No. 848,029. PATENTED MAR. 26, 1907.

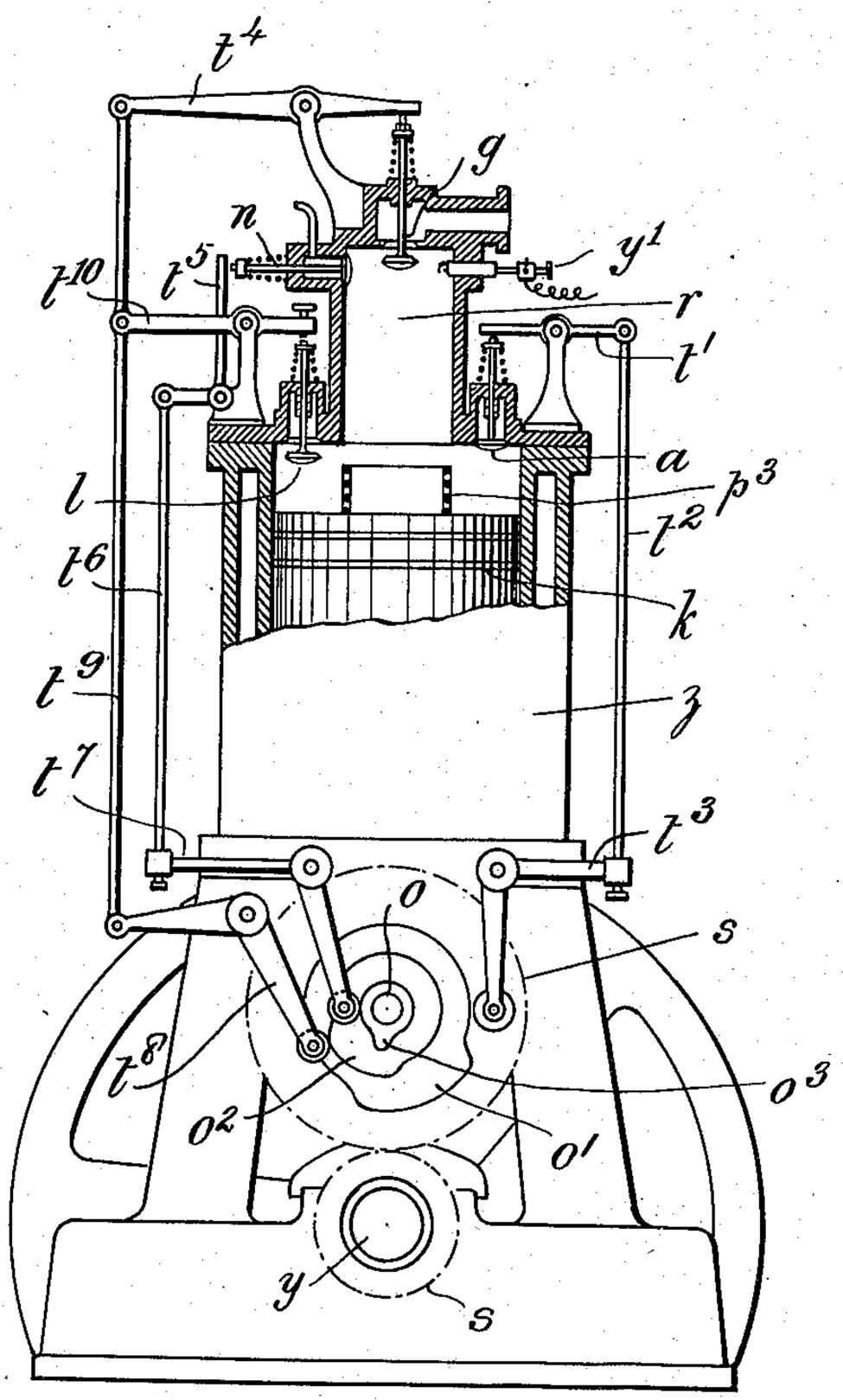
F. A. HASELWANDER.

INTERNAL COMBUSTION ENGINE.

APPLICATION FILED MAY 23, 1901.

3 SHEETS—SHEET 1.

Fig: 1.



Witnesses
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3 SHEETS—SHEET 2.

