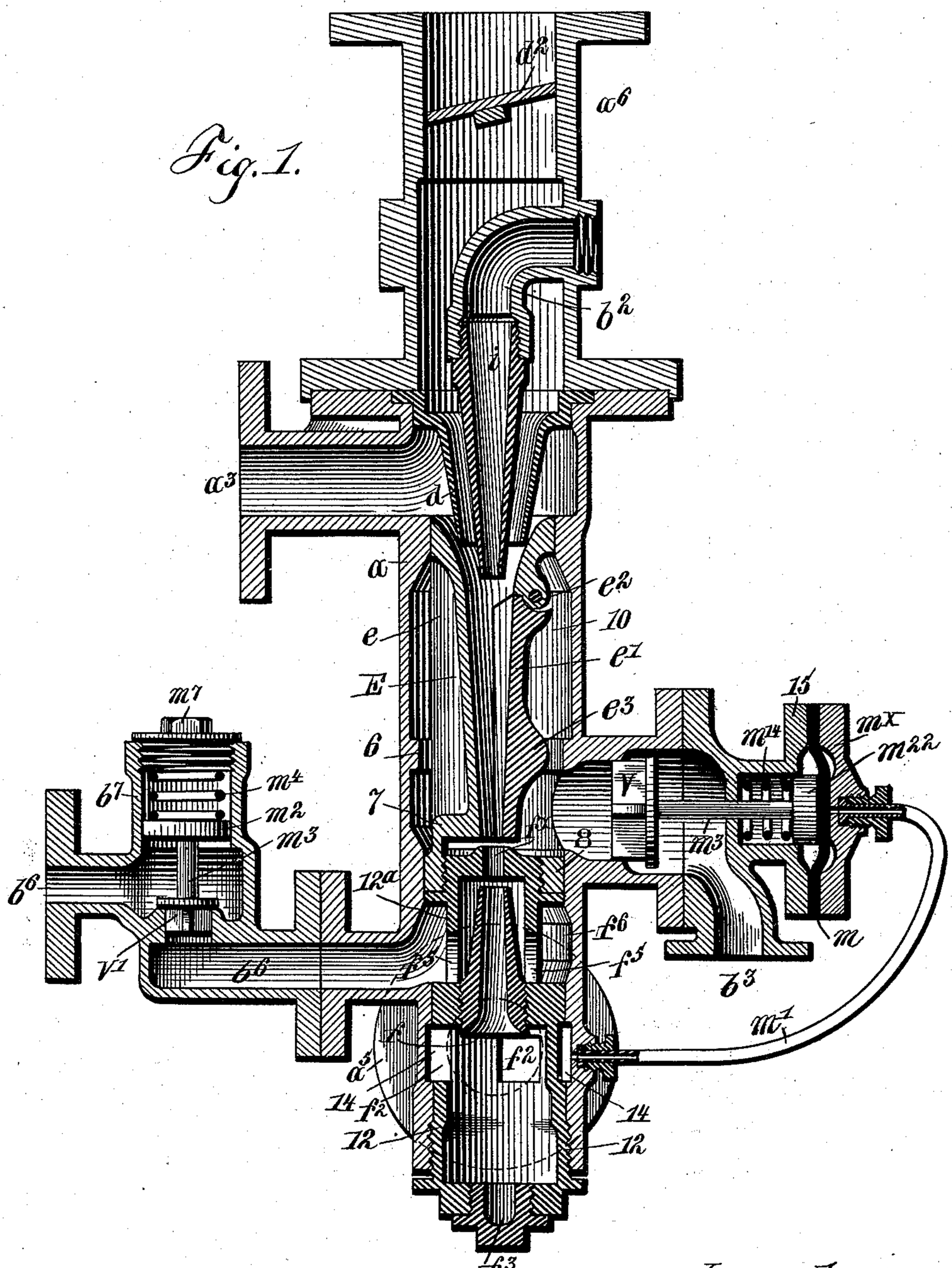
(Model.) 6 Sheets—Sheet 1.

E. DAVIES & J. METCALFE.

INJECTOR.

No. 535,358. Patented Mar. 12, 1895.

Fig. 1.



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(Model.) 6 Sheets—Sheet 2.

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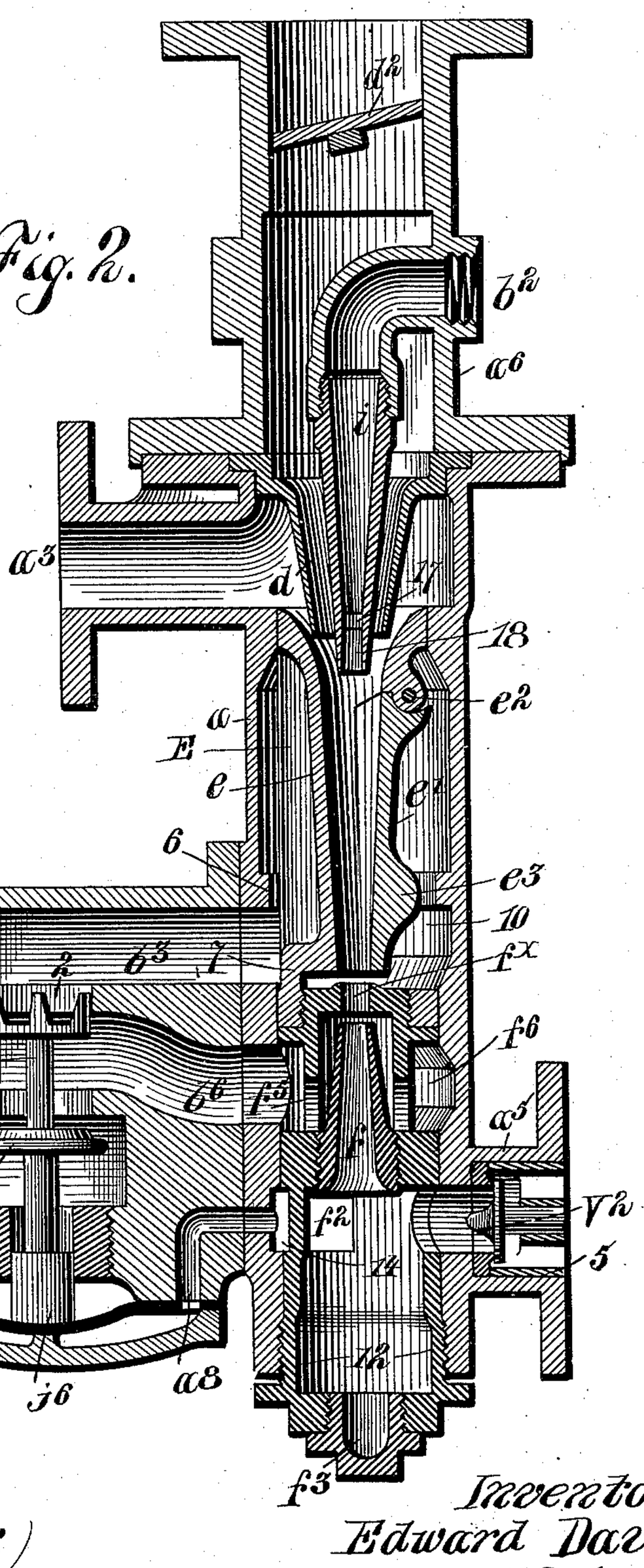
INJECTOR.

