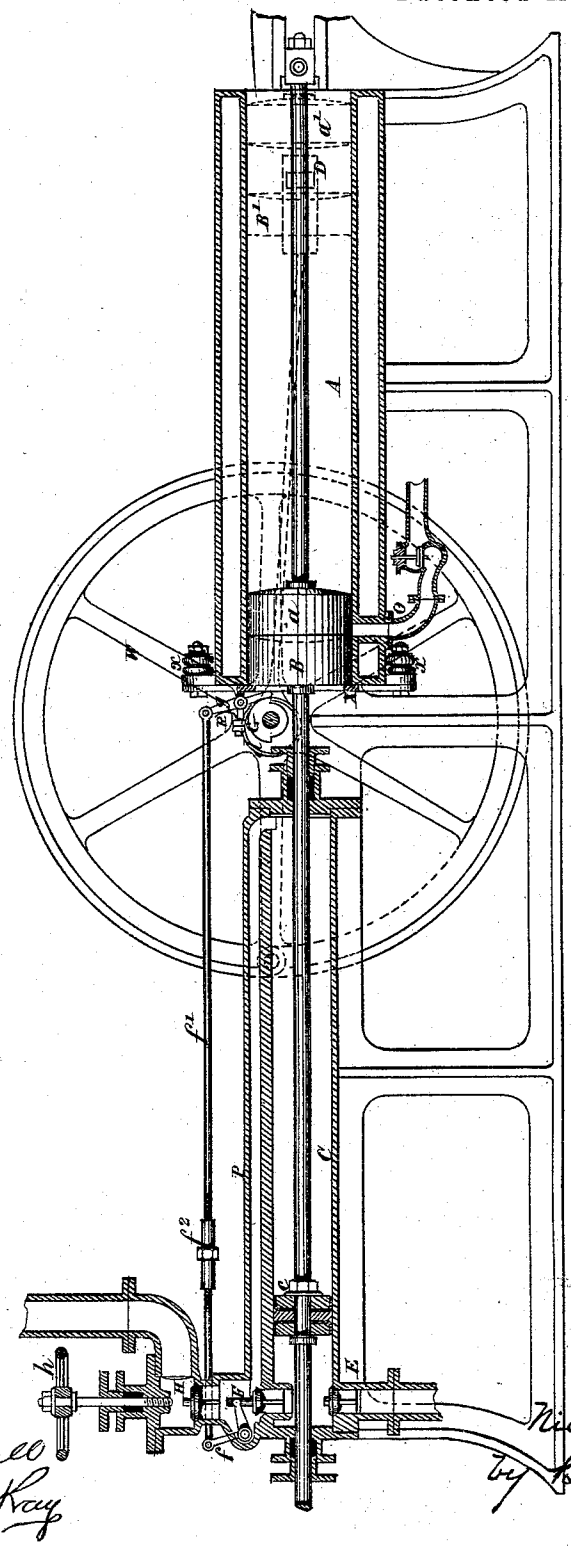
2 Sheets—Sheet 1.

N. A. OTTO.

GAS MOTOR ENGINE.

No. 178,023. Patented May 30, 1876.

Fig. 1.



Witnesses.

R. H. Churchill

James E. Kay

Inventor

Nicolaus A. Otto

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Attys

2 Sheets—Sheet 2.

N. A. OTTO.

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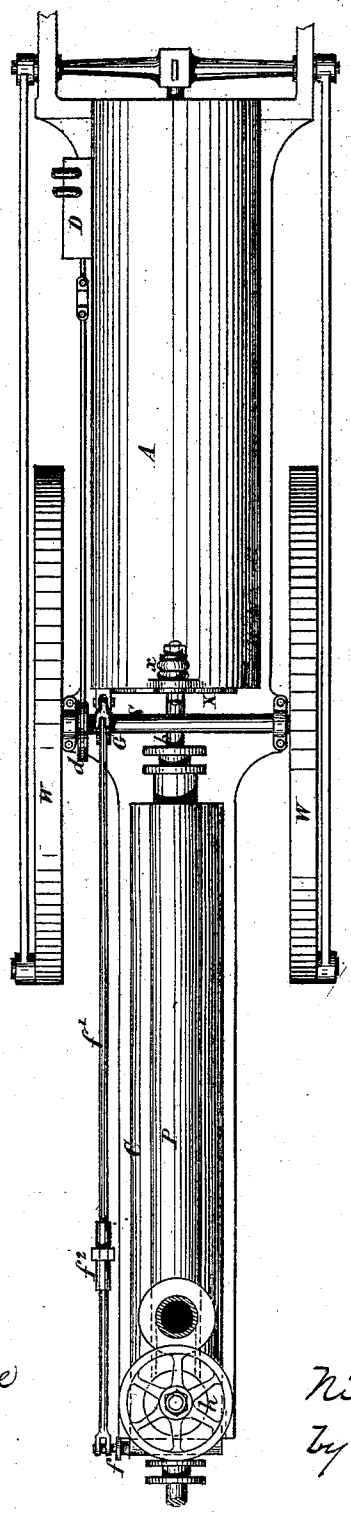