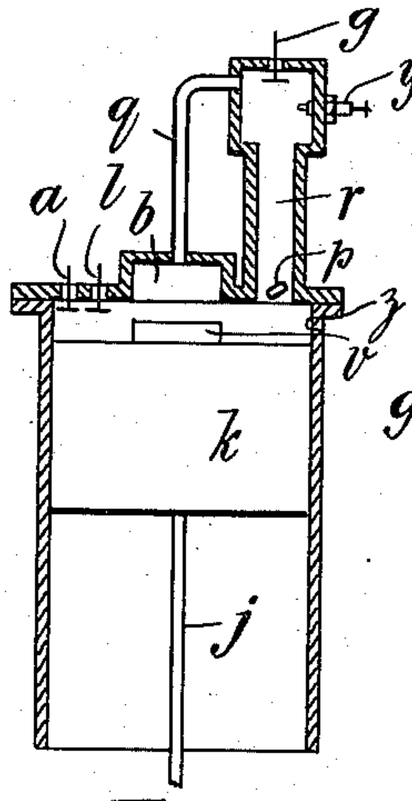

Fig: 2.

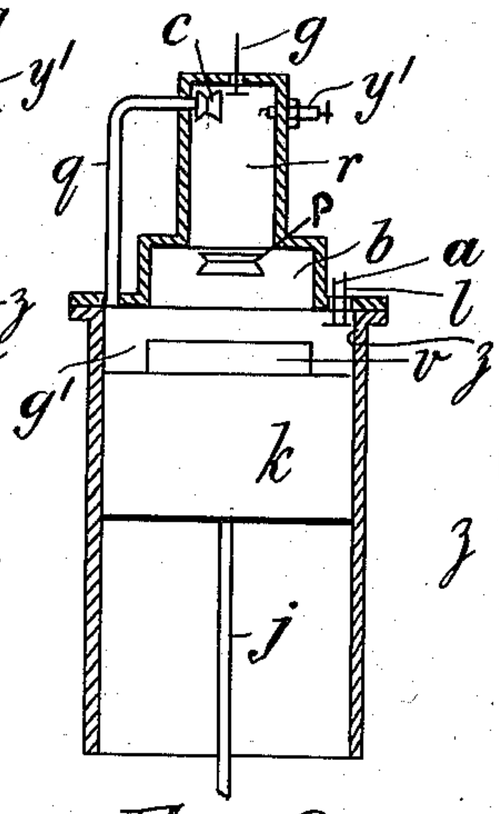

Fig: 3.

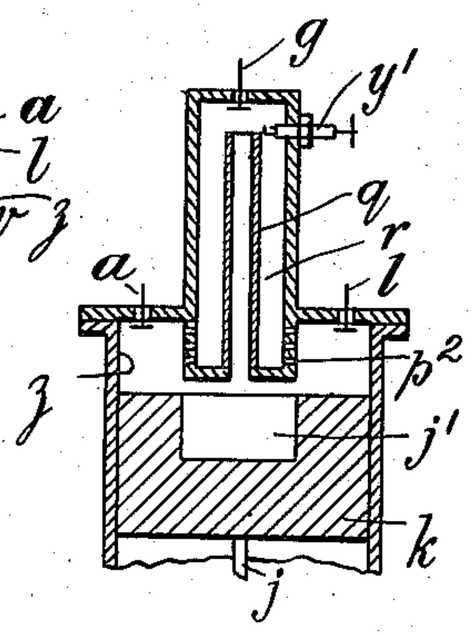

Fig: 4.

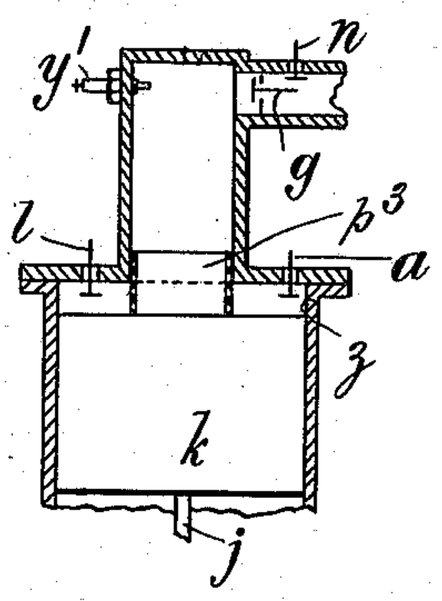

Fig: 5.

