge a^2, and nozzle 3, a tube B, applied to an opening in bridge a^2 above and in line with nozzle 3, intermediate section D, containing a steam chamber or space, two series of ports or passages d^3 d^4, and tubes d' d^2, and an upper section E, the whole arranged for conjoint action, substantially as set forth.

15. The combination, in a blast or exhaust apparatus such as described, of a base formed or provided with two steam-passages a and a steam nozzle or orifice 3, communicating with both of said passages, a central air-passage 5 in line with nozzle 3 and provided with inlet-openings near the base of the apparatus, a steam-chamber surrounding passage 5 and communicating with passage a, two steam-passages communicating with said steam-chamber and terminating the one in nozzle 2 and the other in nozzle 1, an air-passage 4, with its eduction end between nozzles 1 and 2, a confining-flue 7 in advance of nozzle 2 and the discharge end of passage 5, and a confining-flue 6 in advance of nozzle 1 and

the discharge end of flue 7, as and for the purpose set forth.

16. In a blast or exhaust apparatus such as described, containing steam-nozzles 1 and 2, an intermediate air-passage 4, and a steam-chamber from which steam is supplied to both said nozzles, the combination, with the walls forming the air-passage 4 and the steam-passage leading to nozzle 1, of a ring-section, such as D, containing two series of reversely-inclined ports or passages, the one leading from the steam-chamber to the steam-passage of nozzle 1 and the other from the exterior of the apparatus to the air-passage 4, substantially as and for the purpose set forth.

17. In an exhaust or blast apparatus such as described, the combination, with the outer casing E and removable section *e*, of the arms 48, provided with shoulders engaging a groove or shoulders on section *e*, and a clamp for confining said arms, substantially as described.

18. In a blast or exhaust apparatus for locomotives, the combination, with the boiler, its flues and smoke-box, and the ejector located within the smoke-box, of a perforated hood or deflecting-plate extending upward and forward from the bottom of the smoke-box and covering the rear induction-passage, substantially as described.

19. In a blast or exhaust apparatus for locomotives, the combination, with the boiler, its flues and smoke-box, and the ejector located within the smoke-box, of an inclined plate arranged in the front of the smoke-box and covering the front induction-passage of the ejector, and a chute or inclosed passage communicating with said induction-passage, and provided with an opening near the upper end of the inclined plate to receive the ashes, cinders, &c., substantially as and for the purpose specified.

20. In an exhaust or blast apparatus for locomotives, and in combination with the smoke-box and the ejector located therein and discharging into the smoke-stack, a perforated deflecting-plate covering the rear induction-passage, an inclined plate covering the front induction-passage, and a chute or conduit leading from the front induction-passage to and opening through the inclined plate, substantially as described.

21. In an exhaust or blast apparatus such as described, the combination of the ejector located within the smoke-box, a partition above the induction-passage of the ejector, and a chute or chamber communicating with the forward portion of the smoke-box and said induction-passage, and provided with deflecting-plates to retard the passage of cinders, &c., substantially as and for the purpose set forth.

22. In a blast or exhaust apparatus such as described, the combination of the ejector located within the smoke-box, a chamber or chute communicating with the induction-passage of the ejector, a deflecting-plate provided with an opening for the escape of cinders, &c., into said chamber or chute, and a series of hinged or pivoted deflecting-plates projected within the said chamber or chute and connected together, substantially as described.

23. In an exhaust or blast apparatus for locomotives, the combination, with the boiler, its flues, smoke-box, and smoke-stack, and an ejector provided with two or more sets of induction-passages at different levels, of a perforated guard surrounding the upper set of induction-passages, a perforated deflecting plate or guard covering the rear induction-aperture of the lower set of passages, an inclined plate covering the front induction-aperture of the lower passages, and a chute or chamber communicating with said front induction-opening, said inclined plate being provided with an opening or passage for the admission of cinders, &c., into the said chute or chamber, whence they are conducted to the induction-passage of the ejector, substantially as set forth.

24. In an exhaust or blast apparatus such as described, the combination, with the central air passage or flue and central jet-pipe, of an annular steam-nozzle surrounding the central air-passage, an uncontracted flue into which the said steam-nozzle and air-passage open, and an annular air-nozzle surrounding the eduction end of said uncontracted flue and delivering into a second uncontracted flue or passage whose eduction end is surrounded by an annular steam-nozzle, the latter delivering steam through a confining chamber or flue whose inner walls are straight, whereby choking or undue retardation of air or gas and steam within the ejector is prevented, substantially as described.

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