No. 535,358. Patented Mar. 12, 1895.

Fig. 2.



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(Model.) 6 Sheets—Sheet 3.

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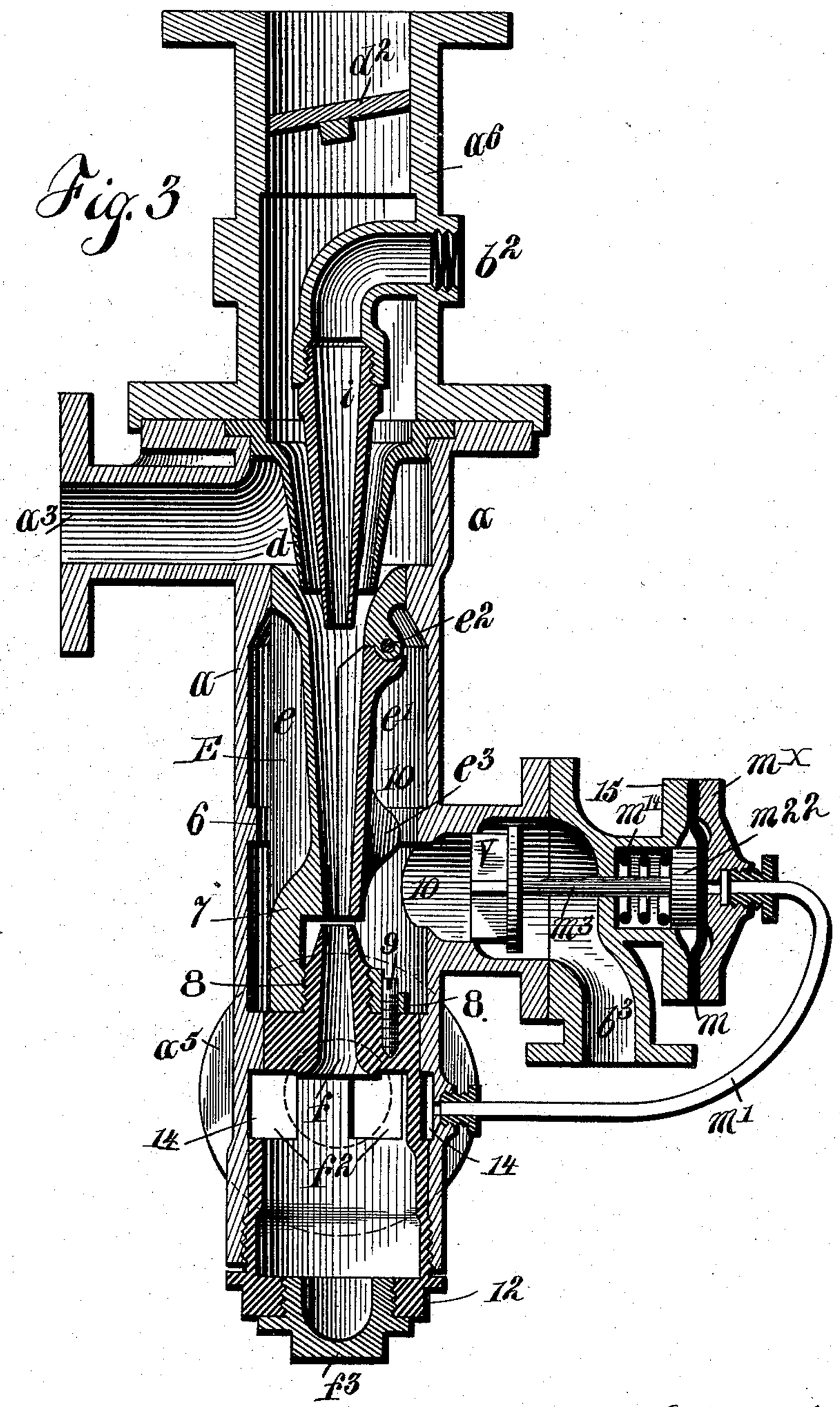
INJECTOR.

No. 535,358. Patented Mar. 12, 1895.

Fig. 3



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(Model.) 6 Sheets—Sheet 4.

E. DAVIES & J. METCALFE.

INJECTOR.

No. 535,358. Patented Mar. 12, 1895.

