2 Sheets--Sheet 1.

N. A. OTTO.

Caloric Engines.

No. 145,123. Patented Dec. 2, 1873.

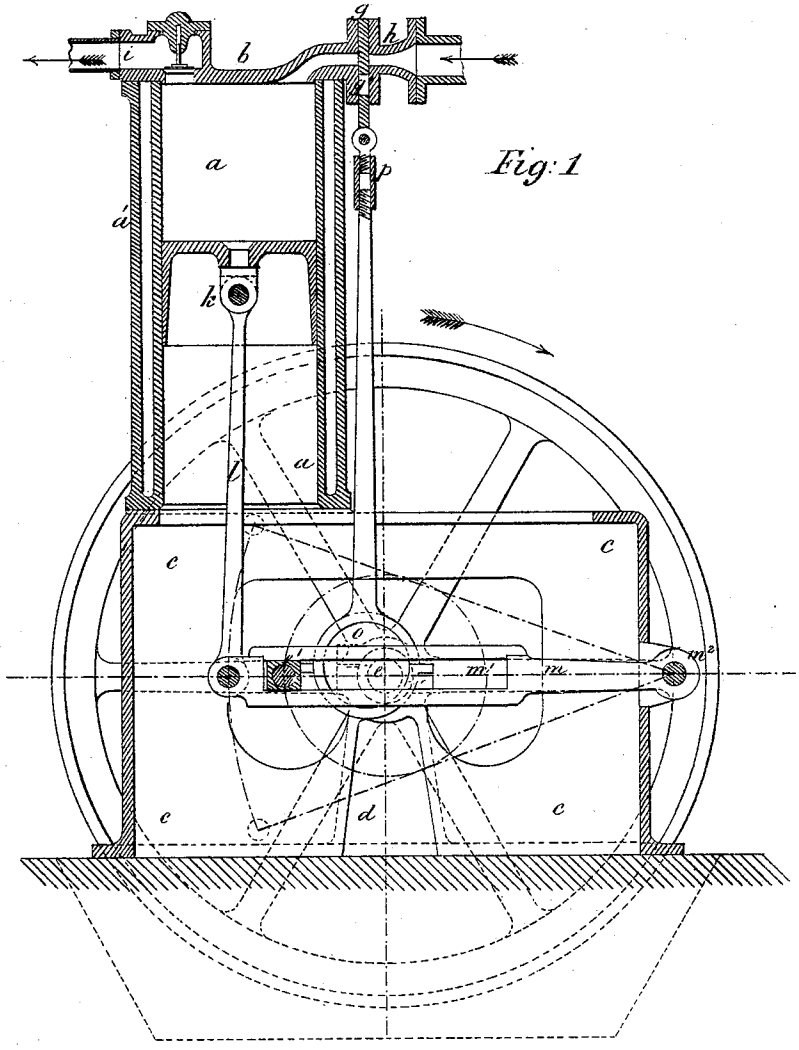

Fig: 1

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Nicolaus August Otto
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2 Sheets--Sheet 2.

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No. 145,123. Patented Dec. 2, 1873.

Fig: 2

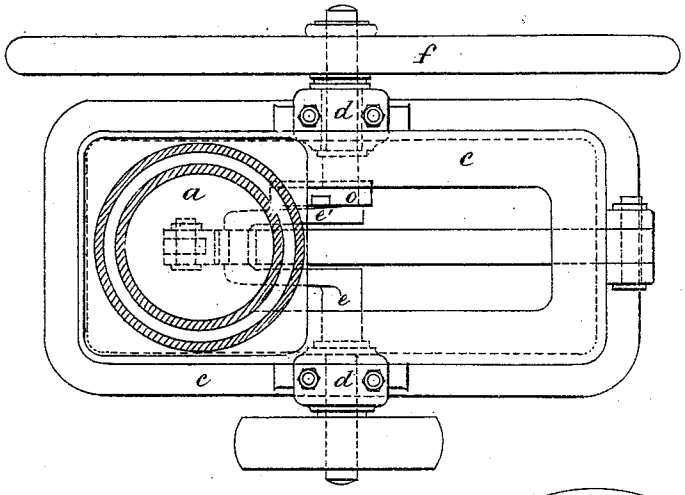
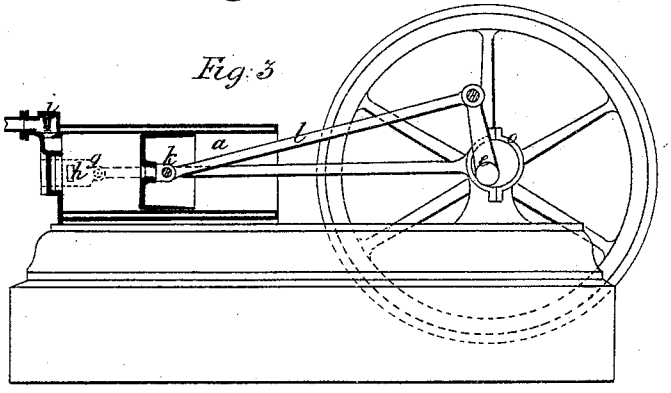


Fig: 3



WITNESSES

James L. Kay

Frederick Standish

INVENTOR

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UNITED STATES PATENT OFFICE.

