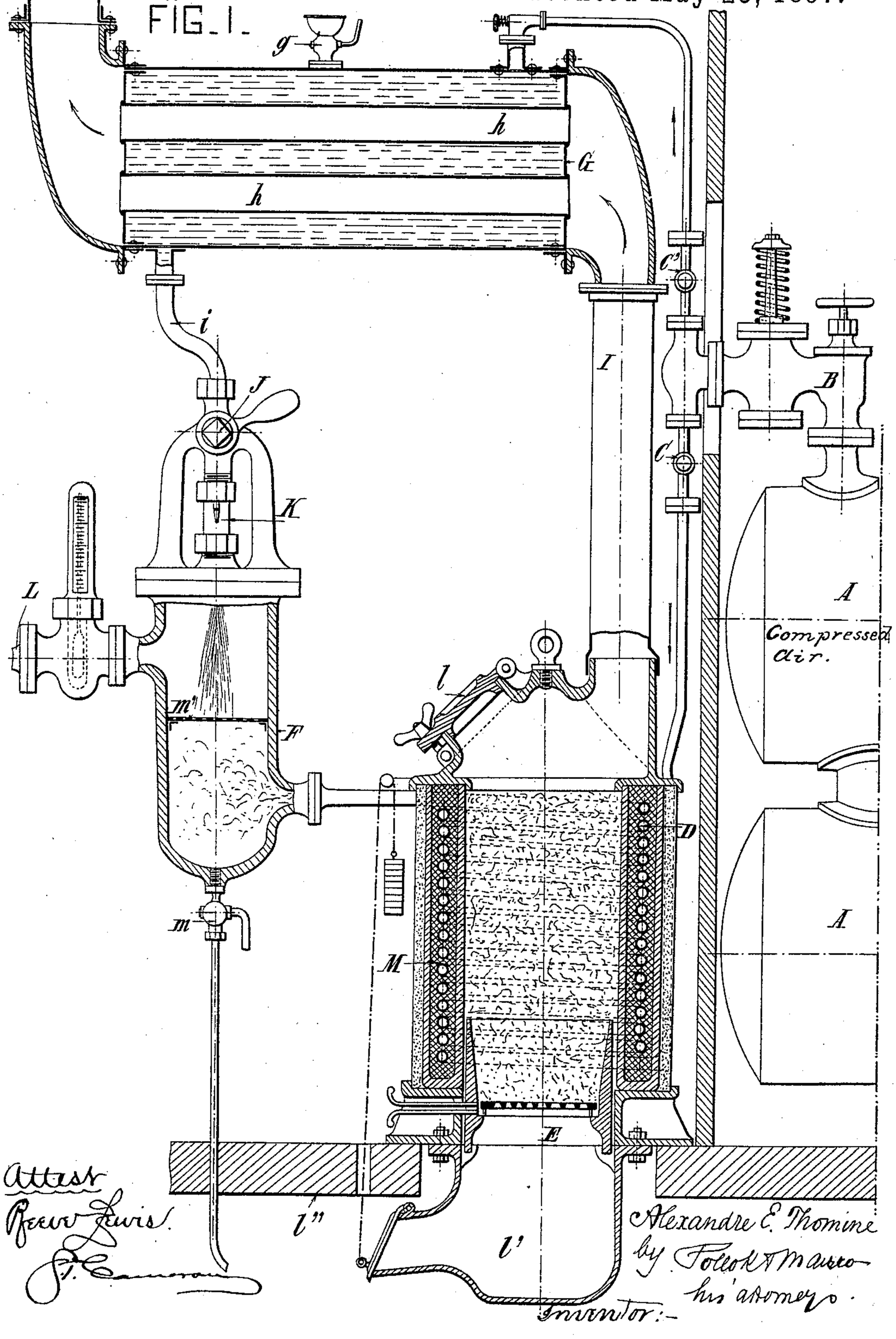
(No Model.) 3 Sheets—Sheet 1.

A. E. THOMINE.

APPARATUS FOR MIXING COMPRESSED AIR AND STEAM IN ANY PROPORTIONS.

No. 583,240. Patented May 25, 1897.

FIG. 1.



Attest
Reeve Lewis.
J. Cameron

Alexandre E. Thomine
by Pollock & Macco
his attorneys.
Inventor:—

(No Model.)

