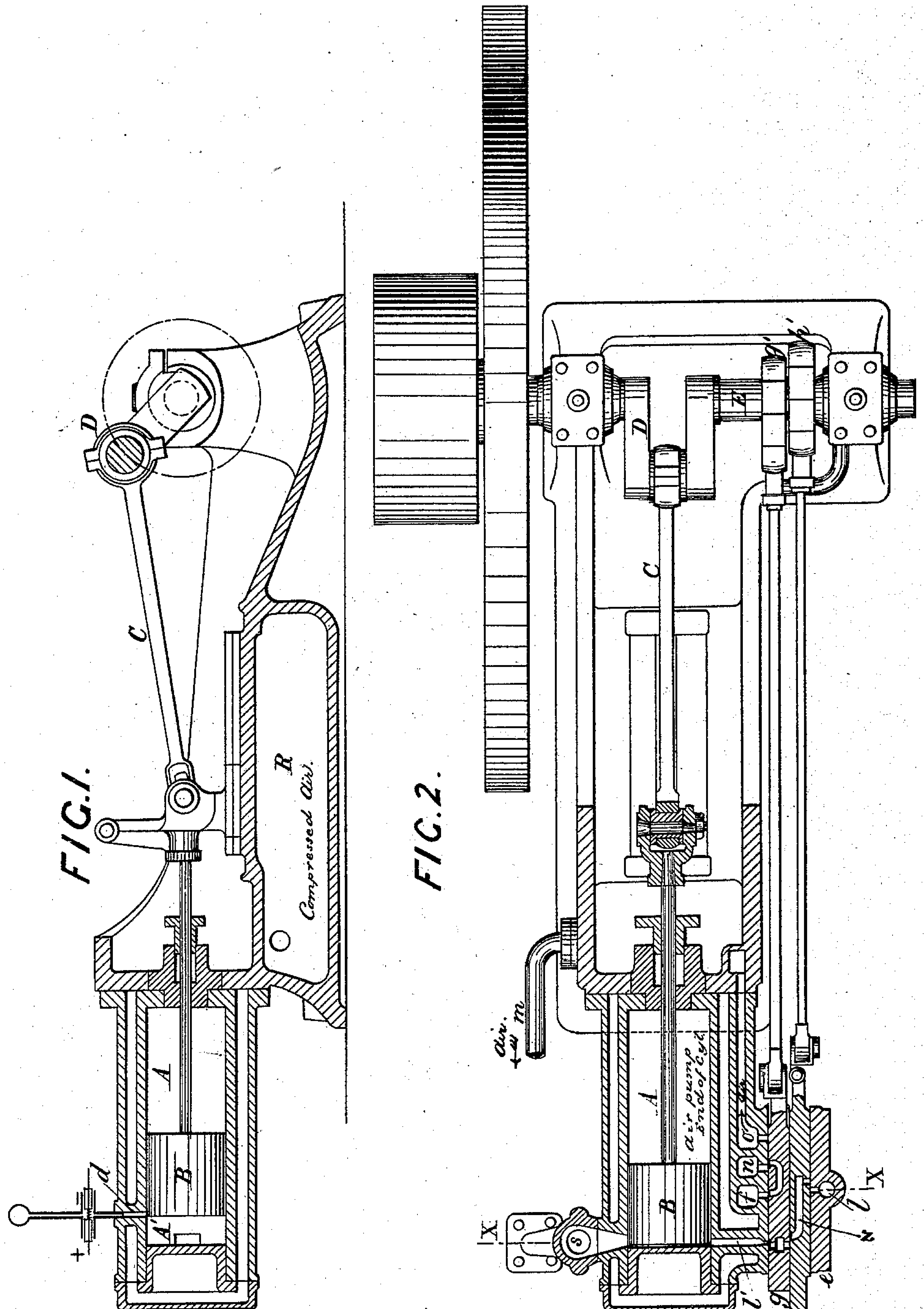
(No Model.) 3 Sheets—Sheet 1.

N. A. OTTO.

GAS MOTOR ENGINE.

No. 388,372. Patented Aug. 21, 1888.



