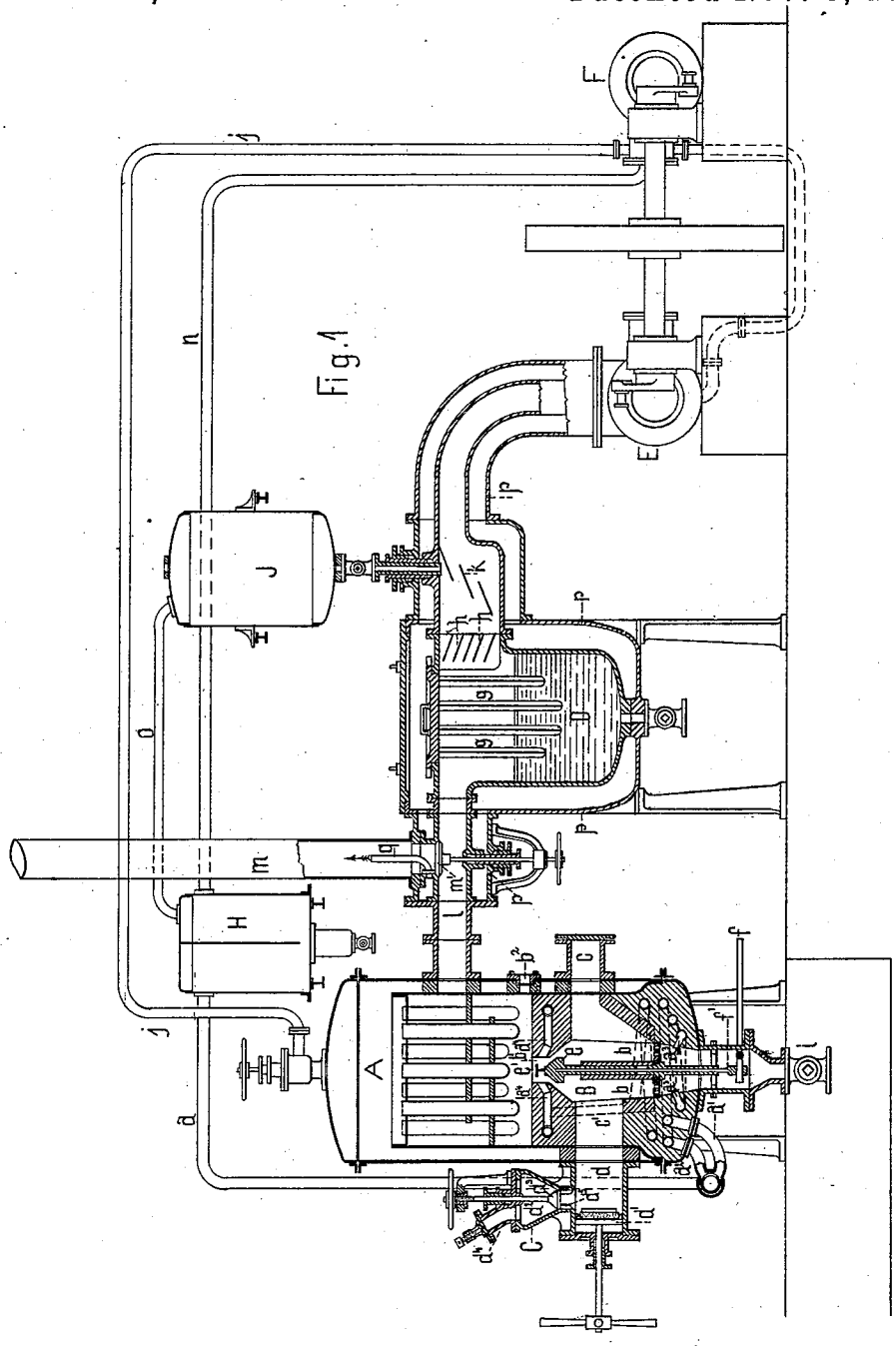
(No Model.) 3 Sheets—Sheet 1.

C. OTTO.

WORKING FURNACES BY COMPRESSED AIR.

No. 352,423. Patented Nov. 9, 1886.

Fig. 1.



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(No Model.) 3 Sheets—Sheet 2.