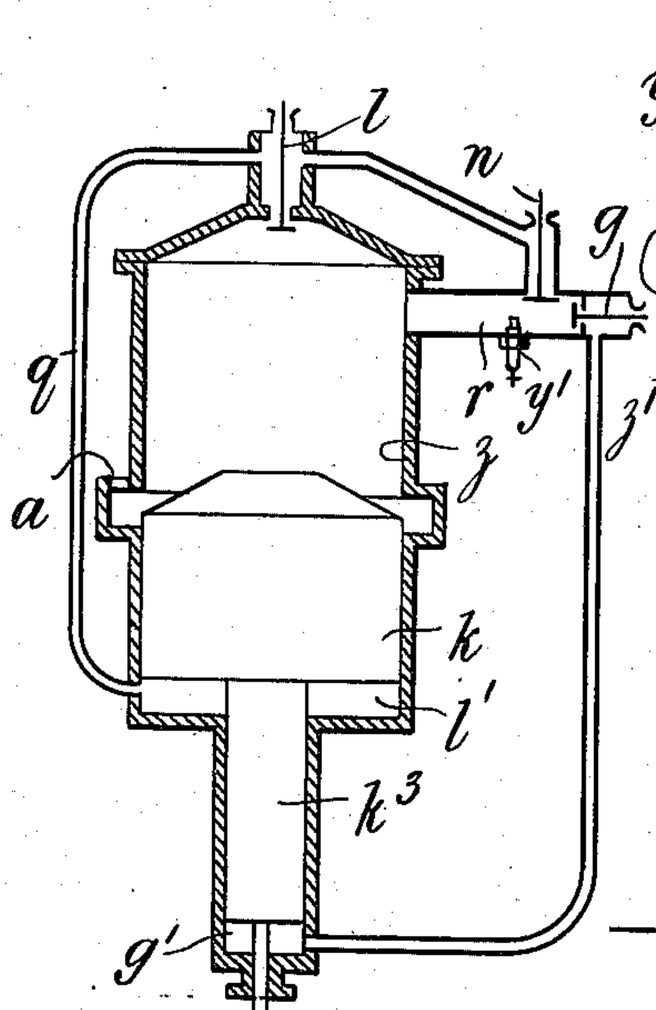

Fig: 6.

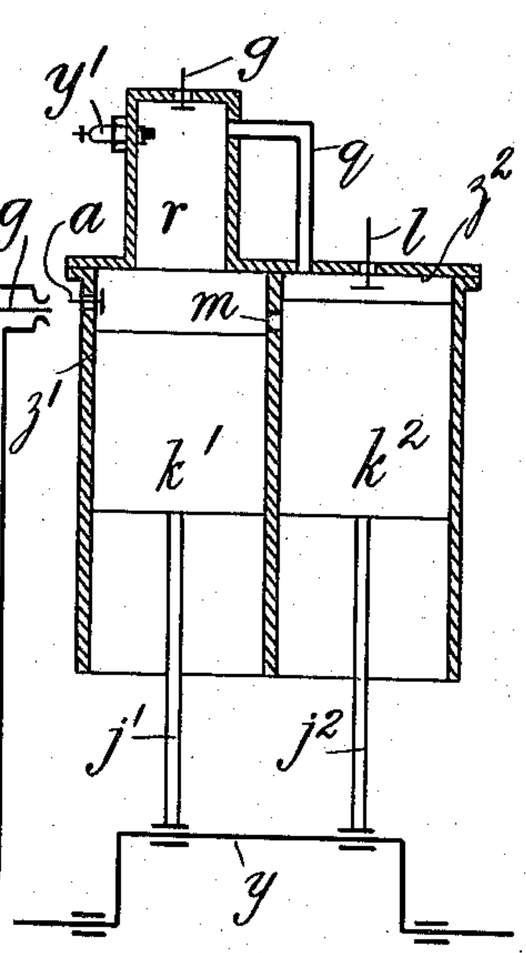

Fig: 7.