Witnesses.
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(No Model.) 3 Sheets—Sheet 2.

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FIG. 3.

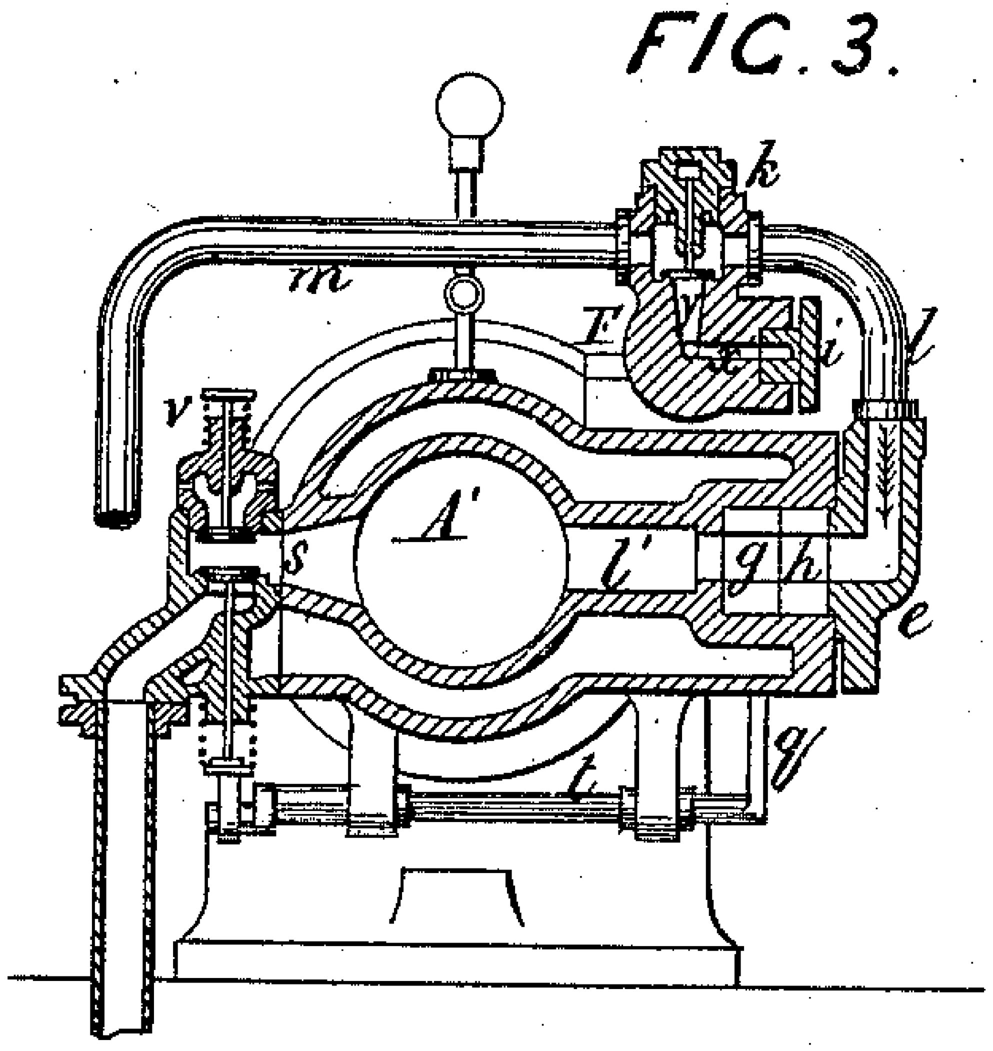


FIG. 10.