NICOLAUS A. OTTO, OF GASMOTOREN-FABRIK DEUTZ, AT DEUTZ, GERMANY.

IMPROVEMENT IN CALORIC-ENGINES.

Specification forming part of Letters Patent No. **145,123**, dated December 2, 1873; application filed July 9, 1873.

To all whom it may concern:

Be it known that I, NICOLAUS AUGUST OTTO, of the Gasmotoren-Fabrik Deutz, at Deutz, in the German Empire, have invented an Improvement in Caloric-Engines; and do hereby declare that the following description, taken in connection with the accompanying sheets of drawings hereinafter referred to, forms a full and exact specification of the same, wherein I have set forth the nature and principles of my said improvement, by which my invention may be distinguished from others of a similar class, together with such parts as I claim and desire to secure by Letters Patent—that is to say:

In applying heated air, gas, or gaseous products of combustion to the working of a piston in a cylinder, for the purpose of obtaining motive power in caloric-engines, it is usual to admit the heated fluid to the cylinder at a pressure exceeding that of the atmosphere, and to employ this excess of pressure for the propulsion of the piston.

In the specification of a patent granted to me in conjunction with E. Langen, dated 13th August, 1867, No. 67,659, for an improvement in air-engines, was described an arrangement wherein a piston was propelled by the pressure of the products of combustion resulting from a gaseous explosion inside the cylinder, without doing work, the work of the engine being performed by the return stroke of the piston, subjected on the one side to the pressure of the atmosphere, and on the other side to the less pressure of the expanded and cooled products of combustion.

In the said engine the piston was, by peculiar devices, connected to and made to actuate the engine-shaft only during its return or working stroke, while it made its other stroke freely under the propulsive action of the expanding gases without actuating the engine-shaft.

Now my present invention relates to a method of and apparatus for obtaining motive power from heated air, gas, or gaseous products of combustion admitted to a cylinder at the pressure of the atmosphere and cooled therein, so that, their pressure on one side of the piston being reduced below that of the atmosphere, the excess of atmospheric pressure on the other side of the piston shall effect its propulsion, the piston in this case being always connected to the engine-shaft.

A certain amount of motive power might be gained according to this principle of action by admitting the heated gases during the entire forward stroke of the piston, and allowing them to cool, either by contact with the cooled sides of the cylinder, or by forcing them into a separate cooled chamber, or by injecting cold water into the cylinder, and the motive power obtained by this means would correspond to the amount of heat abstracted from the gases after the piston had completed its forward stroke, and while it was performing its return stroke; but, according to my present invention, a larger amount of power is obtained from the same expenditure of heat by dilating the gases to a considerable degree before they are cooled to any appreciable extent by radiation or absorption.

For this purpose I cut off the supply of the heated gases to the cylinder at a certain point—say, at two-thirds of the forward stroke of the piston—so that during the remainder of the stroke the confined gases are dilated. By this means a great portion of the heat of the gases is rendered latent, and the remaining portion of the heat is, to a great extent, absorbed by the cooled cylinder-surface, partly while the gases are being dilated, and partly while the piston is passing the dead-center of the crank, the cooling being practically completely effected, and consequently the pressure of the gases is reduced considerably below that of the atmosphere before the piston performs its return stroke.

During the return stroke of the piston the heat rendered latent by the previous expansion of the gases is, of course, liberated again as the gases are compressed by the piston; but the speed of the piston on the return stroke is such that this heat has time to be absorbed by the cooled cylinder-surface, and is thus prevented from producing an increase of pressure due to the presence of such heat. Thus, not only is the motive power expended in dilating the gases regained on the return stroke of the piston; but there results, also,

a further gain of power, which is equal to the difference between the pressure of the gases in the cylinder at each point of the forward stroke, and their reduced pressure at corresponding points of the return stroke.