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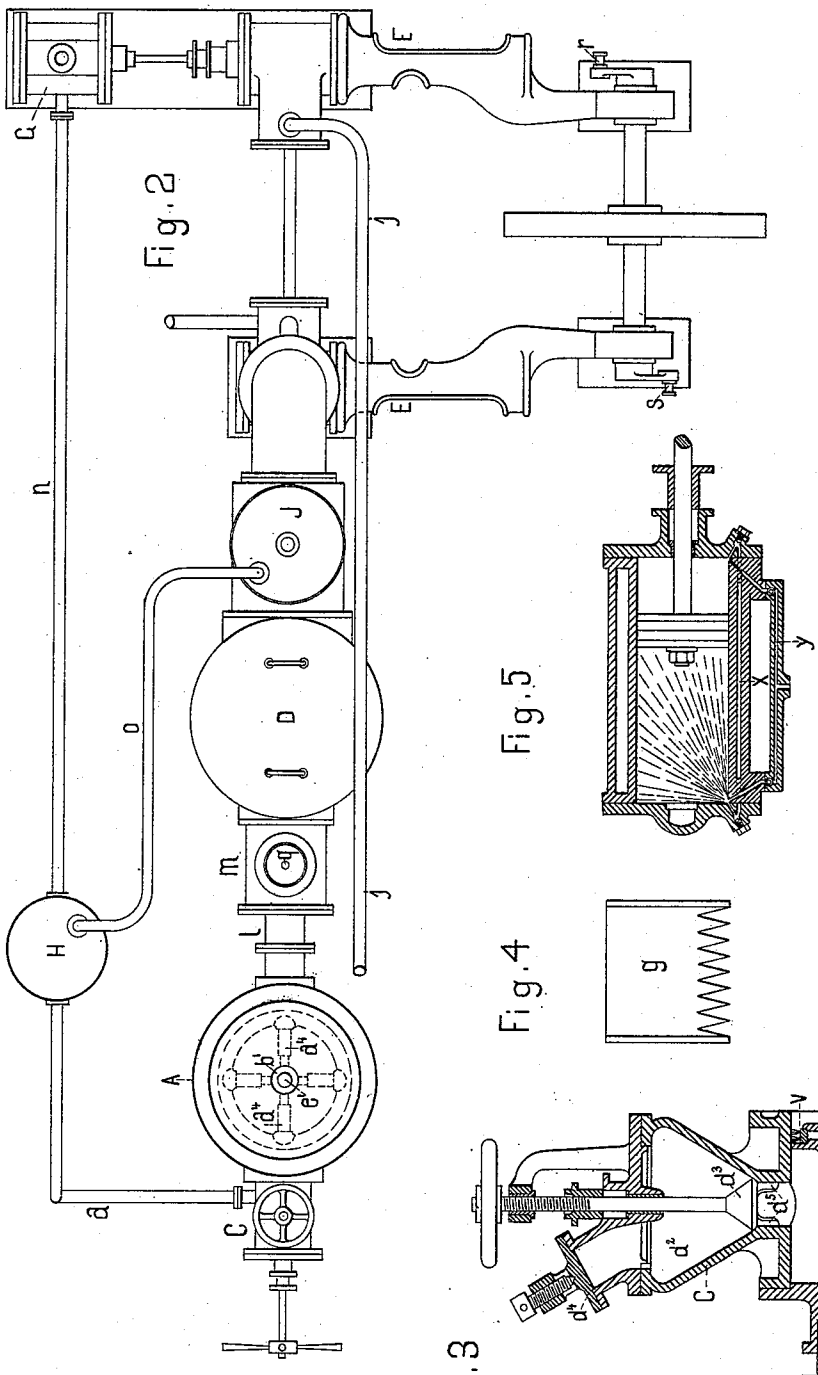

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(No Model.) 3 Sheets—Sheet 3.

C. OTTO.

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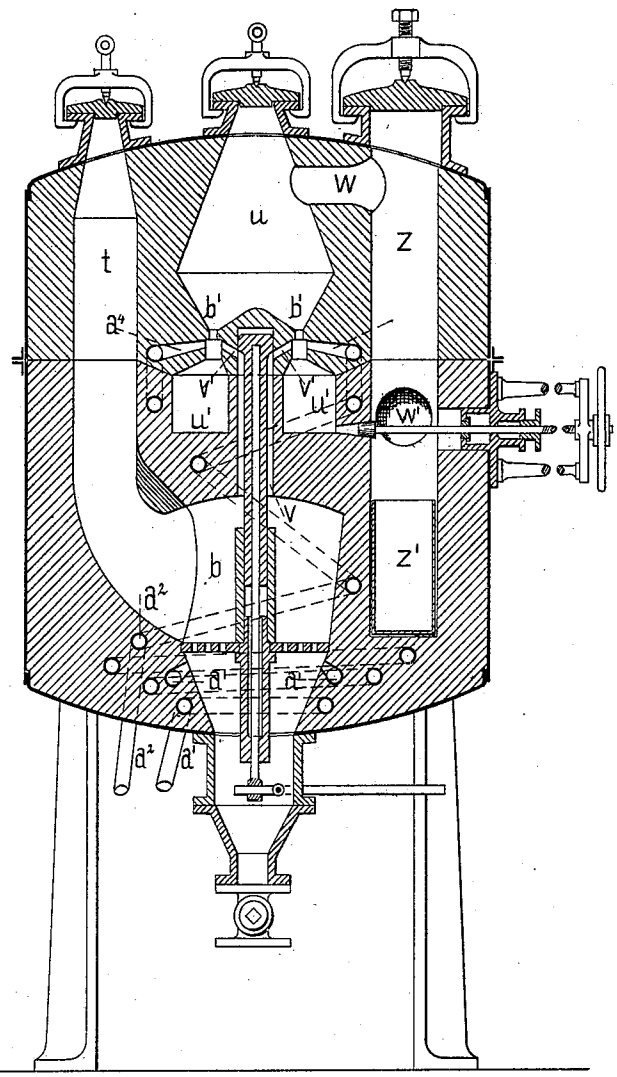
Fig. 6