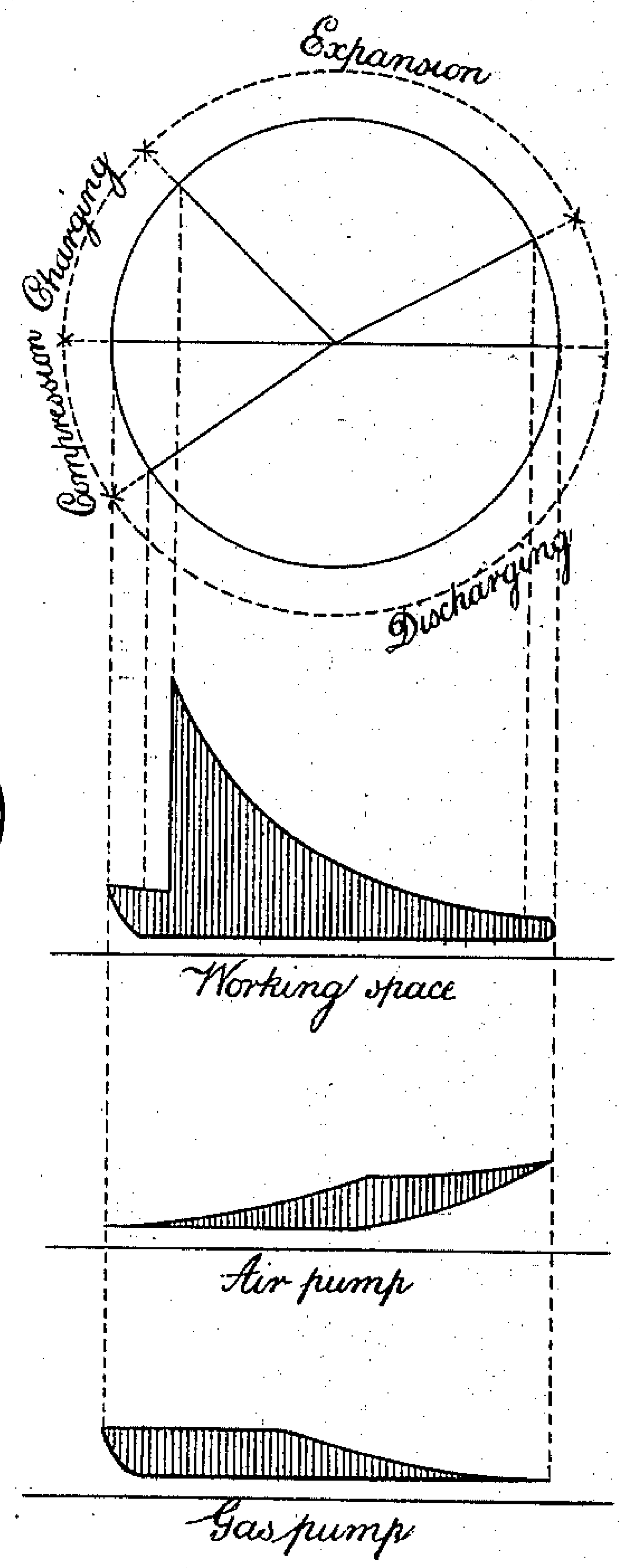


FIG. 4A

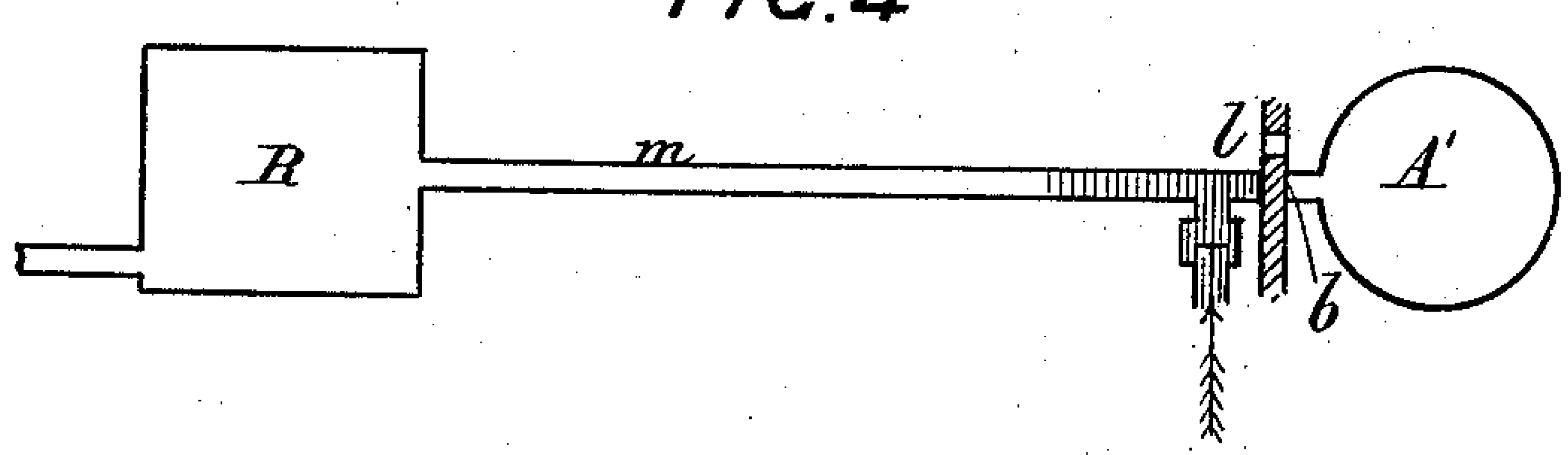