3 Sheets—Sheet 2.

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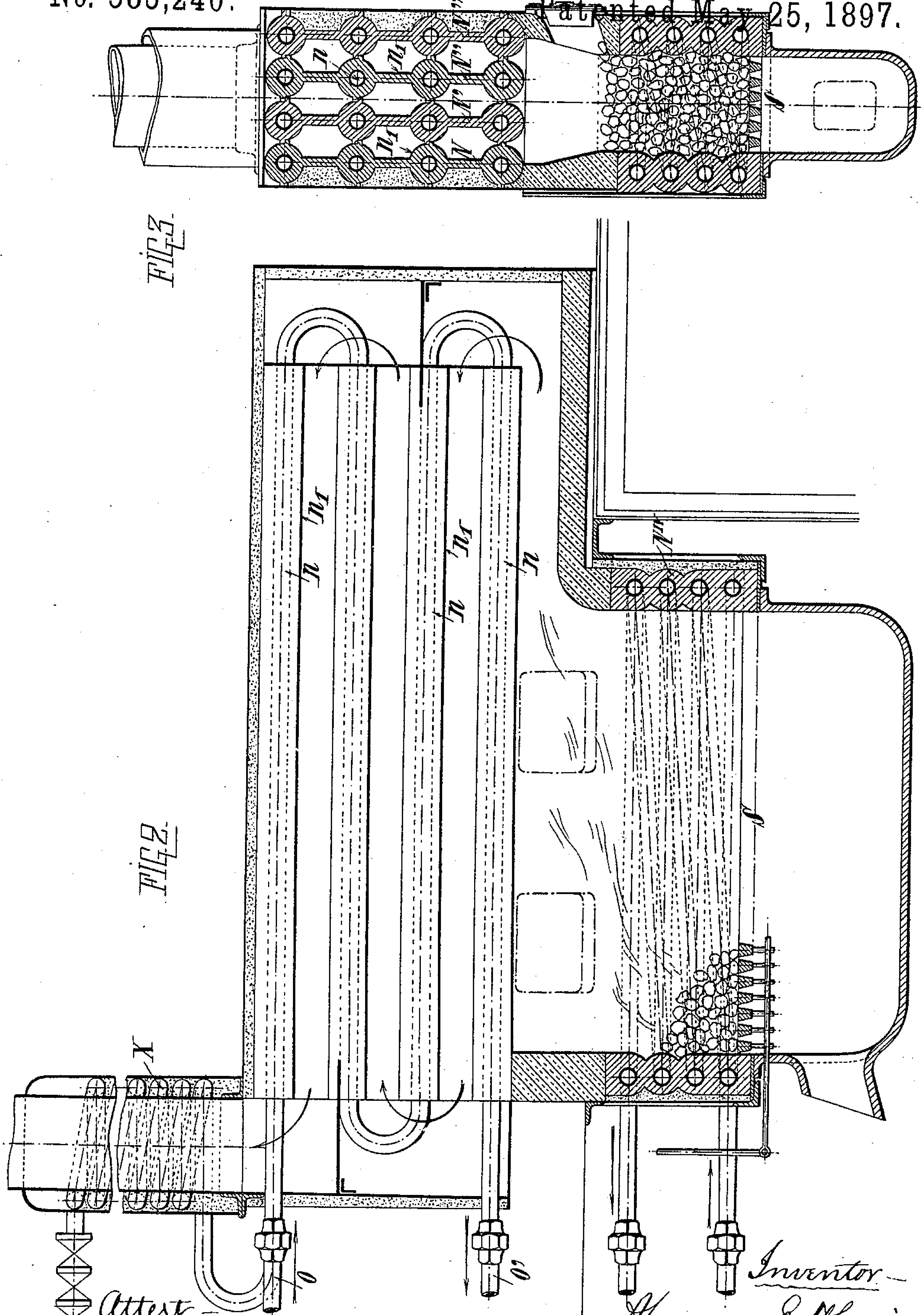

FIG. 3.

FIG. 2.

Attest—
Rene Lewis.
S. T. Cameron

Inventor—
Alexandre E. Thomine
by Pollok & Mauro his attorneys.

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(No Model.) 3 Sheets—Sheet 3.