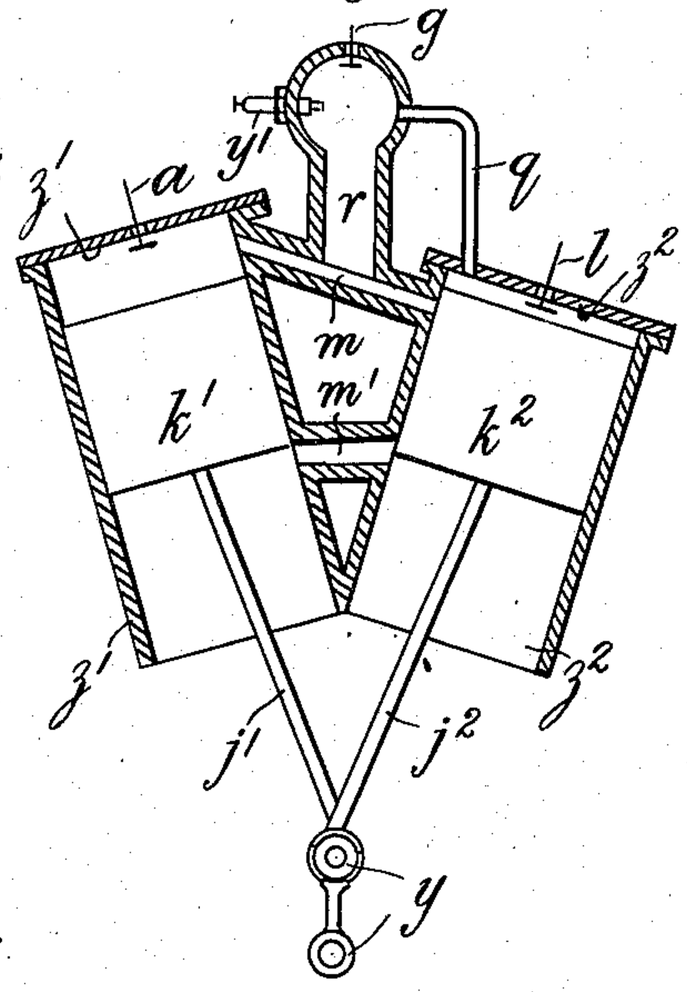

Fig: 8.

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3 SHEETS—SHEET 3.

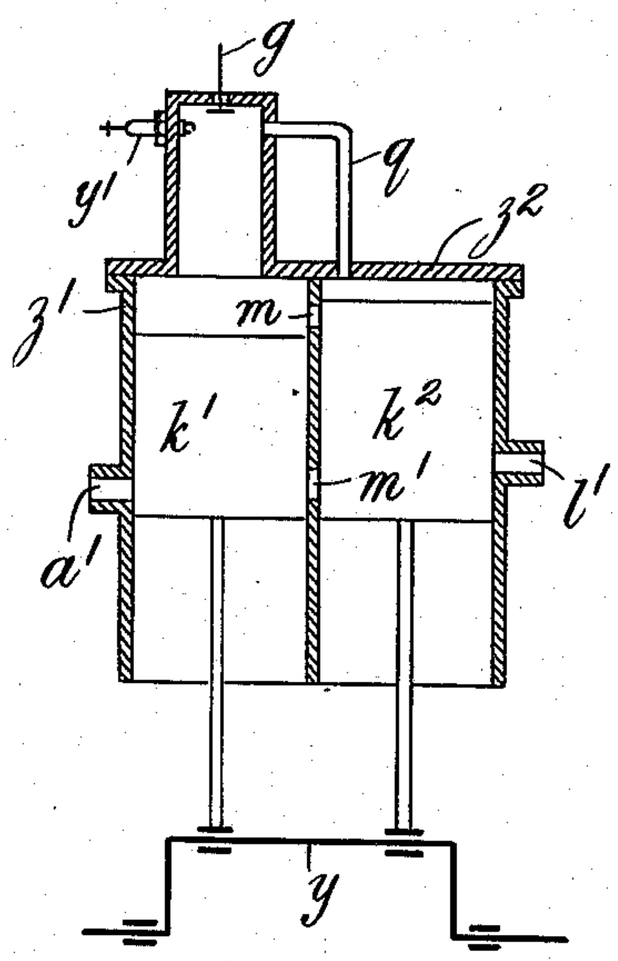

Fig: 9.