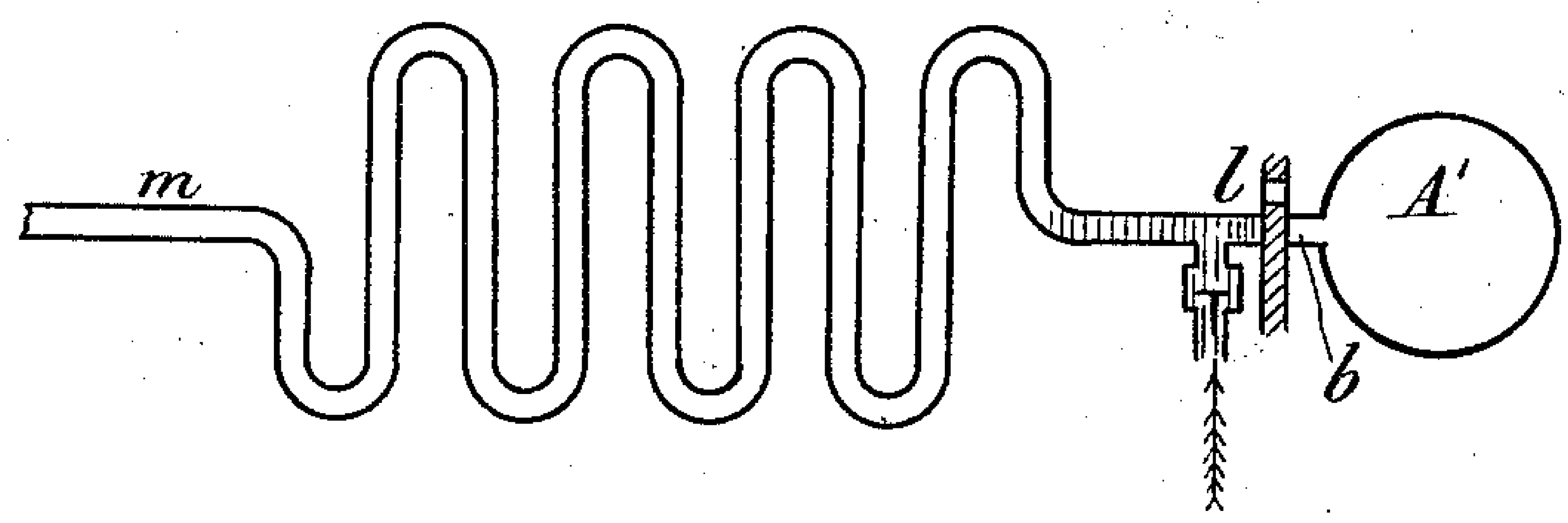


FIG. 4B.



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GAS-MOTOR ENGINE.

