

G. Waisort,

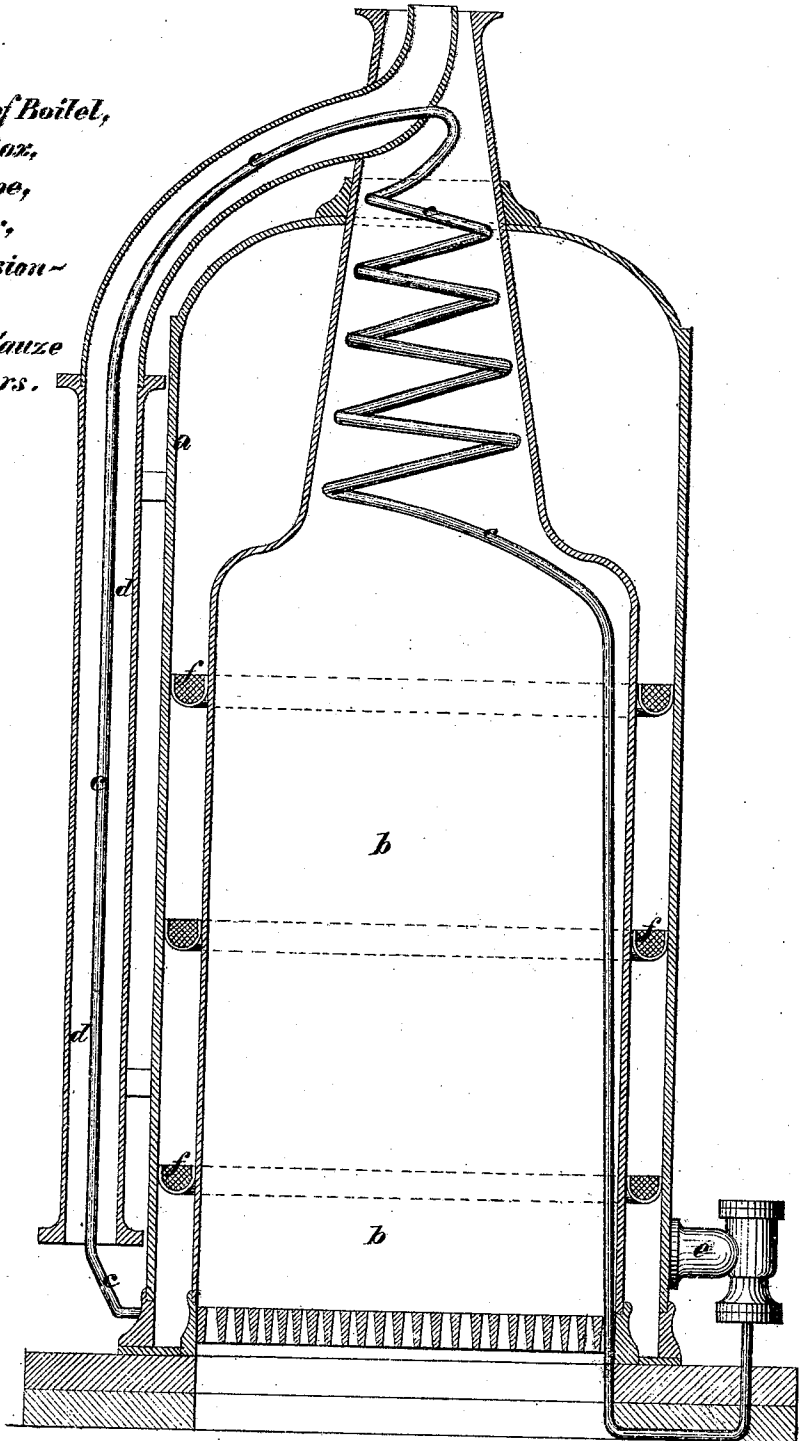
3. Sheets, Sheet 1.

Boiler Heater.

No. 100,090.

Patented Feb. 22, 1870.

- a. Skin of Boiler,
- b. Fire Box,
- c. Air Pipe,
- d. Heater,
- e. Admission-
Valve.
- f. Wire-Gauze
dispensers.