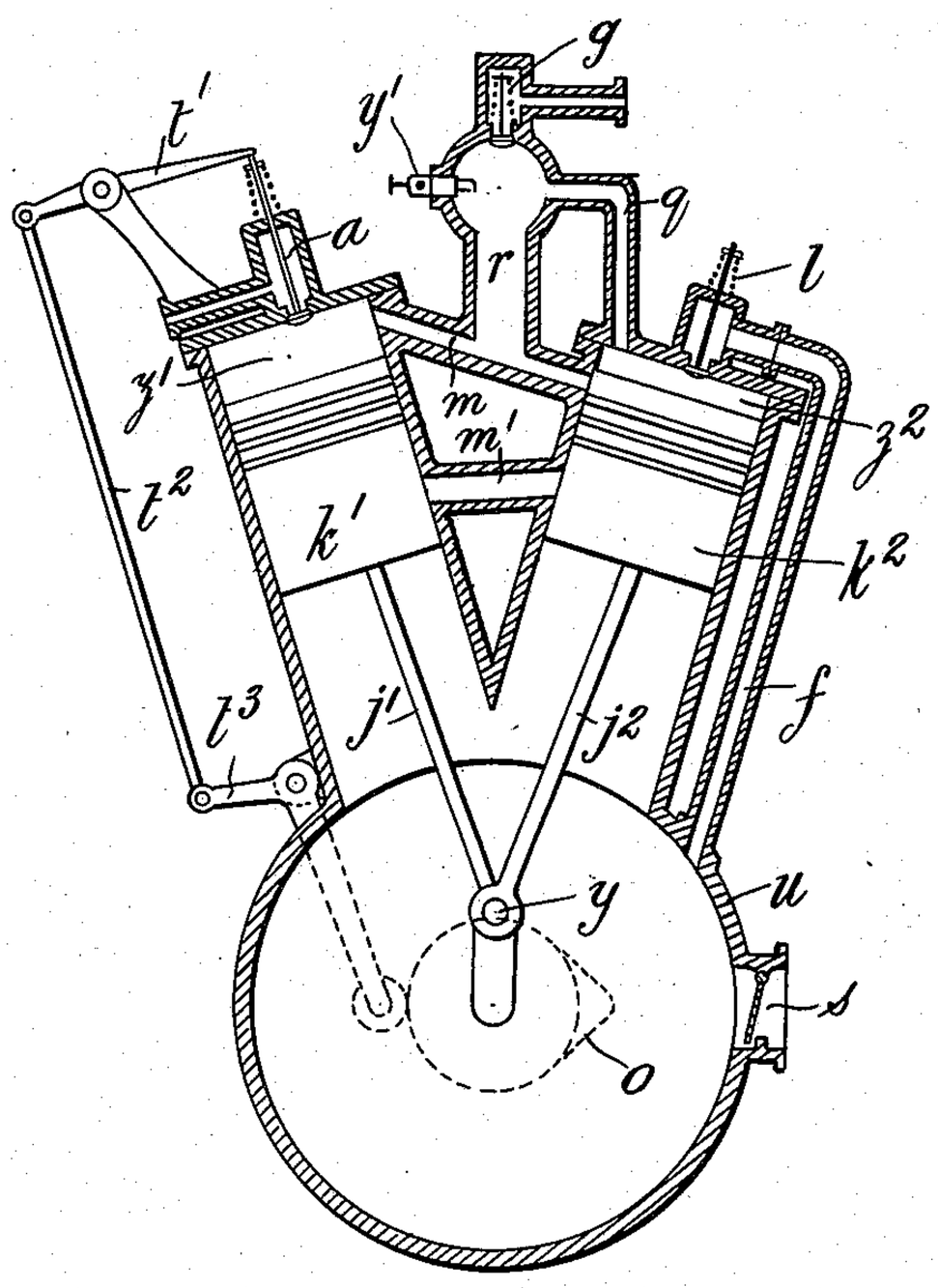

Fig: 10.