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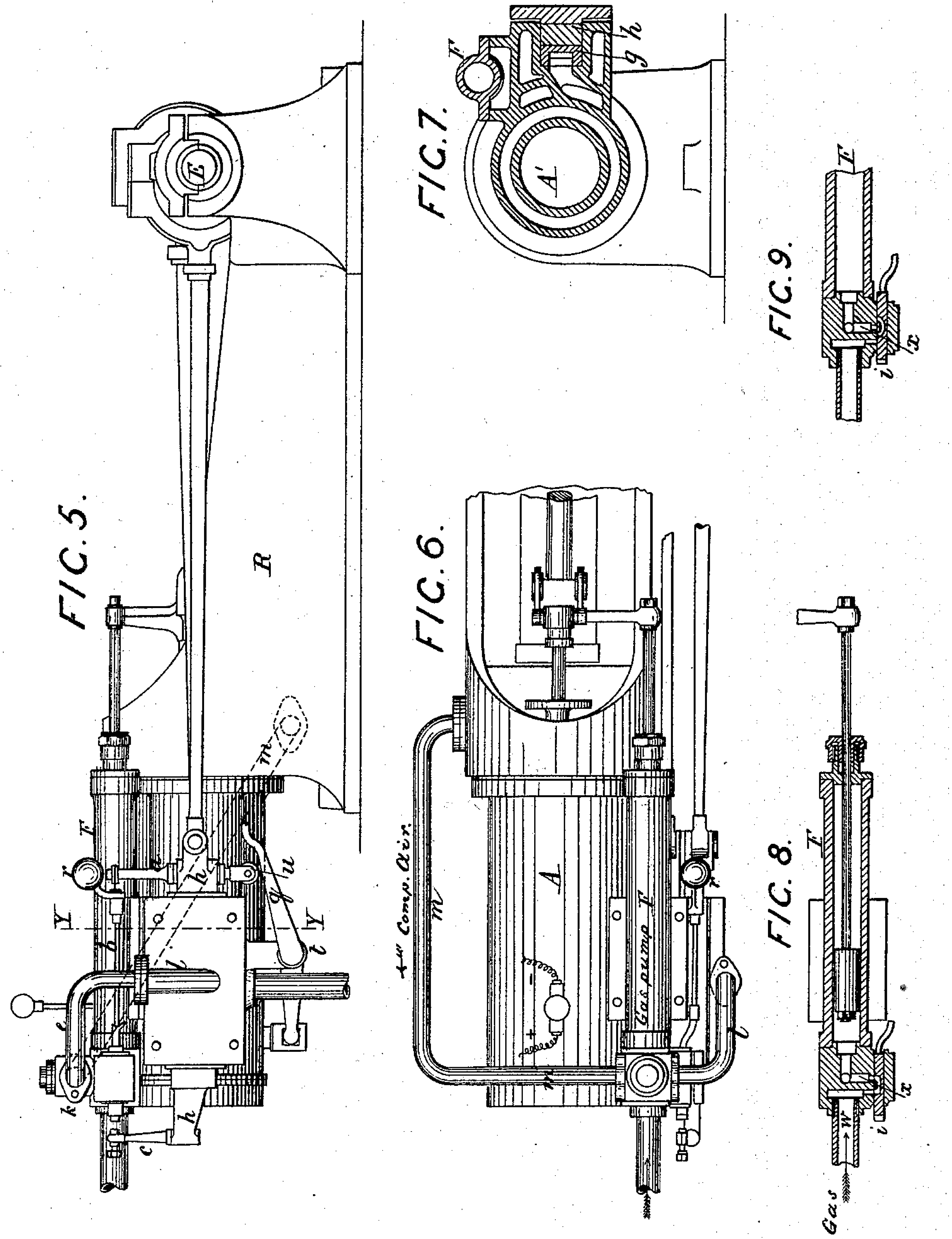

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UNITED STATES PATENT OFFICE.

NICOLAUS AUGUST OTTO, OF COLOGNE, PRUSSIA, ASSIGNOR TO THE GAS MOTOREN FABRIK DEUTZ, OF DEUTZ-ON-THE-RHINE, GERMANY.

GAS-MOTOR ENGINE.

SPECIFICATION forming part of Letters Patent No. 388,372, dated August 21, 1888.