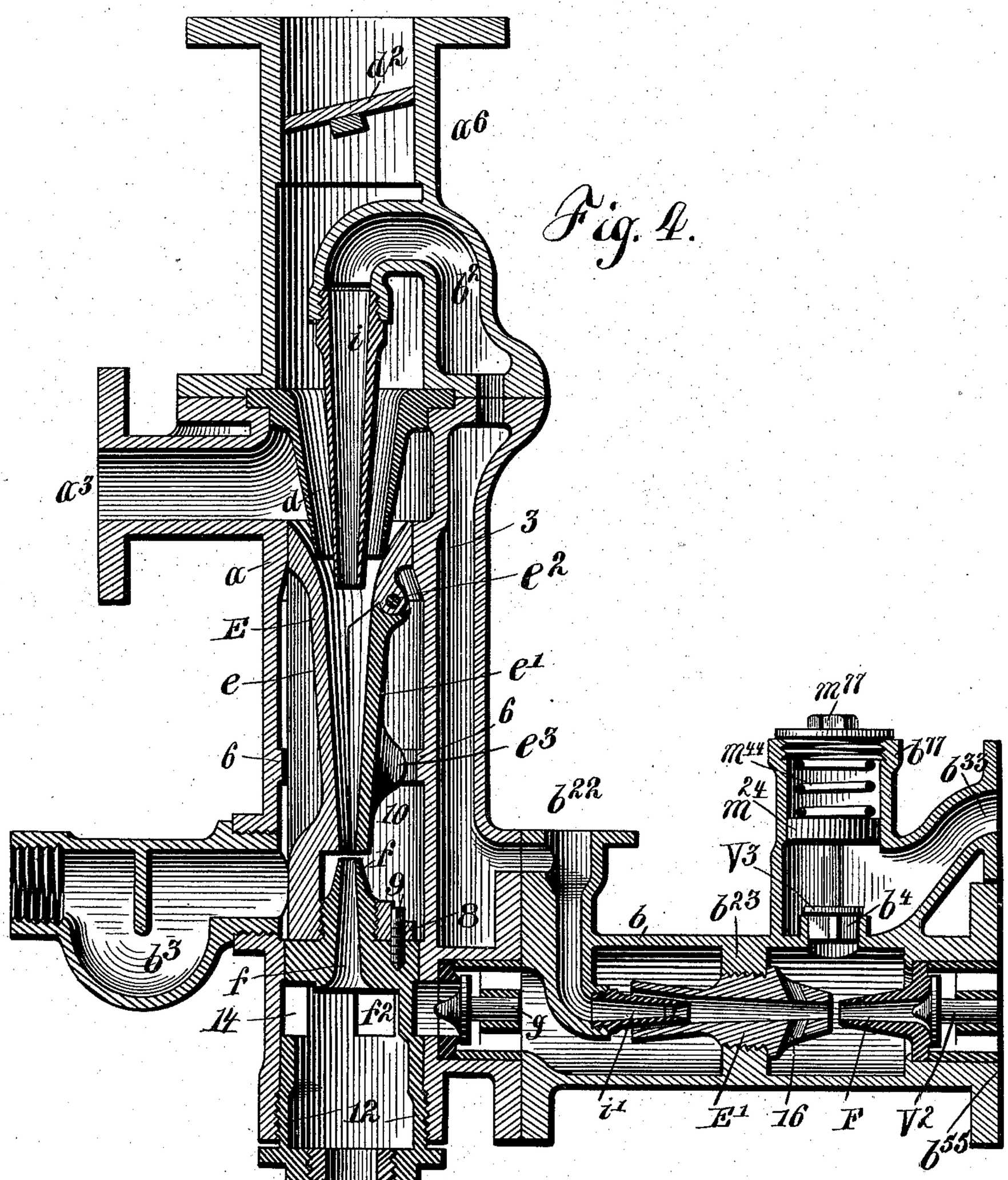

Fig. 4.

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(Model.) 6 Sheets—Sheet 5.

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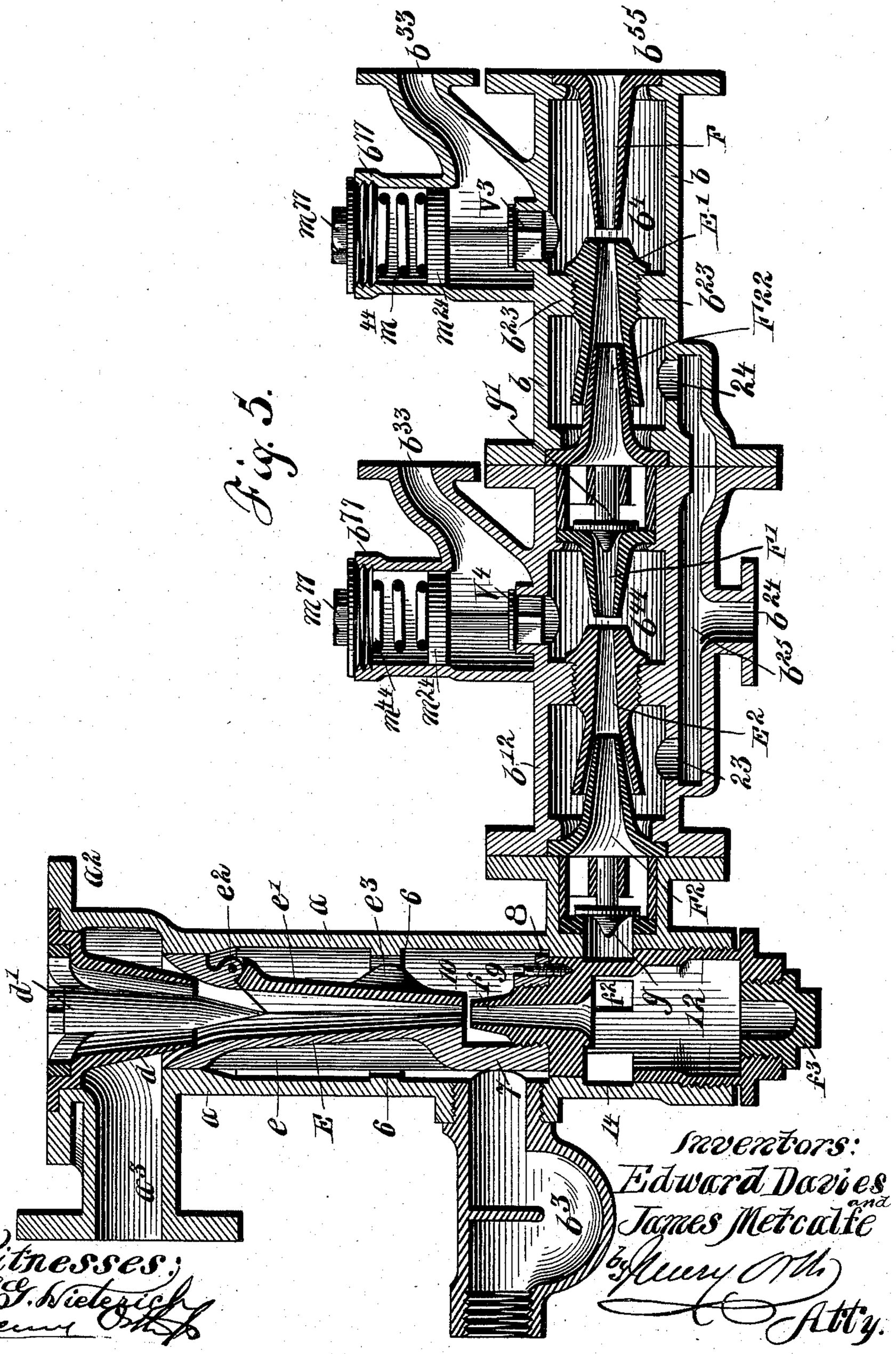
INJECTOR.

No. 535,358. Patented Mar. 12, 1895.

Fig. 5.



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(Model.) 6 Sheets—Sheet 6.

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INJECTOR.

No. 535,358. Patented Mar. 12, 1895.

Fig. 6.