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FIG. 4.

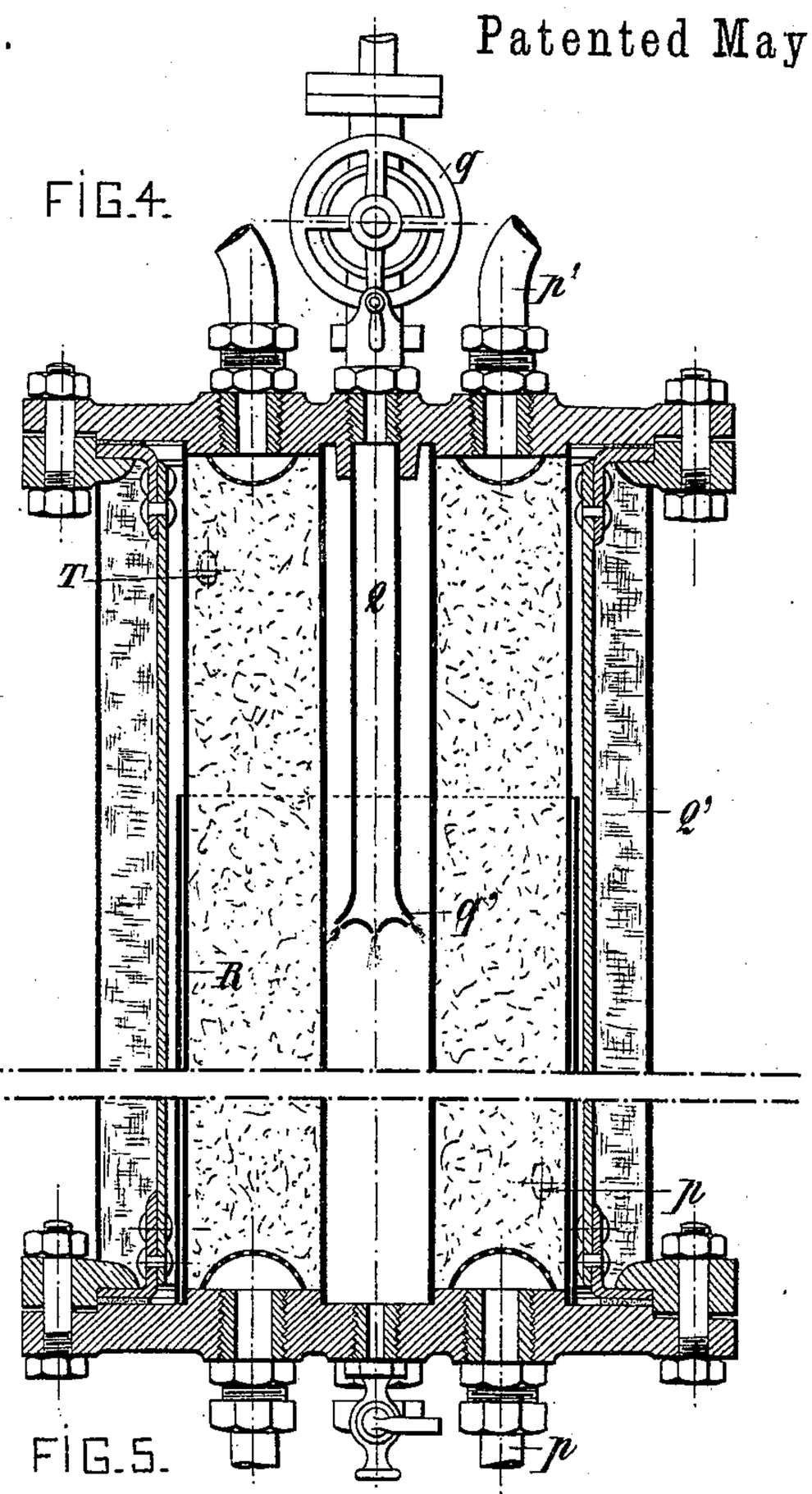
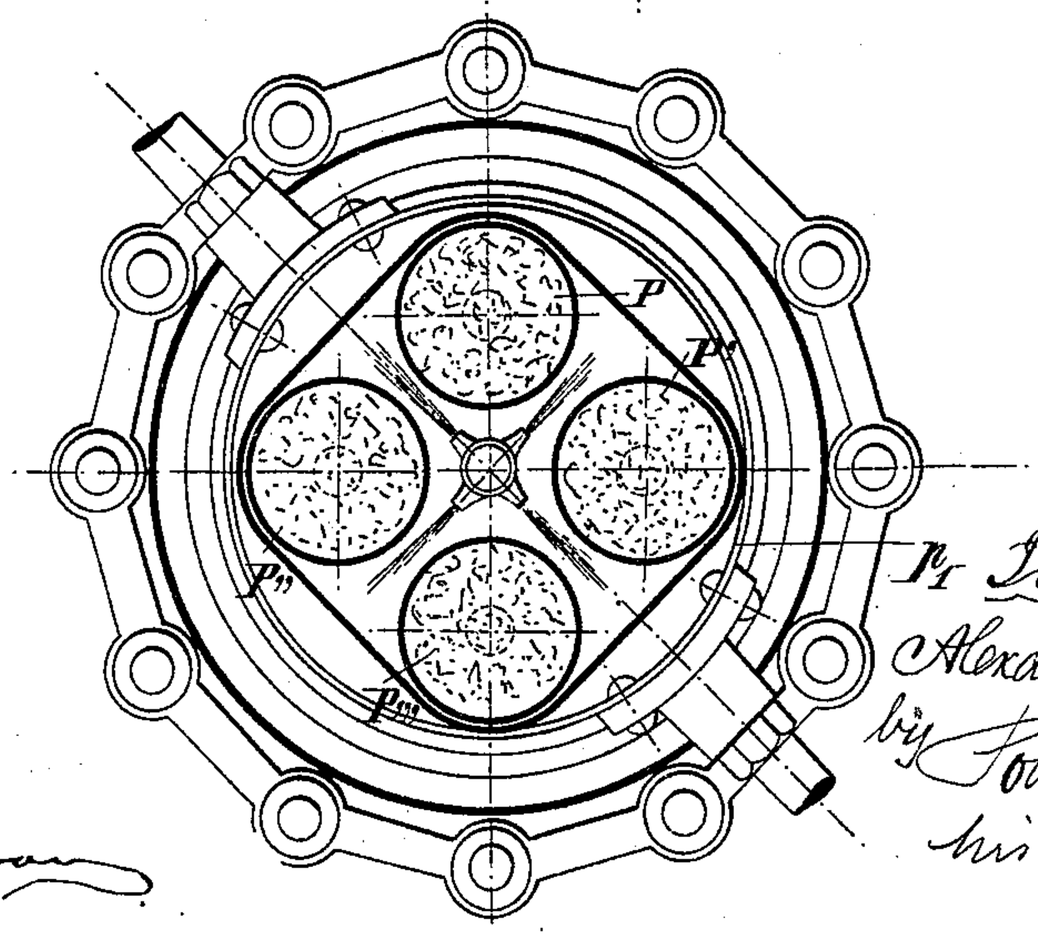