Application filed October 10, 1887. Serial No. 251,945. (No model.) Patented in Germany August 27, 1887, No. 43,185; in England September 8, 1887, No. 12,187; in Belgium September 21, 1887, No. 78,948; in Italy November 12, 1887, XLIV, 190, and in Austria-Hungary March 3, 1888, No. 37,627 and No. 3,857.

To all whom it may concern:

Be it known that I, NICOLAUS AUGUST OTTO, a citizen of Prussia, residing at Cologne, in the Empire of Germany, have invented new and useful Improvements in Gas-Motor Engines, (for which I have obtained a patent in Belgium, September 21, 1887, No. 78,948; in Germany, August 27, 1887, No. 43,185; in Italy, November 12, 1887, Vol. XLIV, No. 190; in Austria-Hungary, March 3, 1888, No. 37,627 and No. 3,857, and by an application for patent filed September 8, 1887, No. 12,187,) of which the following is a specification.

This invention relates to an improved construction of gas-motor engine, in which a reservoir is charged with combustible gas and air in such manner and is so arranged as to feed the engine-cylinder with a compressed mixture of gas and air in a perfectly safe manner.

The employment of a reservoir containing combustible mixture under pressure for the supply of gas-motor engines is well known. In this arrangement the gas and air are either fed in separately by means of gas and air pumps, or both are forced in together by a single pump. In both cases the reservoir is filled entirely with explosive mixture, of which a small portion is admitted to the engine-cylinder. Such engines cannot work without danger, as the contents of the reservoir are liable to be accidentally fired.

The present invention has for its object to obviate this danger by so arranging the reservoir and the charging thereof with gas and air that a considerable quantity of explosive mixture cannot be stored therein at one time.

Referring to the drawings, Figure 1 is a longitudinal section of an engine constructed in accordance with my invention; Fig. 2, a horizontal section thereof. Fig. 3 is a vertical cross-section on the line *x x*, Fig. 2; Figs. 4[a] and 4[b], detail views of two different forms of reservoirs for the gas and air; Fig. 5, a side elevation of the engine; Fig. 6, a partial plan thereof; Fig. 7, a cross-section on the line *y y*, Fig. 5; Figs. 8 and 9, detached views of the gas-pump; and Fig. 10, a diagram illustrating the operation of the cylinder, air-pump, and gas-pump.

As shown in the diagram, Fig. 4[a] of the accompanying drawings, the reservoir may consist of a tube, *m l*, in connection with a chamber, R; but it may also consist only of a long tube, such as a serpentine tube, *m l*, as at Fig. 4[b], having sufficient capacity to contain the required volume of compressed air, together with the necessary volume of compressed gas. Assuming that the reservoir be in both cases filled with compressed air, and that at the part *l* next the working-cylinder there be forced in a certain quantity of gas, being small in proportion to the capacity of the reservoir, this charge of gas will force back the air out of that part, and will remain localized in the part of the tube next the inlet-opening *h*.

The comparatively small sectional area of the tube affords to the air and gas so small a surface of contact that a mingling of the same will only take place to a small extent. If, now, the charge thus contained in the reservoir be let into the cylinder by opening the slide or valve *h*, the gas will first enter, being forced in entirely by the following air, with which it will then become mixed in the cylinder. With this arrangement it will be seen that the reservoir can never become charged with explosive mixture, so that all danger from explosion is avoided. The combustible gas is only forced into the tube *m l* at a point near the inlet to the working-cylinder. The compressed air can also be introduced at that point, in which case it must be forced in first and the gas afterward. It is, however, more advantageous to introduce the air at the opposite end of the reservoir, in which case the air and gas can either be forced in simultaneously or in any desired order.

Figs. 1 to 3 and 5 to 9 show by way of example a construction of gas-engine arranged and operating according to the above-described invention.

In the arrangement here shown the working-piston and the piston of the gas-pump make their strokes together, and the total charge of the gas-pump is forced into the reservoir *m l* before the charge commences to enter the cylinder. These pistons may, however, have their relative movements so arranged that only a portion of the charge of the gas-pump passes into the reservoir *m l* at *l* before the commencement of the charging of the working-cylinder, or after the end of such charging, the other portion being made to enter directly into the cylinder while this is being charged.