Figure 1, Sheet I, of the drawings shows a vertical section, and Fig. 2, Sheet II, shows a sectional plan of the construction of caloric-engine which I prefer to employ in carrying my before-described invention into effect.

a is a vertical cylinder, open to the atmosphere at bottom, and closed air-tight at top by the cover *b*. The cylinder is fixed to a framing, *c*, carrying the crank-shaft *e* with fly-wheel *f* in bearings *d d*. The cylinder-cover *b* is provided with a valve-case, *h*, in which works the slide-valve *g*, and which communicates, through the pipe *h*, with any suitable known apparatus for producing heated air or gas or gaseous products of combustion. The cylinder-cover is also provided with an escape-valve, *i*, through which the gases escape from the cylinder *a*. The piston *k* is made to fit the cylinder in an air-tight manner, by preference, without packing, and is connected by the pitman *l* and slotted lever *m* to the crank *e'*. By causing the crank *e'* to work in the slot m^1 of the lever *m* pivoted, at m^2, to the framing *c*, the piston *k* will, on the rotation of the crank-shaft in the direction of the arrow, be caused to perform its down-stroke quicker than its upstroke. The motion of the slide-valve *g* is effected by the eccentric *o* on the crank-shaft.

The action of the engine is as follows: The piston *k* being at top of its upstroke, and the slide *g* being in such a position that the heated gases can pass through its aperture *g'* from the casing *h* into the cylinder, then, assuming the fly-wheel to be in motion in the direction of the arrow, the hot gases will be drawn into the cylinder by the rapid downward motion of the piston. At about two-thirds of the down-stroke of the piston, or at any other point of the stroke, the slide will have been moved by the eccentric, so as to cut off the supply of hot gases to the cylinder, so that, by the further downward motion of the piston, the confined gases will be dilated. By such dilatation a great portion of the heat of the gases will become latent, and the remaining sensible heat will, to a considerable extent, be absorbed by the cylinder-surface, (which is kept cool by means of a jacket, *a'*, containing cold water or other cooling medium,) partly while the piston is completing its down-stroke, and partly while it is turning the dead-center of the crank and is commencing its upstroke. By this means the pressure of the confined gases will be reduced considerably below that of the atmosphere, so that the upstroke of the piston will now be effected by the excess of pressure of the atmosphere acting upon its under surface, and the momentum thus imparted to the fly-wheel will cause the cooled gases to be expelled through the valve *i*, when the piston, at a certain point of its upstroke, shall have compressed them to a density equal to that of the atmosphere.

The power of the engine can be regulated either by heating the gases used to a greater or less degree, or by admitting a greater or smaller quantity of the heated gas into the cylinder. For the latter purpose the position of the slide is rendered adjustable by means of screw-coupling *p* on the eccentric-rod, so that the slide can be made to cut off at, say, from four-tenths to seven-tenths of the stroke.

By slight modifications of the slide-valve the engine may be worked either by heated air, or by the gaseous products of combustion of all such substances as would not cause an objectionable deposit in the cylinder, such as the products of combustion of air with coal-gas, hydrogen, petroleum, naphtha, alcohol, &c., and the combustion of such substances may be effected either outside the slide-valve, or in the cylinder itself.

By effecting the down-stroke of the piston rapidly, as described, the drawing in of the hot gases is effected in the shortest possible time, and the loss of heat during the time that the gases are entering the cylinder and are being dilated is consequently very small.

Instead of the arrangement described for producing the quick down-stroke and slow up-stroke of the piston, any other known arrangements of mechanism for effecting an alternately quick and slow reciprocating motion, such as are in use in planing and other machines, may be employed.

The engine may, however, be made to work without the before-described difference of speed in the up-and-down-strokes by connecting the piston-rod *l*, directly to the crank-shaft *e*, as shown in the modified arrangement at Fig. 3, Sheet II; but in this case the engine must be made to work more rapidly, and the requisite cooling of the gases must be effected by cutting off the supply of hot gases sooner, so as to obtain a greater degree of dilatation.

The above-described method of operating in caloric-engines permits of the use of engines of the most simple construction, and has the further advantage that the expensive apparatus for producing heated air or gases under considerable pressure is dispensed with.

Such engines may either be arranged in a vertical or horizontal or other desired position, and may be used either as stationary or as portable engines.

Having thus described the nature of my invention, and in what manner the same is to be performed, I claim—

1. The method of utilizing heated gases in caloric-engines, by drawing them, at high temperature and at atmospheric pressure only, quickly into the cylinder, and cooling them therein, whereby the pressure on one side of the piston is reduced below that of the atmosphere on the other side, substantially in the manner and by the means set forth.

2. The mode of utilizing heated gases in a

caloric-engine, by admitting them to the cylinder during only a portion of the forward stroke, and dilating them by the farther motion of the piston, as distinguished from causing them to act expansively against the piston, in the manner and by the means substantially as set forth.

3. In caloric-engines, the jacketed cylinder *a*, open to the atmosphere at one end, with slide *g* for cutting off the supply of heated gases, and valve *i* for discharging the cooled gases, in combination with the piston *k* connected to the crank-shaft *e* with fly-wheel *f*, in such manner that the piston performs its outward stroke quicker than its return stoke, substantially as and for the purposes herein set forth.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses, this 16th day of May, 1873.

NICOLAUS AUGUST OTTO.

Witnesses:
EMIL LOHMANN.
CASPAR BIRKER.