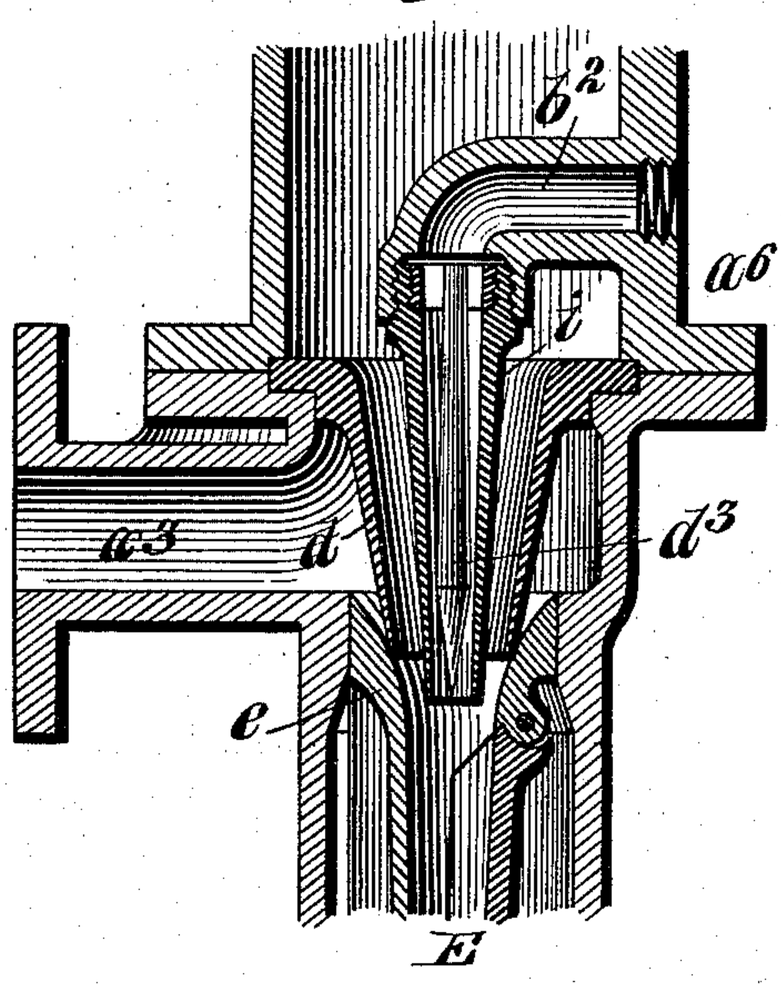


Fig. 7.

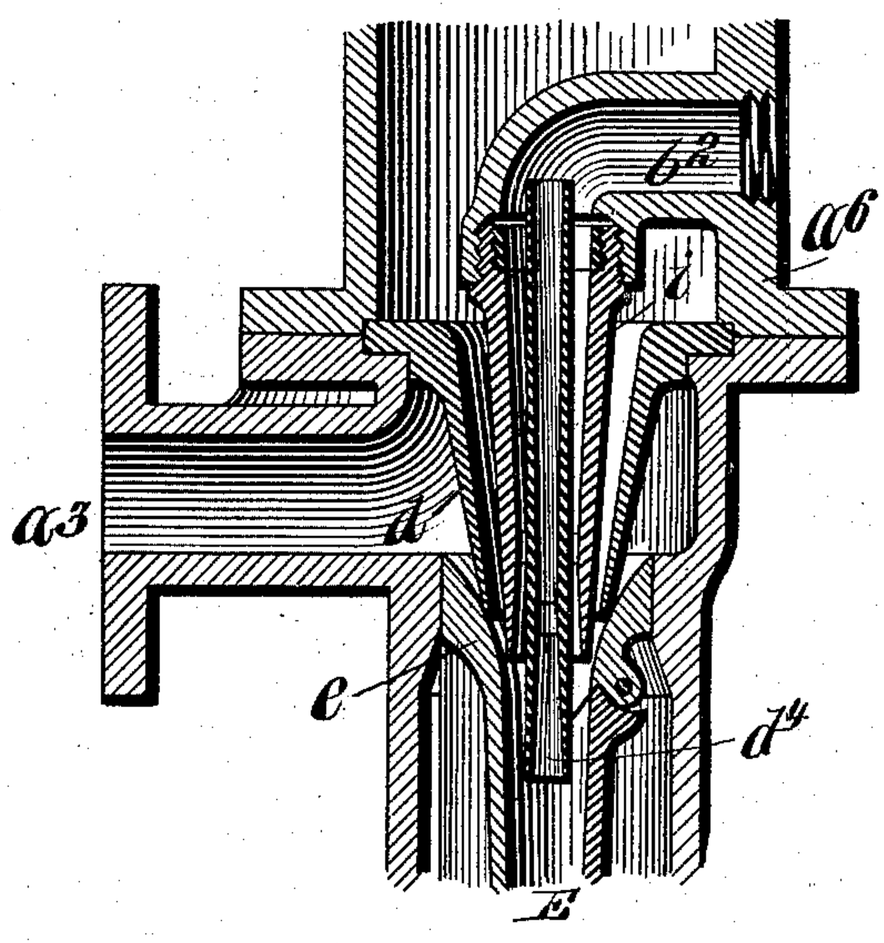


Fig. 8.