G. Warsof,

3. Sheets, Steel. 2.

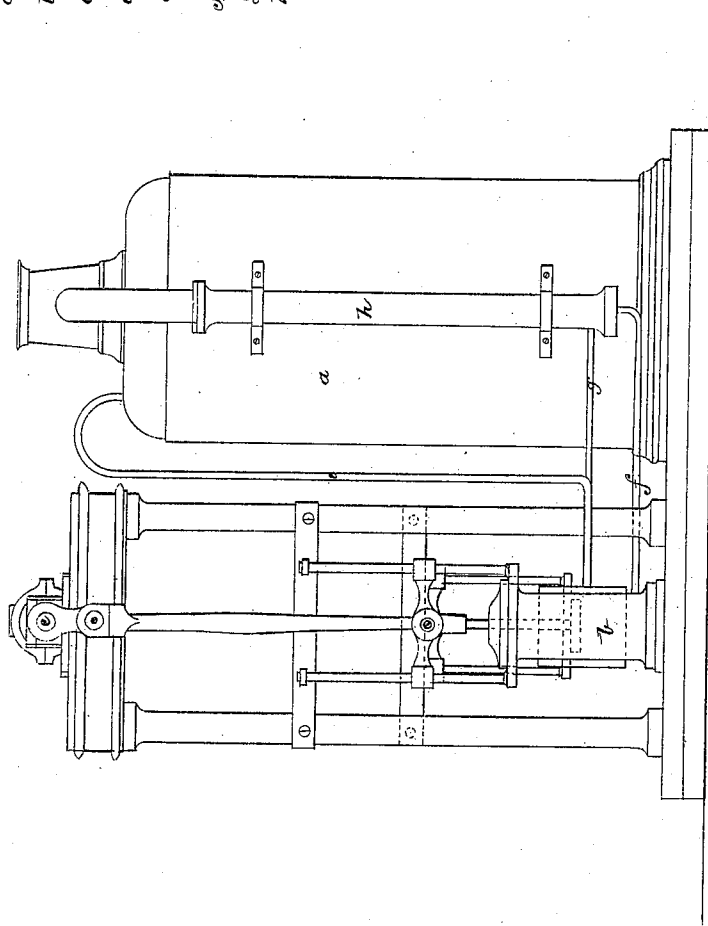
Boiler Heater.

No. 100,090.

Patented Feb. 22, 1870.

- a. boiler
- b. steam cylinder
- c. crank shaft
- d. air pump
- e. steam pipe
- f. air pipe
- g. exhaust pipe
- h. air bearings

Side View



Witnesses to the signature of George Warsof
 Richard Eaton
 Henry Walker Hill

George Warsof

G. Warsof,

3. Sheets, Steel 3

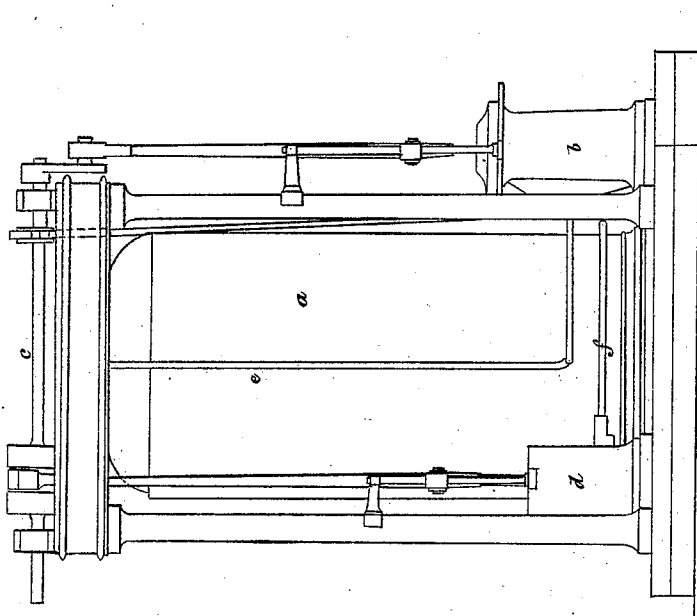
Boiler Heater.

No. 100,090.

Patented Feb 22, 1870.

- a. boiler
- b. steam cylinder
- c. crank shaft
- d. air pumps
- e. steam pipe
- f. air pipe

Front View



Witnesses to the signature of George Warsof
Richard Cotton
Newy Walker Hill

George Warsof

United States Patent Office.

GEORGE WARSOP, OF NOTTINGHAM, ENGLAND.

Letters Patent No. 100,090, dated February 22, 1870; patented in England September 8, 1868.

STEAM AND AIR-ENGINE.