The space A of the cylinder in front of the piston is closed by a cover and constitutes an air-compressing pump operating with a distributing slide-valve, *g*, worked by an eccentric, *g'*. The air drawn in passes, through passages *f*, the passage in the slide, and passage *n*, into the space A, whence, after compression by the outstroke of the piston, it is caused by the passage of the slide *g* to pass through passages *n* and *o* into the air-reservoir R, formed in the cylinder-framing. The gas is compressed by a gas-pump, F, fixed to the engine-cylinder, parallel with the axis thereof. The piston-rod of this pump is connected to the cross-head of the engine-cylinder, and the piston consequently has the same stroke as that of the latter. In the position of the gas-pump slide *i* shown in Fig. 8 the gas passes from the inlet-pipe *w* through the slide-passage and passage X into the pump-cylinder F while the piston is performing its suction-stroke. During the return-stroke of the piston, the slide being brought into the position at Fig. 9, the gas is first compressed and then passes through passage *y* and check-valve *k*, Fig. 3, into the tubular extension *m l* of the reservoir R, which is charged with compressed air. At the end of the instroke of piston B the slide *h*, worked by eccentric *h'*, establishes a communication, by means of its passage Z and a passage in slide *g*, between the tubular reservoir *l m* and the working-space A' of the engine-cylinder, so that the charge of compressed gas and air will enter the latter from the reservoir in the above-described manner. Before the piston B uncovers the passage *d*, Fig. 1, the inlet of gas and air into the cylinder is cut off by the movement of the slides, and the charge is then ignited by any suitable igniting device communicating with the passage *d*. In the arrangement shown the ignition is effected by an electric current. The slide *h* has at each end a standard, *a* and *c*, Fig. 5. To the standard *a* is connected a lever-regulator, the horizontal arm *b* of which is carried by a blade-spring and is connected to a weight *r*. When the engine is running at the normal speed, the lever *b* will push the slide *i* backward, so that the gas can pass into the gas-pump F. At the return-stroke of the slide *h* the standard *c* butts against the other end of the slide *i*, and thus brings it back into the position shown at Fig. 9, in which the gas-supply to the pump is cut off. If the normal speed is exceeded, the lever *b* is raised by the action of the weight *r*, and thus misses the stem of the slide *i*, so that this remains closed, and consequently, no gas being supplied to the gas-pump, the engine-piston will perform its outstroke without doing work. The escape-valve *s* of the cylinder is opened at the end of the piston's outstroke by means of the slide *h*, an arm with roller *u* on the latter being made to depress the lever *q*, which effects the opening of the valve. When the piston B performs its outstroke without admission of gas, as described, it still has a charge of compressed air admitted into it. This charge is, however, not compressed to such an extent that it will still be at atmospheric pressure when fully expanded at end of outstroke, and in order to prevent a partial vacuum being thus formed in the cylinder an automatic vacuum-valve, *v*, Fig. 3, is provided for admitting the outer air therein; or, instead of providing a special valve for this purpose, the discharge-valve *s* may be so arranged as to open automatically when a partial vacuum is formed in the cylinder.

Having thus described the nature of my invention and the best means I know for carrying the same into practical effect, I declare that what I claim is—

In a gas-motor engine worked by charges of combustible gas and air under pressure, the method of forcing into a reservoir containing air under pressure a quantity of combustible gas sufficient for one cylinder-charge, such quantity being situated next the inlet-port of the engine in a part of the reservoir of restricted area, so that it will practically not mix with the air in the reservoir and will be entirely introduced into the cylinder by the pressure of the air on the opening of the inlet valve or slide, substantially as herein described.

In testimony whereof I have signed my name to this specification, in the presence of two subscribing witnesses, this 22d day of September, A. D. 1887.

NICOLAUS AUGUST OTTO.

Witnesses:
WILHELM V. LANGSDORFF,
WILHELM RINCK.