Fig. 2.

WITNESSES.

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UNITED STATES PATENT OFFICE.

NICOLAUS AUGUST OTTO, OF DEUTZ, GERMANY.

IMPROVEMENT IN GAS-MOTOR ENGINES.

Specification forming part of Letters Patent No. **178,023**, dated May 30, 1876; application filed January 10, 1876.

To all whom it may concern:

Be it known that I, NICOLAUS AUGUST OTTO, of the Gas-Moteren Fabrik-Deutz, at Deutz, in the Empire of Germany, have invented an Improvement in Gas-Motor 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:

My invention relates to gas-motor engines of that kind in which a mixture of combustible gas and air is ignited within a cylinder, the explosion propelling a loose piston without doing work; and then, as the products of combustion contract by cooling, reducing the pressure within the cylinder, another piston is forced inward by the excess of atmospheric pressure, and this piston, being connected to cranks on a fly-wheel shaft, gives, during its instroke, an impulse to the rotation of the shaft, which is utilized as motive power. A portion of the power thus developed may also, according to the construction which I will describe, be applied to the pumping or forcing of water or other liquid.

In engines of the kind referred to, it has been usual to apply clamps, friction-clutches, ratchets and pawls, or other mechanical devices, for the purpose of holding at suitable times the loose piston, or, in some forms of such engines, for alternately connecting one piston to the rotating shaft, and disconnecting it therefrom, so as to make this piston act in the double capacity of loose and working piston.

The object of my invention is to dispense with such mechanical devices, which have proved a source of difficulty in the construction of such engines, and of rapid wear in their working, and to substitute for them the hydraulic action of water or other liquid, as I will now describe, referring to the accompanying drawings, of which—

Figure 1 represents a longitudinal section, and Fig. 2 a plan, of a gas-motor engine according to my improved construction.

A is a water-jacketed cylinder, open at both ends, and fitted with a working piston, *a*, which is connected by a cross-head and side rods to crank-pins on two fly-wheels, W W, keyed on a shaft, S. In the same cylinder is fitted a loose piston, B, which is connected by a rod, *b*, to a piston, *c*, fitted in a hydraulic cylinder, C. On the side of the cylinder A, near its outer end, is fitted a slide, D, such as is usually employed in engines of the kind referred to above, worked by an eccentric, *d*, for the admission of the combustible gaseous mixture and the igniting-flame to the cylinder A. There is also provided, near the inner end of the cylinder A, an outlet-opening, O, fitted with a valve opening outward, for the issue of the products of combustion from the cylinder. The hydraulic cylinder C has a side passage, P, communicating from the one end to the other, and is provided at its outer end with a suction-pipe and valve, E, opening inward with a valve, F, which is free to open upward, tending to close of itself when there is excess of pressure on its upper side, but which can be raised from its seat by a bell-crank lever, *f*, worked by a rod, *f'* from a lever, *g*, operated by a cam, G, on the fly-wheel shaft S in the one direction, and by a spring, R, in the other direction. Above the valve F is a discharge-valve, H, opening outward, which can be held down more or less closely to its seat by a screwed spindle, worked by a hand-wheel, *h*.

I will first describe the working of the engine when the valve H is held down on its seating, the hydraulic cylinder C and its passage P being fully charged with water, oil, or other suitable liquid.