The Schedule referred to in these Letters Patent and making part of the same

To all to whom it may concern:

Be it known that I, GEORGE WARSOP, of 17 Bromley Place, Nottingham, a subject of the Queen of Great Britain, have invented or discovered new and useful "Improvements in Apparatus for Obtaining Motive Power by Means of Air and Steam;" and I, the said GEORGE WARSOP, do hereby declare the nature of the said invention, and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement thereof, that is to say:

The machinery which I employ consists of a steam-boiler, and an engine, which may be similar to those now in use, and the engine works an air-pump or pumps drawing in cold air and forcing it through a coil of pipes, or other suitable chamber, heated by the furnace, and from this heated coil or chamber the air passes into the boiler, and is caused to rise in a finely divided state through the water therein contained. The air and steam together pass from the boiler to work the engine.

The heating of the air, after it leaves the pump or pumps, may be effected by passing it through hollow fire-bars, or apparatus such as is now employed for superheating steam, may be used for heating the air.

The air is caused to be finely divided as it passes through the water, by means of partitions of wire-gauze or other open-work or perforated material.

In order that my said invention may be most fully understood, I will proceed to describe the manner in which I prefer to carry the same into effect.

I take an ordinary high-pressure steam-engine, but of larger size than would, if it were worked in the ordinary manner, be required for the office which it has to perform, and I apply to this engine an air-pump or air-pumps, by preference, of such capacity that for each stroke they will together yield a measure of compressed air of the boiler-pressure of the engine equal to about one-half to five-eighths the measure of mixed air and steam which is expended at each stroke of the engine.

In this case more than half of the power obtained in the working-cylinder will be expended again in compressing the air, and the area of the working-cylinder must be proportionally large. These proportions, however, may be varied, and it is advantageous frequently to so construct the engine that they may be varied from time to time, as may be required, by altering the effective length of stroke of the air-pumps, then, by reducing the quantity of air, a greater power may be obtained from the engine, but less economically.

The air-pumps may conveniently be worked by eccentrics or cranks on the main shaft of the engine, and may be of ordinary construction.

I prefer that the valves of the air-pump should be ordinary conical valves, and the valves should be of

sufficient area to give free passage to the compressed air, with but a short lift, for it is important to the proper working of the engine that the valve should close again rapidly, as soon as the stroke of the pump is completed. The inlet-valve may in each case be a spring-pallet, working over a passage in the piston, which is of a sufficient area freely to admit the air, and the pallet-spring is not sufficiently strong to oppose to it any considerable resistance, but the spring is yet sufficient, when the entry of the air ceases to cause the immediate return of the pallet, so that it may cover closely the mouth of the inlet-passage at the time that the delivering-stroke of the air-pump commences.

The boiler may be of any good construction; so long as it has a considerable water capacity and depth it need not be larger than in the ordinary proportion to the effective power of the engine. In the flue, or otherwise in connection with it, an air-heating apparatus is provided. Such a heating apparatus may be used as has heretofore been employed for superheating steam. It should be capable of raising the compressed air from the air-pumps to a temperature at least equal to, and advantageously it may somewhat exceed the saturated steam temperature corresponding with the pressure at which it is intended to work.

The engine may be worked at any high pressure; 50 pounds per square inch above the atmospheric pressure is a suitable and convenient pressure, but greater economy may be obtained by the use of a higher pressure.

Coils of wrought-iron pipes in the boiler furnace and flue form a convenient air-heating apparatus, and in small engines a part of the coil may advantageously form the fire-bars of the boiler. The compressed air, after passing through the heating apparatus, is admitted into the boiler at the lowest part of the water-space, through a valve which is employed to prevent the escape of water from the boiler into the heating apparatus. This valve, also, it is found convenient to make like the exit-valves of the air-pumps.

The heated air, as it rises up through the water in the boiler, is caused to be divided into as many and minute streams as possible by means of suitable partitions. I have found for this purpose the use of wire-gauze to be convenient, and I arrange it as observation may in each case suggest. Wherever the air rises up in quantity, there I oppose to it a number of thicknesses of wire-gauze, sufficient to reduce the flow, and in this way I distribute the air and cause it to ascend equally, or nearly so, in every part of the boiler. It is important that the distribution of the air among the water in the boiler should be attended to, for in this engine one main purpose which the water in the boiler performs is to regulate the heat of the air; absorbing from it any excess of heat it may have acquired before it enters the boiler, or supplying heat

to it, as the case may require. The air and steam together pass from the boiler to the engine, and are admitted to the working-cylinder as when using un-mixed steam, but in this case the power of the engine will result for the greatest part, or in great part, from the expansion of the air by heat between the time when it is taken in by the air-pumps and the time when it is passed, together with the steam, into the working-cylinder. The degree to which the steam and air are expanded in the working-cylinder, will, as heretofore, depend on the conditions of the application in each particular case; but I would remark that, with this engine, expansion may advantageously be carried to a considerable extent without there being any necessity to steam-jacket the cylinder, the cylinder being simply clothed with felt in the usual way.