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UNITED STATES PATENT OFFICE.

CARL OTTO, OF GREIFENHAGEN, PRUSSIA, GERMANY.

WORKING FURNACES BY COMPRESSED AIR.

SPECIFICATION forming part of Letters Patent No. 352,423, dated November 9, 1886.

Application filed August 14, 1886. Serial No. 210,936. (No model.)

To all whom it may concern:

Be it known that I, CARL OTTO, a subject of the King of Prussia, and residing at Greifenhagen, Kingdom of Prussia, Germany, have invented new and useful Improvements in Working Furnaces by Means of Compressed Air, of which the following is a specification.

My invention relates to closed furnaces in which combustion is maintained by compressed air; and the object of the same is to utilize the compressed combustion-gases thus obtained, in the first place for the generation of steam or, in addition thereto, for other technical purposes, and in the second place for producing the mechanical work or a part thereof required to compress the air to be supplied to the furnace.

To this end my invention consists in the combination, with a closed furnace, of a steam-boiler receiving heat from the former, a pump for supplying compressed air to the furnace, a hot-air engine worked by the compressed combustion-gases from the said furnace, and a motor co-operating with the hot-air engine in driving the air-pump.

The invention also comprises means for purifying the combustion-gases on their course from the furnace to the hot-air engine and mixing them with steam, and means for feeding the furnace with solid fuel. If any fuel is burned in a closed space under pressure, the temperature, as well as the quantity of heat developed, increases considerably, and the combustion-gases produced are capable of exercising a greater calorific effect on a given surface—for instance, on the heating-surface of a steam-boiler—on account of their superior calorific capacity, (relatively to the unit of volume,) originating from their greater density. On issuing from the space or apparatus in which they have first given off heat there is still present in these gases the remaining heat and the whole mechanical energy resulting from their expansive force, which are both lost if the gases are allowed to escape into the atmosphere, so that under these conditions an economical advantage does not arise from the use of compressed air. A utilization of the said heat and mechanical energy may, however, be attained by causing the issuing combustion-gases to operate expansively in a hot-air engine, and in employing the mechanical work thus produced for working the pump which supplies the compressed air required for sustaining the combustion.

On the annexed three sheets of drawings an apparatus involving my invention is represented by Figure 1 in a vertical sectional elevation, and by Fig. 2 in plan, partly in section. Fig. 3 shows the fuel-feeder to a larger scale. Fig. 4 is a part in detail. Fig. 5 is a section of the air-pump, and Fig. 6 represents a portion of a modified apparatus with furnace adapted for melting metals.

In Figs. 1 and 2, A is a steam-boiler provided with the inside furnace, B. C is a fuel-feeder adapted for introducing fuel into the furnace B while being under pressure. D is an apparatus in which the combustion-gases issuing from the said furnace are purified, and in which, if their temperature should be too high, they are cooled down to the proper degree and impregnated with steam. E is the hot-air-engine; F, a steam-engine coupled with the former; G, the air-pump; H, an air-vessel inserted between the latter and the furnace, and in which separates out any water introduced into the air-pump for the purpose of refrigeration; and J, a water-reservoir, from which the water evaporating in the purifier D is replaced.