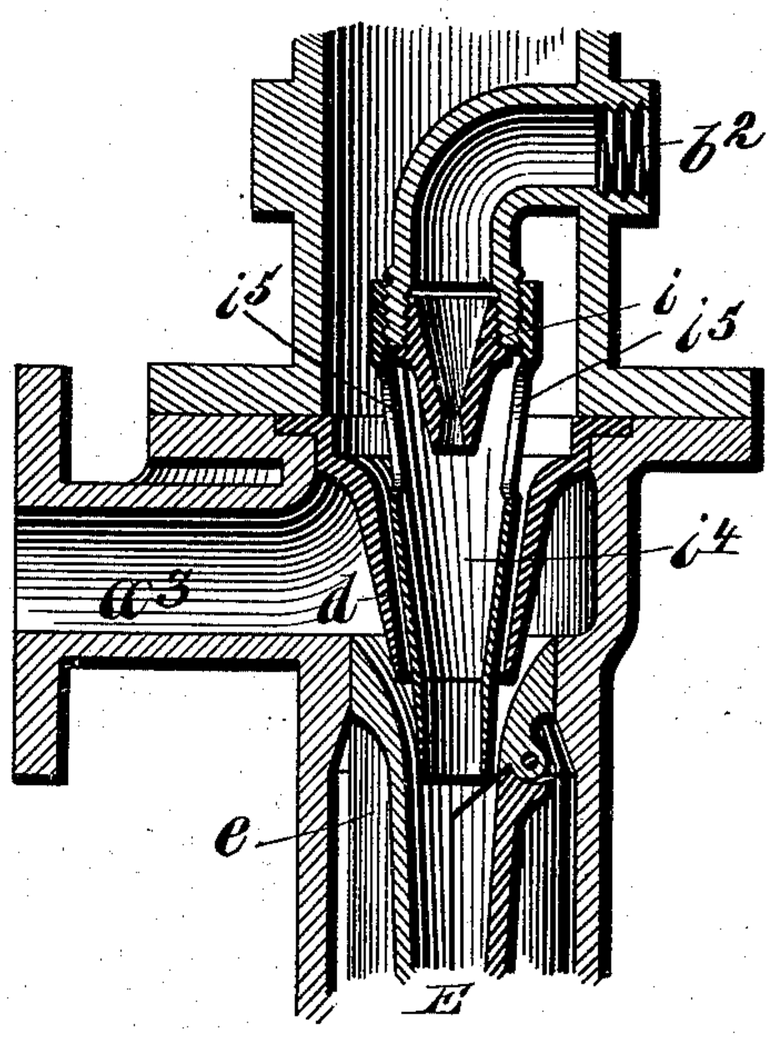
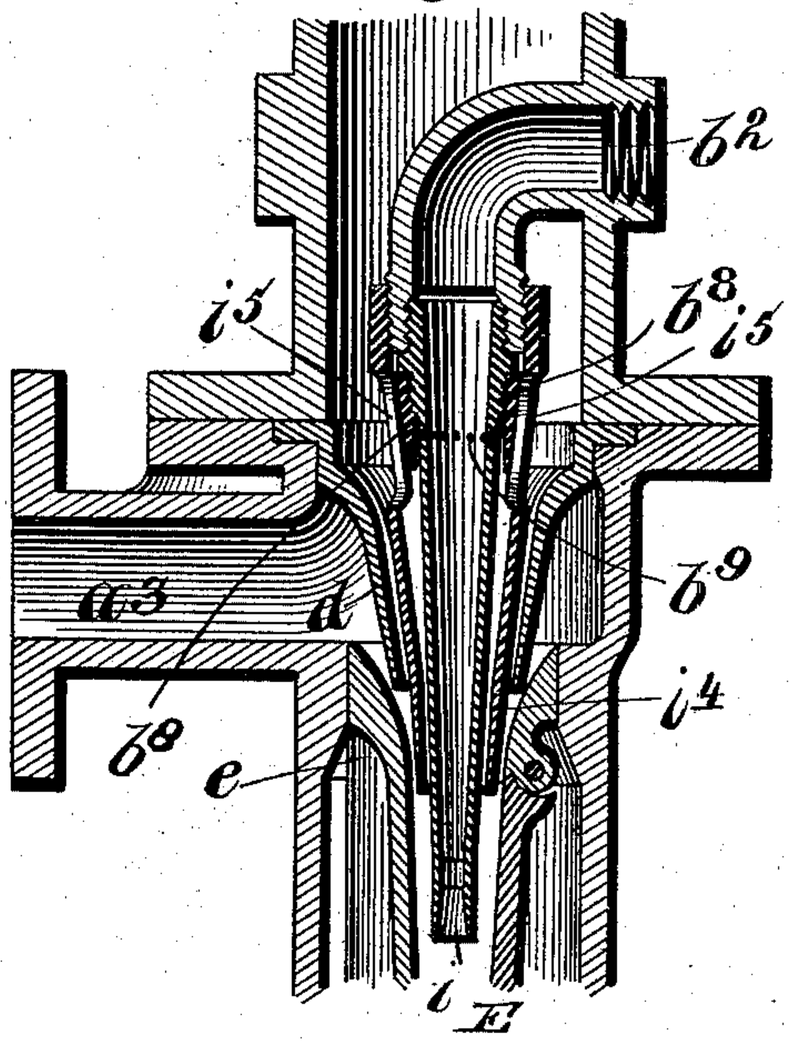


Fig. 9.



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James Metcalfe.
By Henry Orth
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UNITED STATES PATENT OFFICE.

EDWARD DAVIES, OF LLANDINAM, AND JAMES METCALFE, OF ABERYSTWITH, ASSIGNORS TO THE PATENT EXHAUST STEAM INJECTOR COMPANY, LIMITED, OF MANCHESTER, ENGLAND.

INJECTOR.

SPECIFICATION forming part of Letters Patent No. 535,358, dated March 12, 1895.

Application filed January 31, 1894. Serial No. 498,653. (Model.) Patented in England April 20, 1887, No. 5,730; in France December 31, 1887, No. 187,911, and March 30, 1888, No. 189,692; in Belgium January 3, 1888, No. 80,151, and March 31, 1888, No. 81,249; in Italy April 2, 1888, XLVI, 99; in Germany April 4, 1888, No. 46,517; in Victoria April 30, 1888, No. 5,796; in New South Wales May 4, 1888, No. 665; in Queensland May 15, 1888, No. 484; in Spain July 13, 1888, No. 8,147, and in Austria-Hungary August 7, 1888, No. 14,320, 38/2,017, and No. 31,378, XXII, 1,920.

To all whom it may concern:

Be it known that we, EDWARD DAVIES, of Plas Dinam, Llandinam, in the county of Montgomery, and JAMES METCALFE, of No. 28 North Parade, Aberystwith, in the county of Cardigan, England, have invented certain new and useful Improvements in Injectors; (for which we have obtained Letters Patent in Great Britain, No. 5,730, dated April 20, 1887; in France, No. 187,911, dated December 31, 1887, and No. 189,692, dated March 30, 1888; in Belgium, No. 80,151, dated January 3, 1888, and No. 81,249, dated March 31, 1888; in Italy, No. 99, Vol. XLVI, dated April 2, 1888; in Germany, No. 46,517, dated April 4, 1888; in Victoria, No. 5,796, dated April 30, 1888; in New South Wales, No. 665, dated May 4, 1888; in Queensland, No. 484, dated May 15, 1888; in Spain, No. 8,147, dated July 13, 1888, and in Austria-Hungary, dated August 7, 1888—Austria, No. 14,320, 38/2,017, and Hungary, No. 31,378, XXII/1,920;) and we do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same, reference being had to the accompanying drawings, and to letters and figures of reference marked thereon, which form a part of this specification.

Our invention has relation to injectors, and more especially to injectors known as compound injectors, adapted to be operated by low pressure and by high pressure steam, or either.