When the expansion is to be carried far, it is desirable that the air should enter the boiler at a temperature considerably above that of the water which the boiler contains, and then the mixed steam and air will pass off from the boiler at a heat a good many degrees above that of saturated steam at a corresponding pressure; or, in fact, the steam which the mixture contains will be to a small extent superheated, and so is in a state to be very advantageously worked expansively.

The exhaust steam and air from the engine, I cause to pass through a tubular casing. It is clothed with felt to prevent loss of heat, and the pipe which receives the compressed air, immediately it comes from the air-pumps, is made to pass through the interior of the casing from end to end, entering it near where the exhaust air and steam escape, and leaving it to pass to the air-heater near where the exhaust steam and air enters from the cylinder.

The casing should be made sufficiently long to avoid any great loss of heat with the exhaust air and steam.

I would remark that by means of these arrangements the theoretical economy of an air-engine, that is to say, that of an engine worked by the expansion of air by heat, are to a considerable extent practically realized, while many of the difficulties attendant on the use of air-engines are avoided.

The steam-boiler affords a ready means of regulating the temperature of the air, as already stated, and also of obtaining the requisite pressure for starting. It insures that the the temperature of the mixed air and steam passing to the cylinder shall never rise so high as to injure the lubricants there employed, and the steam itself, as in an ordinary steam-engine, furnishes sufficient moisture to prevent the rubbing surfaces from being absolutely dry.

The manner adopted for heating the air, also, it may be observed, is such as to preclude the possibility of the air carrying with it dust and cutting particles into the working-cylinder.

The engine may, where the nature of the work renders it desirable, have more than one working-cylinder, and again, it is not essential to my invention that the engine should be of the cylinder construction. It may be a rotary engine, although in all cases I prefer a cylinder engine.

The invention is applicable to locomotive as well as to stationary and portable engines, and in its application to locomotive-engines, a considerable advantage is that the quantity of water which is required for its supply is much smaller than is required by an ordinary steam-engine of the same power.

In the case of locomotives, the air may first be heated by passing through a coil of pipes in the smoke-box before passing into the heating apparatus in the furnace, and so utilize the waste heat in the smoke-box.

In some cases, especially in large engines, a separate fire may be employed for the air-heater; in other cases the air may be forced at once into the boiler without being previously heated, and so be made to take up its heat entirely from the water in the boiler. I believe, however, that it is always more advantageous to employ an air-heater to heat the air previous to its admission to the boiler.

The annexed drawing represents a stationary engine constructed according to my invention.

In the side and front views—

- a* represents the boiler;
- b*, the steam-cylinder;
- c*, the crank-shaft;
- d*, the air-pump;
- e*, the steam-pipe;
- f*, the air-pipe;
- g*, the exhaust-pipe, and
- h*, the air-heater.

In the section—

- a* represents the skin or shell of the boiler;
- b*, the fire-box;
- c*, the air-pipe;
- d*, the heater;
- e*, the admission-valve, and
- f*, the wire-gauze air-dispersers.

The air is conducted through the fire-box and heater and injected into the boiler, rising up through the annular dispersers *f*, arranged between the fire-box and the boiler-skin.

I do not broadly claim forcing heated air into a boiler, as that has been done previously to my invention.

I claim as my invention—

The combination of the boiler, the fire-box, and the air-dispersers, all these parts being constructed to operate substantially as hereinbefore set forth.

Also, the combination of the boiler, the fire-box, the air-supply pipe, and the air-dispersers, all these parts being constructed to operate substantially as hereinbefore set forth.

Also, the combination of the boiler, fire-box, air-supply pipe, air-heater, and air-dispersers, all these parts being constructed to operate substantially as herein before set forth.

Also, the combination of the boiler, air-pump, air-supply pipe, and the air-dispersers, all these parts being constructed to operate substantially as hereinbefore set forth.

Also, the combination of the boiler, air-pump, air-pipe, heater, and the air-dispersers, all these parts being constructed to operate substantially as hereinbefore set forth.

Also, the combination of the boiler, steam-cylinder, crank-shaft, air-pump, air-pipe, heater, and exhaust-pipe, all these parts being constructed to operate substantially as hereinbefore set forth.

GEORGE WARSOP.

Witnesses:

G. J. WARREN,
H. W. SPENCER,
Both of No. 17 Gracechurch Street, London.
JOHN HARRISON,
Notary Public, London.