The boiler A is represented as a vertical cylindrical boiler with Field tubes. In the lower part of this boiler is formed, by means of a fire-proof lining, a shaft, *b*, into which air is introduced below the grate arranged therein through the pipe *a*, the branch pipe a', and the apertures a^3, while through the branch a^2 of the pipe *a* and the nozzles a^4 air is conveyed to the upper contracted portion or neck, b'. A gas-furnace with generator is thus constituted, in which the main combustion takes place in and immediately above the neck b'. For heating the air supporting the combustion, the pipes a' and a^2 are formed in serpentines and embedded in the fire-proof lining. A cock inserted between the pipe *a* and the pipes a' a^2 serves for the regulation of the admission of air to the latter, while the combustion at b' may be so regulated by a fire-proof cone, *e*, adjustable by the lever *f* and rod f', that a clear flame will be produced, even with the least possible admission of air.

The mixture of the air entering at a^4 with

the gas, and consequently the intensity of combustion, may be promoted by a platinum disk, e', fixed upon the cone e by a pin of like metal. In order to allow the flame to be observed, a small window, consisting of a pane of mica, is arranged at b^2. i is a cock for blowing off ashes.

The furnace is first supplied with fuel and the fire kindled through the aperture c. During the working this aperture remains closed, the fuel being then introduced by means of the contrivance C, or fuel-feeder, consisting in a cylinder, d, with piston d', movable by hand, the hopper d^2, communicating with the said cylinder and adapted to be closed against the inside pressure by the cover d^4, and the piston-like valve d^3, fitted with screw and hand-wheel. When the said valve is in closed state, the hopper may be opened and filled with fuel. The hopper having then been reclosed by the cover d^4 and the piston d' drawn back, the valve is raised, so that the contents of the hopper will drop into the cylinder d, and thereupon screwed down again. The fuel may then be pushed by the piston from the cylinder into the channel c, so that finally it will be conveyed into the furnace. This operation does not require any considerable force, provided the piston fits loosely enough to allow the gas-pressure to act on both surfaces of the same; also, the closing of the valve d^3 does not present any difficulty, as when the valve is rotated the guides d^5, with which the same is provided, scrape off the coals from the walls of the channel of connection between d and d^2, so that the valve then easily enters into the said channel. The piston is preferably fitted with a brush of wires. While the fire is being raised, air is allowed to enter through the cock i and the aperture c, and the combustion-gases issue through the pipes l and m into the atmosphere or a chimney. After a sufficient steam-pressure has been attained, the steam-valve is opened for establishing communication between the boiler and the cylinder of the steam-engine F through the pipe j, and thereby starting the same. The said engine then puts in motion the air-pump G, connected thereto, so that compressed air will be forced through the pipe k into the air-vessel H, and thence through the pipes a, a', and a^2 into the furnace. At the same time the pipe m is closed by the valve m', the compressed combustion-gases, after having given off the greater portion of their heat to the boiler for the generation of steam, being thereby compelled to pass through the apparatus D (to be described hereinafter) to the cylinder of the hot-air engine E, where they are utilized expansively to assist the steam-engine in its operation.

Theoretically the hot-air engine should do more work than the air-pump absorbs; but on account of the inevitable losses caused by leakage and radiation, the mechanical effect of the hot-air engine is ordinarily somewhat inferior to the power required for driving the pump, and this deficiency must be compensated by the steam-engine or by any other motor. The remaining power of the steam-engine may be utilized for other purposes.

The aforesaid apparatus D is but conditionally a necessary appurtenance. If the combustion-gases passing off from the boiler are sufficiently pure, and if they are not of too high temperature to be introduced directly into the hot-air engine, the said apparatus may be dispensed with; but usually, if mineral coal is employed as fuel, the gases contain ashes, vapors of tar, and sulphurous acid, which would injure and clog the engine. Besides, the temperature of the gases is not to be controlled sufficiently by the regulation of the combustion. In order to separate out the said noxious admixtures and to prevent the temperature from exceeding a certain limit, the gases are conducted through a watery alkaline solution contained in the vessel D, and which, on one hand, retains the sulphurous acid, the tarry vapors, and the ashes, while on the other hand it takes up the surplus of free heat of the gases with generation of steam. If, for instance, the temperature of the gases entering into D is 200° centigrade, and that of the liquid, which is under pressure, 150°, the quantity of heat corresponding to the difference of 50° will become latent in the steam produced. Upon the expansion of the gases in the cylinder of the hot-air engine, and the decrease of temperature resulting therefrom, the steam will be condensed, and its latent heat, in becoming free again, will be given back to the gases. In order to cause the gases to pass through the said liquid in thin streams, the vessel D is provided with the baffle-plates g, having notches at their lower edge, with which they dip into the liquid. (See Fig. 4.) The inclined plates h have the purpose of separating out from the gas-current any liquid carried along by the same, and to return it to the vessel D. The water evaporated in D is replaced, either at intervals or continuously, from the reservoir J, which is connected by the pipe o with the air-vessel H, in order to produce therein the same pressure as in D. The water runs from J into D over the inclined plates k. For preventing or diminishing radiation of heat, the apparatus D, the gas-pipes connected therewith, and the hot-air cylinder are surrounded by a jacket, p, through which the exhaust-steam from the steam-engine is conducted to the pipe q, opening out into the pipe m.