By low pressure injector, we mean one that imparts velocity to a fluid, as water, for feeding a boiler or for other purposes, by means of steam at or near atmospheric pressure, such as exhaust steam from an engine, or high pressure steam purposely wire drawn. By high pressure injector, we mean one that imparts velocity to a fluid, as water, for feeding a boiler or for other purposes, by means of boiler steam or steam at a high pressure for the purpose of increasing the velocity of a jet of fluid produced by low pressure or exhaust steam, or by both low pressure or exhaust steam and high pressure or live steam.

It is well known that boilers working under a pressure much above seventy-five pounds per square inch cannot be fed by an injector worked with low pressure or exhaust steam. Such an injector is therefore not available for feeding locomotive boilers, and to make such injectors available provision has been made for the use of high pressure or live steam in conjunction with the low pressure or exhaust steam, provision having also been made whereby said injectors are made to work automatically.

Our invention has for its object certain improvements in this class of automatically operating injectors, and more particularly in the arrangement and the means for controlling the overflow valves of the high pressure or live steam injector, or of both the latter and the low pressure or exhaust steam injector.

Our invention has for its further object the provision of means whereby the velocity and consequently the penetrating power of a jet of fluid may be still further increased by admitting live steam at different points to the passage through which the jet of fluid produced by low pressure or exhaust steam or by the latter and live steam, is propelled.

Our invention has for its further object an improved construction of live steam nozzle or cone, when such a cone is combined with a low pressure or exhaust steam cone.

Our invention has for its further object the provision of means whereby the overflow valves for both low pressure and high pressure injectors are controlled by the pressure arising from a jet of fluid produced by low pressure or by low and high pressure steam to close the overflow passage; but that our invention may be fully understood we will describe the same in detail, reference being had to the accompanying drawings, in which—

Figure 1 is an axial section of an injector, embodying some of our improvements. Figs. 2 and 3 are similar views illustrating modifications in the means for controlling the overflow. Fig. 4 is an axial section illustrating a plurality of live steam injectors combined with an exhaust steam injector. Fig. 5 is a like view of an injector similar to that shown in Fig. 4 illustrating a different arrangement of the live steam injectors relatively to the exhaust steam injector, and Figs. 6, 7, 8, and 9 are sectional details illustrating modifications in the construction of the live steam cone when combined with the exhaust steam cone.

Referring more particularly to Fig. 1, *a* indicates the exhaust steam injector casing; a^3, the water branch; b^3 and b^6, the overflow branches; *d*, the exhaust steam cone; E, the combining cone, and *f* the receiving and discharging cone.

To the receiving end of casing *a* is secured the live steam injector casing a^6 adapted to be secured to the source of exhaust steam supply, a suitable valve, as a throttle valve d^2 being provided for controlling the passage of the exhaust steam. In casing a^6 is formed a live steam passage b^2 whose outlet lies in the axial plane of said casing and of the exhaust steam injector, said outlet being screw-threaded interiorly for the reception of the live steam nozzle or cone *i* that projects through said exhaust steam nozzle *d* into the combining cone E. The last named cone is what we term an expansion cone of the same construction as that shown in Letters Patent of the United States No. 240,101, of April 12, 1881, (granted to Edward Davies, one of the parties hereto.)

The object of using an expansible or two-part combining cone is to facilitate the starting of the injector allowing a free passage of the fluid into the overflow chamber and out through the overflow branch. In said Fig. 1, *e* indicates the fixed part of the combining cone, *e'* the movable part hinged to said fixed part at e^2, and at e^3 is a boss or projection on said movable part *e'* by means of which and an annular abutment 6 formed on casing *a* the lateral movement of said movable part *e'* of cone E, and consequently the degree of expansion of its steam passage is limited.

The receiving and discharging cone *f*, as shown, is screwed into a casing 12 or formed integral therewith, said casing being provided with a tubular extension 12^a having formed in its end a supplementary short receiving nozzle $f^\times$, and being provided with overflow ports f^5 communicating with an overflow chamber f^6 encompassing said tubular extension, there being an overflow space or gap between the intermediate short receiving and discharging nozzle or cone $f^\times$ and the receiving and discharging nozzle *f*, proper.

The casing 12 is screwed into casing *a* and has an opening in its outer end normally closed by a screw-plug f^3, by means of which access may be had to the cones for inspection or for removal of obstructions. By connecting casing 12 detachably with the exhaust injector casing *a*, the combining and discharging cones together with the intermediate short receiving and discharging cone $f^\times$ can be bodily removed, and also adjusted within certain limits relatively to the exhaust and live steam cones, the two-part combining cone E being provided with an arm 7 that terminates in an interiorly screw-threaded ring bearing 8 into which the extension 12^a of casing 12 is screwed. The casing 12 has ports f^2 leading into a delivery chamber 14 formed in casing *a* about said casing 12 below cone *f*, and said chamber has a delivery branch a^5 for connection with a steam boiler, for instance. The overflow from chamer f^6 passes into and out of an overflow branch b^6 in which is formed a valve port and seat for a loaded valve V' guided in its movements in a tubular branch b^7 of the overflow branch b^6, said branch b^7 being closed by means of a screw plug m^7. The load for the valve consists of a spring m^4 having bearing on a piston or circular head m^2 on the stem m^3 of valve V' and on the aforesaid plug m^7. There is also an overflow gap or space between the combining cone E and the intermediate short receiving and discharging cone $f^\times$, the overflow passing into an overflow chamber 10 and thence to overflow branch b^3. In this branch is also formed a valve port and seat for a valve V, held normally open by means of a spring m^{14}, and the stem m^3 of said valve also has a piston or circular head m^{22} that works in a piston cylinder 15, which also contains the spring m^{14}. Between said cylinder and its head $m^\times$ is secured a diaphragm *m*, and in said cylinder head is formed a passage leading to the back of the said diaphragm, said passage being connected with the delivery chamber 14 by a suitable passage or pipe *m'*.

In starting the injector either by exhaust steam or by exhaust and live steam, the two overflow chambers are in communication through the short intermediate receiving cone $f^\times$, such fluid as flows over into chamber 10 passing freely out of overflow branches b^3 and b^6, valve V in overflow branch b^3 being open under the action of its spring, while the pressure of the overflow causes valve V' to open also, said valves remaining open until the jet is established, when the pressure in branch b^6 will be reduced below that exerted upon valve V' by the load or spring m^4, whereby said valve will close. At the same time, pressure arising from the jet of fluid produced by exhaust steam or by combined exhaust and live steam in the delivery chamber 14 will also be exerted through pipe *m'* upon the diaphragm *m*, and through the latter upon the valve piston, causing valve V to close, the jet being first established in the expansible cone. The valve V' then closes, and lastly the valve V, when the jet will be fully established. It is obvious that so long as there is a supply of water and steam the injector will continue to

work, or it will automatically re-start, should the jet be interrupted.