FIG. 5.



Attest:
Peter Lewis.
S. T. Cameron

Inventor:
Alexandre E. Thomine
by Tolton & Mauro
his attorneys.

UNITED STATES PATENT OFFICE.

ALEXANDRE EDMOND THOMINE, OF PARIS, FRANCE.

APPARATUS FOR MIXING COMPRESSED AIR AND STEAM IN ANY PROPORTIONS.

SPECIFICATION forming part of Letters Patent No. 583,240, dated May 25, 1897.

Application filed December 15, 1896. Serial No. 615,823. (No model.)

To all whom it may concern:

Be it known that I, ALEXANDRE EDMOND THOMINE, of Paris, France, have invented new and useful Improvements in Apparatus for Mixing Compressed Air and Steam in any Proportions, which is fully described in the following specification.

In air-motors it is impossible, as is well known, to use compressed air expansively if it be cold and dry. The effective work of a motor in which expansion of the fluid used cannot be utilized is therefore very feeble. To obviate this, it was thought necessary to use the compressed air in a heated form. But even this means being quite inadequate, it was thought to use the compressed air both hot and moist—that is, mixed with vapor of water.

The apparatuses heretofore used to effect this mixture are based simply upon the passage of compressed air through a layer of hot water of more or less depth. This arrangement, as will be understood, without speaking of certain other objections which result from its use, produces a mixture of air and vapor the proportions of which cannot be regulated and the quantity of vapor is always very small. In certain cases it may be advantageous to obtain a veritable mixture of air and vapor, the proportions of which are such that the quantity of the latter may be relatively considerable, the vapor at the time of the utilization of the mixture thus formed performing both as a fluid and a compressed-air motor.

The present invention has for its object the production of a mixture of compressed air and vapor in proportions which can be regulated at will.

The invention will be better understood by reference to the accompanying drawings, forming part of this specification, wherein—

Figure 1 represents diagrammatically the apparatus by means of which a mixture of compressed air and vapor can be effected under the conditions indicated, and Figs. 2, 3, 4, and 5 are various modifications which may be given to the apparatus according to its industrial application.

The dry and cold compressed air to be mixed is contained in the reservoirs A A, whence it proceeds through an expansion-box B, which is provided with a stop-cock in two directions C C′. The portion of the air which passes through the pipe C finds its way to the mixing-chamber F through the coil D, where it is heated by being subjected to the action of the fire upon the grate E. The other portion of the air which is conveyed by the pipe C′ passes into the upper part of the chamber G, that contains water introduced through cock *g*. The gases of combustion from the grate E, rising through the flue I, traverse the tubes *h*, heating the water in the cylinder G, surrounding the same. The compressed air which comes from the pipe C′ presses upon the heated water contained in the cylinder G, which issues at the under side through the pipe *i* and penetrates the mixing-chamber F by passing through cock J, by means of which the quantity of water injected into the mixing-chamber is regulated. There is, moreover, a nozzle K, which admits of the mass of water introduced into the mixing-chamber being divided into drops or transformed into spray of requisite quantity. Such is the general character of the circulation of the fluid through the apparatus. In order to put it into action, the expansion-box B is opened. The air passing through C is heated in the coil D and finds its way into the mixing-chamber F, where it meets with water that is introduced by the nozzle K. The hot air coming in contact with water converts the latter into vapor, which is carried away with the air through the pipe L to the motor. The fire-chamber may be of any desired character and adapted for use with any kind of fuel, whether solid or liquid, but, preferably, it should be of continuous operation and capable of being regulated. In the example shown in the drawings the fuel is put in through the door *l* and the ashes and cinders drop into the ash-box *l′*. The coil D is preferably surrounded by a mass of lead or an alloy having lead for a base. The heat of the fire-chamber will melt the lead or the alloy thereof and the coil is thus maintained at a temperature as regular as possible, but which can be varied at will according to the intensity of the fire, which in its turn may be regulated by means of registers or valves. The mixing-chamber I have provided with a clearing-pipe *m* and a partition of a metallic web *m′*, against which

the hot air will impinge and thereby become diffused, thus increasing the surface of contact between the water and the air. Instead of the one partition m' it will be understood several may be employed. In practice in order to increase the quantity of vapor which is to be carried off by a given quantity of air at a certain final temperature I provide for increased circulation, so that the air may be heated over again several times before it enters the motor-cylinder, the air circulating after each reheating through a divided mass of great volume and around which water is injected, which is transformed into vapor in such a way that at each cycle of the air the lost heat by the latter is utilized to transform a certain quantity of water into vapor.

In Figs. 2, 3, 4, and 5 of the annexed drawings I have shown examples of apparatus based upon such multiple reheating of the air. The air-reheater is composed of distinct tubular elements N N′ N″ N‴, the number of which depends upon the amount of reheating the air is to be subjected to before its utilization. Each of these elements consists of four horizontal tubes n, which are embedded in cast-iron sleeves n', Figs. 2 and 3. The compressed air at the issue from the reservoir in which it is stored traverses, before entering the first tubular element, a coil X, placed around the flue or chimney. From the coil the air, whose temperature has already been raised, arrives at the first tubular element by the conduit O and circulates in the tubes n, which are united one to the other, and issues by the tube O′. The heated air will then enter the apparatus shown in Figs. 4 and 5, in which the transformation of the water into vapor is produced. This apparatus is composed, essentially, of vertical tubes P P′ P″ P‴, having each an inlet-orifice p and an outlet-orifice p'. The number of the tubes depends on the number of cycles the air is to perform before utilization. Each of these tubes is filled with a dividing substance, such as copper shavings or any other suitable substance, or it may be provided with deflecting-surfaces for increasing the circulation of the air.