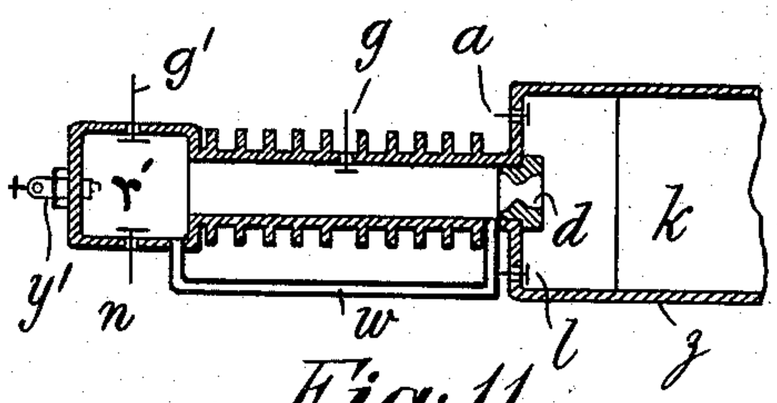

Fig: 11.

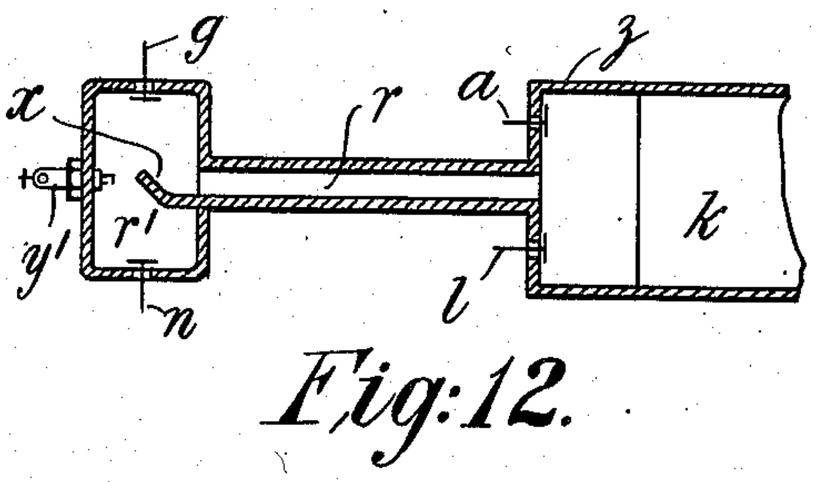

Fig: 12.

Witnesses.
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UNITED STATES PATENT OFFICE

FRIEDRICH AUGUST HASELWANDER, OF MANNHEIM, GERMANY.

INTERNAL-COMBUSTION ENGINE.

No. 848,029. Specification of Letters Patent. Patented March 26, 1907.

Application filed May 23, 1901. Serial No. 61,586.

To all whom it may concern:

Be it known that I, FRIEDRICH AUGUST HASELWANDER, a subject of the Emperor of Germany, residing at 1 Käferthalerstrasse, Mannheim, in the German Empire, have invented a new and useful Improved Internal-Combustion Engine, of which the following is a specification.

This invention relates to internal-combustion engines, and has for its object improvements in connection with the introduction of the combustible into the combustion-chamber and in the mixing of the materials to form the explosive mixture. In the engine according to this invention the air and the combustible, the latter in the form of a gas, vapor, liquid, or solid, are introduced separately and are kept separate during the compression-stroke of the working piston in two interconnected spaces.

The principal novel feature of the invention consists in the means for effecting the mixture of the air and combustible by the explosion of an auxiliary combustible mixture either before, at, or just after the end of the compression-stroke.

Other features of novelty will be hereinafter mentioned and pointed out in the claims.

In the accompanying drawings, Figure 1 is a part-sectional elevation showing an engine constructed in accordance with this invention. Figs. 2 to 9 are diagrammatic sectional views showing several ways of constructing the engine according to this invention. Fig. 10 shows in greater detail a particular form of construction. Figs. 11 and 12 are diagrams illustrating types of engines suitable for working with liquid or solid combustibles.