I will assume that the working piston *a* has, by the revolution of the fly-wheels, been brought to the extreme of its outstroke, as indicated by the dotted lines *a'*, the loose piston B having been arrested in the position B', so that the space between *a'* and B' has received a charge of the combustible gaseous mixture. This mixture being ignited the piston B is propelled inward, and, in case of its tending to move too far, is checked by a ring, X, provided with elastic buffers *x*. As B is thus propelled it forces the piston *c* outward, and displaces the liquid in the hydraulic cylinder C by causing it to flow from the outer end of the cylinder past the valve F, which opens for its

passage, along the conduit P to the inner end of the cylinder. The loose piston having been thus propelled to B, just past the outlet O, the gaseous products in the cylinder A tend to contract by their cooling, and thus the pressure within the cylinder is reduced below that of the external atmosphere.

The excess of external pressure now tends to force back the piston B, but it is held stationary by its connection to the piston *c* because the valve F closes and prevents the liquid from flowing back to the outer end of the cylinder C. The external pressure therefore forces the piston *a* inward, and its movement gives an impulse to the fly-wheels. As the piston *a* approaches B the gaseous products of combustion in the space between the two pistons become compressed; but the momentum of the fly-wheels continue the instroke of *a*, so that these products are forced out by the outlet O. The piston *a*, having thus come close up to B, the cam G causes the valve F to rise from its seat, so as to give free passage for the liquid from end to end of the hydraulic cylinder C. The piston *a*, being now caused by the momentum of the fly-wheels to make its outstroke, the piston B follows it. The cam G is, however, so formed and set that when B has got to the position B′ the valve F is permitted to close, stopping the loose piston at B′. The piston *a* now continuing its outstroke to *a′*, a charge of the combustible gaseous mixture is drawn through the slide D into the space between *a′* and B′, and the igniting-flame being also drawn in, the mixture is exploded, whereupon the action is repeated, as already described. According to this mode of working the whole of the power developed is transmitted to the fly-wheel shaft, and for an engine intended to work in this manner the suction and discharge pipes and valves E and H may be dispensed with.

I will now describe a mode of operating whereby a portion of the power is applied to pumping or forcing liquid. This is effected by turning the hand-wheel *h*, so as to give the valve H freedom to rise more or less from its seat. When this is done the piston *c*, during its instroke or movement toward the shaft S, draws in a portion of the liquid by the suction-valve E, and discharges a portion of the liquid contents of the cylinder by the valve H, the opening of the valve F being adjusted by varying the throw of the cam G, or, more simply, by altering the length of the rod f^1 by an adjusting-nut, f^2, so as to permit less or more of the liquid to pass it from P to the outer end of the cylinder C during the instroke of *c*. When the engine operates in this manner the pistons *c* and B are not held stationary during the instroke of *a*, because liquid can enter by the valve E and issue by H; but while *a* is making its instroke, B makes part of an outstroke to meet *a*, and then the momentum of the fly-wheels carrying *a* onward, B is pushed back and the products of combustion are discharged at O, as already described. Moreover, while *a* is making its outstroke, B following, it is not absolutely stopped in the position B′ by the liquid in C, which is free to flow by the valves E and H, but it naturally stops when the gaseous mixture is admitted by D, because the atmospheric pressure on B′ is then counterbalanced.

Having thus described the nature of my invention, and the best means I know of carrying the same into practical operation, I claim—

In gas-motor engines, wherein a combustible gaseous mixture is exploded without doing work, and the contraction of the products of combustion due to cooling is utilized for producing motive power—1. The method of alternately arresting and permitting the movement of a piston by regulating the flow of a liquid in a hydraulic cylinder, substantially in the manner and for the purposes herein set forth: 2. The combination of the loose piston B with a piston, *c*, working in a hydraulic cylinder provided with passage P and valve F, operated by a cam, G, substantially as herein described, with reference to the accompanying drawings: 3. The combination of the loose piston B and piston *c*, working in a hydraulic cylinder having passage P and valve F, operated by a cam, G, with the suction-valve E and adjustable discharge-valve H, for the purpose of utilizing part of the motive power for pumping or forcing liquids, substantially as herein described, with reference to the accompanying drawings.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses, this ninth day of November, 1875.

NICOLAUS AUGUST OTTO.

Witnesses:
GUSTAV KLEINJUNG,
FRIEDRICH ALBERT SPIECKER.