The spring m^4 may under some conditions be dispensed with while the spring m^{14} can be dispensed with, since it will require but a comparatively small pressure to move the valve off its seat, especially as it is not necessary that the valve piston m^{22} should fit fluid tight in its piston cylinder.

The mode of controlling the overflow as described in reference to Fig. 1 may be modified with a view to simplifying the construction of the injector, by controlling both valves V and V′ by pressure arising from a jet of fluid produced by exhaust steam, or by combined exhaust and live steam. Such an injector we have shown in Fig. 2, in which the overflow branches b^3 and b^6 are formed or arranged on the same side of casing a, the branch b^3 communicating with branch b^6 through a valve port 2 controlled by valve V, and said branch b^6 having also a valve port and seat for its valve V′ intermediate of its inlet and discharge. Both valves V and V′ are mounted on the same stem j^3 that is provided with a piston head j^6 working in a piston cylinder 15. The valve V is a cylindrical valve and has wings j^4 that guide the same, while the valve V′ is slightly conical so as to gradually close its port. It will be seen that the valves are normally open, or that they will readily open under the pressure of the overflow, but whenever the pressure in the delivery chamber becomes greater than the overflow pressure, or when the jet is fully established, at which time the pressure in overflow chambers 10 and f^6 is practically *nil*, the pressure arising from said jets will be exerted upon the diaphragm m, the fluid passing to the back thereof through a passage a^8 formed in casing a, instead of passing through a pipe, as in the construction shown in Figs. 1 and 3, said pressare being exerted through the diaphragm upon the piston head or stem j^3 of the valves V′, V, causing the same to close their respective ports. The valves V and V′ are so arranged that the former valve will close first and then the valve V′, which, as stated, is slightly conical, will gradually close its port. Should the jet fail, the pressure acting upon the valves V and V′ to open the same, increases, while the force upon the diaphragm m to close valve V decreases, thus allowing the said valves to open until the jet is again established.

Parts of the injector not referred to specifically are similar to corresponding parts shown in Fig. 1, and are indicated by like reference symbols.

We have found that the efficiency of the live steam nozzle i may be greatly increased by contracting its bore at a point some distance from its delivery end, and by gradually increasing the diameter of said bore from said contracted portion to its said delivery end, as shown at 17, 18, respectively of Fig. 2; and in said Fig. 2 we have also shown a valve seating and guide casing 5 in the delivery branch a^5 for the usual back pressure valve V^2.

The means for controlling the overflow as described in reference to Figs. 1 and 2 may be further modified, and the construction of the injector materially simplified by dispensing with the short intermediate receiving and discharging cone $f^\times$, Figs. 1 and 2, and hence the overflow branch b^6. Such an injector we have shown in Fig. 3, the receiving and discharging cone f being formed integral with casing 12 screwed to ring bearing 8 of the combining cone E. To prevent accidental unscrewing of said cone f from combining cone E, we lock the former or casing 12 to the ring bearing 8 by means of a lock screw 9. In this construction the spring m^{14} for valve V may also be dispensed with. Other parts of the injector not particularly referred to are the same in construction as the corresponding parts of the injector described in reference to Figs. 1 and 2 and bear similar symbols of reference.

In the injectors above described we have shown the live steam nozzle or cone i combined with the exhaust steam cone d for the purpose of increasing the velocity and consequently the penetrating power of a jet of fluid. We have discovered that the velocity of a jet of fluid produced by combined exhaust and live steam may be materially increased by means of steam admitted into the steam passage at one or more points before the jet issues from the injector. One form of this class of injectors we have shown in Fig. 4, in which live steam is admitted to the exhaust and live steam passage, that is to say, in which the propelling power of the combined exhaust and live steam is reinforced by an additional quantity of live steam.

The compound injector comprising an exhaust and live steam injector may be of the general construction of those shown in Figs. 1 and 2, the one illustrated in Fig. 4 being of substantially the same construction as the one illustrated in Fig. 3, with the exception of the overflow branch b^3, which is of a well-known construction and need not be described in detail. There are further structural modifications due and necessary to the altered condition of the injector. For instance, the live steam passage b^2 communicates with a passage 3 in casing a, and the latter passage with a live steam branch or passage b^{22} formed on the casing b of what we will hereinafter refer to as the supplementary live steam injector, said passage b^{22} also extending axially into the supplementary live steam injector casing b, and having secured thereto the supplementary live steam nozzle or cone i' that projects into the supplementary combining cone E′ screwed into an axial bearing b^{23} formed in casing b, said cone having overflow passages 16 formed therein, F indicating the supplementary receiving and discharging cone, and between said cones E′ and F there is an overflow gap leading to overflow chamber b^4. The overflow chamber b^4 is connected with an over-

flow branch b^{33} in which is formed a valve port and seat for the controlling valve V^3, which in construction and operation is in every respect similar to the valve V′ shown and described in reference to Fig. 1; m^{44} indicating the spring, m^{24} the valve stem head, b^{77} the tubular guide bearing for said spring and piston head, and m^{77} the plug that closes said bearing. V^2 indicates the back pressure valve in the delivery branch b^{55} of the supplementary live steam injector.

The operation of the injector described in reference to Fig. 4 is substantially the same as that described in reference to Figs. 1, 2, and 3, except that the velocity of the jet of fluid produced by the combined exhaust and live steam injectors is further increased under the action of the supplementary live steam. Not only is the velocity and consequently the penetrating power of the jet of fluid produced by the combined exhaust and live steam materially increased by the action of the supplementary live steam admitted into the fluid or steam passage of the injector, but an increment of heat is also added to the jet which is comparatively hot when it reaches the boiler.

If desired, the load of the exhaust valve V^3, *i. e.*, the spring m^{44}, may be dispensed with by substituting a valve controlled by a diaphragm similar to that for valve V Fig. 1.