For the purpose of reducing the power required for the compression of the air, the air-pump is provided with means for diminishing the heat produced by the said compression. Preferably these means consist in the arrangement shown by Fig. 5 for injecting water in the form of spray into the cylinder of the pump during the suction period. This arrangement comprises a narrow channel, x, with contracted ends connecting the two ends of the cylinder in the manner shown by the drawings, and in the water-pipe y, opening

out with its ends, which are also contracted at a right angle and close to the ends of the pipe *x*. Two spray apparatuses are thus formed, which are actuated alternately by the air which is being compressed. This arrangement, however, does not form any part of my invention. The water thus mixed with the air separates out again in the air-vessel H, whence it is blown off at intervals.

The cylinders of the air-pump and of the hot-air engine are preferably made of the same size, and the expansion-gear of the latter is so adjusted that the gases will expand to about atmospheric pressure. This degree of expansion is admissible, because the frictional resistances of the said engine are overcome by the steam-engine, which in its turn profits by the economization of heat by means of the joint arrangement. Considering that during each stroke the resistance in the air-pump increases, while the pressure in the hot-air engine decreases, it is advantageous to so connect the respective pistons that the piston of the hot-air engine begins its stroke under full pressure somewhat before the maximum pressure has been attained in the pump. The work produced in the former and that consumed in the latter will, under these conditions, nearly balance each other in the different portions of the stroke. In the arrangement shown by the drawings, and in which the air-pump is actuated directly by the piston-rod of the steam-engine, this relation between the said pistons is attained by placing the crank *r* of the steam-engine at the requisite obtuse angle to the crank *s* of the hot-air engine.

The heat developed in the furnace may be utilized for other purposes besides that of generating steam—for instance, for melting metals. An apparatus adapted for this purpose is represented by Fig. 6. The gas generator *b*, provided with fuel-magazine shaft *t*, is placed below the melting-furnace *u* with hearth *u'*. The gas produced in *b* is conducted by the channel *v* to the apertures *v'*, and the air from the pipe a^2 to the apertures a^4. The combustion-gases pass through the channels *w* and *w'* into a steam-boiler. The shaft *z* is designed for the reception of a mold, *z'*, into which the liquid metal may be run under pressure in view of producing castings that are free from pores.

I claim as my invention—

1. The combination, with a closed furnace, of a steam-boiler receiving heat from the former, a pump for supplying compressed air to the furnace, a hot-air engine worked by the compressed combustion-gases from the said furnace, and a motor co-operating with the hot-air engine in driving the air-pump, substantially as and for the purpose described.

2. The combination, with a steam-boiler, A, of a closed furnace, B, an air-pump, G, supplying compressed air to the furnace through the pipes *a'* and a^2, the hot-air engine E, worked by the compressed combustion-gases from the furnace, and a steam-engine, F, connected to the boiler A and coupled with the engine E, the said engines E and F driving the air-pump G, substantially as and for the purpose specified.

3. The combination, with a closed furnace, a steam-boiler, a pump supplying compressed air to the furnace, a hot-air engine connected to the furnace, and a motor co-operating with the hot-air engine in driving the air-pump, of means for purifying the compressed combustion-gases on their course from the furnace to the hot-air engine, for reducing their temperature and for mixing them with steam, substantially as hereinbefore set forth.

4. The combination, with the closed furnace B, steam-boiler A, air-compressing pump G, hot-air engine E, connected to the furnace, and steam-engine F, connected to the boiler and coupled with the engine E, of the gas-purifier D, containing a watery alkaline solution and provided with the baffle-plates *g*, substantially as described.

5. The combination, with the closed furnace B, in which combustion is kept up under pressure, of the fuel-feeder C, comprising the cylinder *d*, piston *d'*, hopper d^2, with cover d^4, and valve d^3, provided with means for operating it and keeping it closed against the pressure acting thereon, substantially as and for the purpose specified.

6. The combination, with a steam-boiler, A, the air-compressing pump G, the hot-air engine E, and the steam-engine F, of a furnace adapted for melting metals, substantially as set forth.

In testimony whereof I have hereunto set my hand in the presence of two subscribing witnesses.

CARL OTTO.

Witnesses:
FRANZ MARLOW,
C. PARLZLAFF.