As shown in the drawings, the four tubes P, P′, P″, and P‴ are lodged in the interior of a larger tube p', which also is provided with two orifices for inlet and outlet T and p, respectively. Centrally located in tube p' is the pipe Q, which by means of the cock q is connected with the reservoir containing water under pressure, which, if necessary, may be given by compressed air.

The lower end of the pipe Q terminates in injector-nozzles q', from which water in a highly-divided state is ejected and projected around the tubes P P′ P″ P‴. The four tubes P, P′, P″, and P‴ are surrounded by a partition R in the interior of the outer tube p', but, as shown in Fig. 4, it stops at a certain height.

The various tubes which I have described are lodged in an envelop Q′ of insulating substance, so as to avoid loss of heat into the atmosphere.

The operation is as follows: The compressed air issuing from the reservoir traverses the coil X and enters the first tubular element N. Through the outlet-pipe O′ of this first element the air penetrates into the tube P and rises through the copper shavings, thus losing some of its temperature. Then issuing by the conduit p' it returns to the second tubular element N′, where it becomes reheated. It then comes back into the second tube P′, where it is cooled down again, as when it passed through tube P. The circulation is thus continued until the air issuing from the fourth tubular element N‴ shall have traversed the last tube P‴. The air now proceeds to the last reheater N^{iv}, which is placed around the fire-chamber S, and after having been subjected to a final reheating it will reach the exterior tube p', which surrounds the four tubes P P′ P″ P‴. The air thus rises in the tube, and as soon as it shall have risen above the partition R it will come in contact with the vapor which has been formed in the interior of tube p', as during the circulation of the air there was projected by the injector q' water in divided state which was converted into vapor by coming in contact with tubes P P′ P″ P‴. The mixture of air and vapor thus produced finally leaves the apparatus through orifice T to be carried to the motor. The partition R has for its object the prevention of the deposits of water which may be transformed into vapor being carried along by the air. Tubes P P′ P″ P‴, instead of being grouped, as shown, may be separated in such manner that at each cycle the air may be impregnated with a certain quantity of vapor. With such circulation the tubes P P′ P″ P‴ should be modified so that the air may meet the vaporized water at each of its passages in one of the tubes. With this mode of circulation the proportions of vapor in the mixture will gradually increase from zero up to any quantity previously determined by the regulating of the apparatus.

It will be understood that it is easy with the apparatus described to regulate both the temperature incident to the heating and cooling at each cycle and the proportions of air and of vapor which finally leave the apparatus through the orifice T.

Instead of water I can use petroleum or any other liquid capable of being vaporized and producing with compressed air a motor mixture.

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

1. In apparatus for the purpose set forth, the combination with a reheater, having tubes through which the compressed air passes successively, of a vaporizer through which the air passes after leaving the reheater and be-

fore returning to it again, and a mixing-chamber, in which the vapor formed in said vaporizer, and the air after finally leaving said reheater, are mixed, substantially as described.

2. In apparatus for producing a mixture of compressed air and vapor, the combination of the air-reheater, comprising clusters of tubes, and the vaporizer having tubes connected in series with the said clusters of tubes, so that the air passes from the reheater to the vaporizer alternately, the vaporizer being provided with an inlet-pipe whereby liquid is discharged against the tubes through which the heated air passes, and thereby converted into vapor, the last of said cluster of tubes being connected with the chamber in which said vapor forms, substantially as described.

3. The combination with the reheater, comprising several clusters of tubes, of the vaporizer comprising tubes connected in series with the clusters of the reheater, so that the air passes from one to another, said tubes containing means for dividing the air, a mixing-chamber inclosing said tubes, and an inlet terminating in a discharge-nozzle, whereby liquid is sprayed against the tubes through which the heated air passes, the last cluster of tubes of the reheater being connected by a pipe leading into said mixing-chamber, substantially as described.

In testimony whereof I have signed this specification in the presence of two subscribing witnesses.

ALEXANDRE EDMOND THOMINE.

Witnesses:
J. ALLISON BOWEN,
A. ROUSSOMNER.