Instead of combining one of the live steam nozzles or cones with the exhaust steam cone to produce a compound injector, as described in reference to Figs. 1, 2, and 3, and instead of combining with such an injector a supplementary live steam injector, as described in reference to Fig. 4, the several injectors may be arranged one after another, as shown in Fig. 5. In the injector shown in said Fig. 5 a back pressure valve g is interposed between the exhaust and primary live steam injector, and a similar valve g' between the last named injector and the supplementary injector, live steam being admitted to both live steam injectors through branch b^{24} and a passage b^{25} communicating by ports 23 and 24 respectively with the casing of said primary and supplementary live steam injectors and with the combining cones E^2 and E′ thereof. These live steam injectors are constructed substantially like the supplementary live steam injector described in reference to Fig. 4, except that the combining cones E^2 and E′ are devoid of overflow ports 16, Fig. 4, F^2 indicating the receiving and discharging cone for fluids from the exhaust steam injector, F′ the like cone for the primary live steam injector, F^{22} the receiving and discharging cone of the supplementary live steam injector for fluids from the primary live steam injector, and F the final receiving and discharging cone of said supplementary live steam injector. It will further be seen that the combining cones E^2, E′ are constructed to perform the function of live steam cones, the receiving and discharging cone F^2 for the exhaust steam injector projecting into the live steam cone end of the combining cone E^2 of the primary live steam injector, while the receiving and discharging cone F^{22} projects into the like end of the combining cone E′ of the supplementary live steam injector, such a construction of combining cone being also shown in Fig. 4, so that the live steam instead of being introduced through a live steam cone extending into the combining cone in the form of an axial jet, passes around the receiving and discharging cone and into the combining cone in the form of an annular jet. The exhaust steam injector is of the same construction as the one shown in Fig. 4, except that a solid centering spindle d' is employed in the exhaust steam cone.

The parts not specifically described in reference to the injector shown in Fig. 5, are of the same construction as the corresponding parts of the injector described in reference to Fig. 4, and are indicated by the same reference symbols. Inasmuch as the primary and supplementary live steam injectors are similar in construction to the supplementary live steam injector described in reference to said Fig. 4, with the exceptions noted above, we have indicated the corresponding parts thereof with the same reference symbols, except that different affixes are used for such corresponding parts of the primary injector shown in Fig. 5.

In some cases either the primary or the supplementary live steam injector may be supplied with a part of the steam which has exhausted from the cylinder or cylinders of a compound steam engine as it passes from one cylinder to another.

We have hereinbefore stated that we prefer to use a live steam cone or nozzle whose bore or interior area is contracted at a point some distance from its delivery end and gradually enlarged from said point to said delivery end. This may be effected in a cone of the usual taper form by means of a solid spindle d^3 made tapering in opposite directions from a given point some distance from the delivery end of the nozzle, as shown in Fig. 6. The same results may be obtained by combining two live steam nozzles of the construction of that shown in Fig. 4 arranged one within the other, as shown in Fig. 7, such a nozzle being adapted for use with an exhaust steam cone with or without a loaded overflow valve, both nozzles i and d^4 extending into the combining cone E of the exhaust steam injector.

Another very effective arrangement of live steam nozzles or cones is shown in Fig. 8, the live steam cone i being short and projecting axially into a cone i^4 provided at its upper end with ports i^5, so that some of the exhaust steam can enter the cone i^4 and combine with the live steam passing therethrough. In this arrangement the bore of the combining cone i^4 is of uniform diameter for a portion of its length from its discharging end. The action of the small central live steam jet is to draw

in a part of the exhaust steam, and the result is a more efficient compound injector which will deliver its jet against a greater boiler pressure than is the case with a single cone i in the exhaust steam cone.

In Fig. 9 we have illustrated another combination of live steam nozzles, in which the live steam cone i is made very long and with a flaring or trumpet shaped delivery end, and said cone has steam ports b^9 in its upper end to allow live steam to pass through to a small peripheral space formed between cone i and an encompassing small cone b^8 screwed onto said cone i. The live steam entering the annular space referred to passes between cone i and the encompassing cone i^4 and mingles with and assists in drawing exhaust steam through the ports i^5, said encompassing cone i^4 having its delivery end for a portion of the length of the cone of the same diameter to admit of the passage of the increased volume of exhaust steam.

Having thus described our invention, what we claim as new therein, and desire to secure by Letters Patent, is—

1. An injector comprising a low pressure or exhaust steam passage, a high pressure or live steam passage, and means for admitting live steam to the last named passage at different points, for the purposes set forth.

2. An injector comprising a steam passage, an overflow passage communicating with said steam passage, a valve controlling the overflow passage, and means whereby pressure arising from a jet of fluid produced by steam will cause said valve to close.

3. A compound low pressure or exhaust steam and high pressure or live steam injector, comprising a high pressure or live steam passage, an overflow passage communicating with said live steam passage, a valve controlling the overflow passage, and means whereby pressure arising from a jet of fluid produced by low pressure or exhaust steam will cause said valve to close.

4. A compound low pressure or exhaust steam and high pressure or live steam injector, comprising low and high pressure steam passages, an overflow passage communicating with each of said passages, valves controlling said overflow passages, and means whereby pressure arising from a jet of fluid produced by steam will cause both overflow valves to close.

5. In a compound low pressure or exhaust steam and high pressure or live steam injector, the combination with the steam and combining cones of the exhaust steam injector, of a live steam nozzle or cone arranged axially within said exhaust steam cone, said live steam cone having its bore gradually reduced toward the delivery end and thence gradually enlarged to said delivery end the latter end extending into the combining cone.

6. In a compound low pressure or exhaust steam and high pressure or live steam injector, the combination with the combining and steam cones of the exhaust steam injector, of a live steam cone adapted to inject steam axially into said combining cone, and means for combining a portion of the exhaust steam with the live steam before the latter reaches the combining cone.

7. In a compound low pressure or exhaust steam and high pressure or live steam injector, the combination with the combining and steam cones of the exhaust steam injector, of a live steam cone adapted to inject steam axially into said combining cone, and an auxiliary cone provided with ports in communication with the exhaust steam passage whereby a portion of the exhaust steam is drawn into the live steam cone and caused to combine with the jet of live steam, for the purpose set forth.

8. In an injector, a combining cone and an open ended receiving and discharging cone detachably connected together, said receiving and discharging cone provided with delivery ports, in combination with the injector casing in the end of which said receiving and discharging cone is detachably seated, said casing provided with a delivery branch in communication with the aforesaid delivery ports, and means for closing the outer open end of the receiving and discharging cone, substantially as and for the purpose set forth.

9. In an injector, the combination with the casing interiorly screw-threaded at one end, and a combining cone movable in said casing, of a delivery casing provided with delivery ports and adapted to be screwed in the end of the injector casing and a receiving and discharging cone detachably secured to the combining cone, for the purpose set forth.

10. In an injector, the combination with the casing interiorly screw-threaded at one end, and a combining cone movable in said casing, of a delivery casing as 12, open at one end, and a screw plug closing said open end, said delivery casing provided with delivery ports and adapted to be screwed in the end of the injector casing, and a receiving and discharging cone detachably secured to the combining cone, for the purpose set forth.

In witness whereof we have hereto signed our names in the presence of two witnesses.

EDWARD DAVIES.
JAMES METCALFE.

Witnesses:
PETER J. LIVSEY,
WILLIAM FAULKNER.