Referring first to Fig. 1, z represents the cylinder of an engine, k its piston, and y the crank-shaft. a is the exhaust-valve, which is operated by a rocker t', actuated by a rod t^2, and bell-crank lever t^3 from a cam o', which latter is mounted on a half-speed shaft o, driven by gear-wheels s from the crank-shaft y. By this means the valve a is opened once in each alternate revolution of the crank-shaft y. l is an air-inlet valve which is operated by a rocker t^{10}, rod t^9, and lever t^8 from a cam o^2 on the shaft o. r is a charge-chamber provided on the cylinder-head and having a gas-inlet valve g, which is operated by a rocker t^4 from the link t^9 and cam o^2. The charge-chamber also has an air-inlet valve n near the top, this valve being operated through a rocker t^5, link t^6, and lever t^7 from a cam o^3 on the cam-shaft o. The cams o', o^2, and o^3 of course lie side by side on the cam-shaft o. y' is an ignition device of any suitable type—as, for instance, a sparking plug. This engine operates on the four-stroke cycle in the following manner: During the suction-stroke fresh air is drawn in through the inlet-valve l to the cylinder z and gas enters through the valve g into the chamber r. Toward the end of the suction-stroke the air-inlet valve n is also opened, so that a small quantity of air is admitted and is allowed to mix with the part of the gas at the top of the charge-chamber r. During the compression-stroke of the piston k the air and gas remain separate, and no further mixture of the charge takes place, especially as under certain circumstances some remains of the exhaust-gases lie in a layer between the charges of air and gas. At or about the end of the compression-stroke the small auxiliary gas mixture which has been formed at the top of the charge-chamber r by the last part of the gas admitted and the small quantity of air introduced past the valve n is exploded in any suitable manner, either by the igniter y' or it may be automatically, if the compression is sufficiently high. The explosion of this auxiliary charge drives the gas in the charge-chamber r forward into the compressed air at the head of the cylinder z, mixing the gas with the air in a most efficient manner, while the ignition of the charge is produced either from the auxiliary mixture or by self-ignition, due to the pressure, or by any ignition apparatus. The perforated distributing-wall p^3 on the end of the piston serves to distribute the gas as it is forced into the cylinder by the explosion of the auxiliary mixture, and by this means a more thorough mixing of the charge is produced.

Fig. 2 shows diagrammatically another form of construction wherein the air for making the auxiliary mixture is supplied by a displacing device—that is to say, by means connected with the piston which on the in-stroke will cause a portion of the air in front of the piston to be trapped and compressed separately from the remainder of the air. This device was first described in the applicant's German patent, No. 101,453, of October 20, 1897, published on December 27, 1898, and no novelty is claimed in the present application for the principle *per se* as

described in the specification of the said German patent. In the engine shown in Fig. 2 gas is admitted to the charge-chamber *r* by the valve *g*, while air is admitted to the cylinder by the valve *l*, as in the first-described construction. Toward the end of the compression-stroke a projection *v* on the end of the piston *k* enters a recess *b* in the cylinder-head, forcing some of the air in front of the piston through a pipe *q* into the top of the charge-chamber *r*. By this means an auxiliary mixture is formed at the top of the charge-chamber, this mixture being exploded as before and serving to mix the main charges of air and gas. *p* here is a distributing-plate fixed in the charge-chamber *r* and serving to break up the gases when they are blown out from said chamber by the explosion.

In the modified from of construction illustrated in Fig. 3 the charge-chamber *r* is central over the end of the piston, which latter carries a large projection *v*, adapted to enter a corresponding recess *b* in the cylinder-head. *a*, as before, is the exhaust-valve, *l* the air-inlet valve, (behind the valve *a* in the drawing,) and *g* the gas-inlet valve. In this case toward the end of the compression-stroke the air imprisoned in the narrow circular space *g'* round the projection *v* is forced through the pipe *q* and a distributing-nozzle *c* into the top of the charge-chamber *r*, there forming the auxiliary mixture, which is exploded in order to drive together the main charge of gas and air. *p* here is, as before, a plate or the like for breaking up the stream of gases.

Fig. 4 shows another form of construction of the displacing device. In this case a chamber *j'* is formed in the end of the piston *k*, and a projecting part p^2 of the charge-chamber *r* enters the space *j'* toward the end of the compression-stroke. The projection p^2 is perforated at the sides to give communication between the interior of the charge-chamber *r* and the cylinder-head. The pipe *q* in this case extends from the bottom of the projection p^2 up toward the top of the charge-chamber *r*, and toward the end of the compression-stroke the air imprisoned in the space *j'* is forced up the pipe *q* to the top of the charge-chamber *r* in order to form the auxiliary mixture, which serves, as before, when ignited to drive together the main charges of air and gas.

The modification illustrated in Fig. 5 represents the same type of construction as is shown in Fig. 1, except that the valve *n* is placed in the gas-supply pipe behind the valve *g*, and in this case the valve *n* opens just before the end of the suction-stroke in order to admit a little air with the last portion of the gas admitted in order to make the auxiliary mixture.

This invention is not restricted to four-stroke cycle-engines, but it is applicable to any well-known types of two-stroke cycle-engines. Fig. 6 illustrates one method of applying the invention to a two-stroke cycle-engine. The rearward extension k^3 of the piston *k* works in a rearward extension of the cylinder in order to form a gas-pump at *g'*, while the remaining area at the rear of the piston forms an air-pump at *l'*. The gas-pump *g'* communicates with a gas-valve *g* at the end of a charge-chamber *r*, which is arranged at the side in this case, while the air-pump *l'* communicates by a pipe *q* with the main air-inlet valve *l* and the auxiliary air-inlet valve *n*. *a* represents the exhaust-port of the cylinder *z*, which is uncovered by the piston *k* at the end of its outstroke in well-known manner. With this construction shortly before the end of the expansion or working stroke the exhaust-port *a* opens, while the air-valve *l* and the gas-valve *g* are opened. The air flowing into the cylinder *z* scavenges the waste gases from the same and fills the cylinder, while the charge-chamber *r* becomes filled with gas. The secondary air-valve *n* now opens, admitting some air to form the auxiliary mixture at the end of the charge-chamber *r*. The compression-stroke now follows, and toward the end thereof the auxiliary mixture is ignited, whereby the gas is driven out from the charge-chamber *r* into the combustion-chamber proper, whereby the working mixture is made.

A convenient form of construction of engine for working according to this invention is one in which two pistons are employed. Fig. 7 shows one form of construction. z' z^2 are two cylinders placed side by side and connected by a passage at *m*. Their pistons are connected by the rods j' j^2 to the common crank-shaft *y*. The piston k^2 is longer than the piston *k'*, so that the piston k^2 comes nearer to its cylinder-head in the compression-stroke than the piston *k'*. By this arrangement a displacing action is produced, as is about to be described. *l*, as before, is the air-inlet valve; *a*, the exhaust-valve; *q*, the pipe for the auxiliary air, and *g* the gas-valve admitting gas to the charge-chamber *r*. During the suction-stroke the air is drawn in through the valve *l* into the cylinders z' z^2, and gas enters the combustion-chamber *r* through valve *g*. Toward the end of the compression-stroke the piston k^2, acting as the displacing device, covers up the communicating passage *m* between the cylinders and after this forces some air through the pipe *q* into the top of the charge-chamber *r*, there forming the auxiliary explosion mixture, which is ignited and serves to mix the charges.

In the form of construction shown in Fig. 8 the two cylinders z' z^2 are arranged at an angle to one another, and their pistons k' k^2 work by rods j' j^2 on the same crank on the crank-

shaft y. The charge-chamber r here opens into the communicating passage m between the cylinders z' and z^2; but otherwise the arrangement and the manner of working are substantially identical with those described in connection with Fig. 7, so that no further description will be necessary.

The types of engine illustrated in Figs. 7 and 8 can be readily arranged to work on the two-stroke cycle system. Fig. 9 corresponds with Fig. 7 and illustrates this, the only modifications being that the air-inlet opening l' should be arranged to be uncovered by one piston k^2 toward the end of the expansion-stroke, while the exhaust-opening a' is uncovered by the other piston k'. The communicating passage m is provided, as before, and also another passage m' near the lower part of the working space in each cylinder. In this case at the end of the working stroke the ports l' and a' are opened, and the gas escapes through the port a', while air entering at l' scavenges both cylinders, passing from one to the other through the openings m and m' for this purpose. Gas is admitted by the valve g to the charge-chamber r, and during the compression-stroke the air is compressed in the cylinders z' z^2, while the gas is compressed in the charge-chamber r. Finally the piston k^2 passes the opening m and then discharges some air through the passage q to the top of the charge-chamber r, thus forming the auxiliary mixture which serves to mix the main charges of gas and air.

Fig. 10 shows a corresponding adaptation of Fig. 8 to work as a two-stroke cycle-engine. In Fig. 10 the construction has been shown in somewhat greater detail. z' z^2 are, as before, the cylinders standing at an angle to one another, k' k^2 the pistons, and j' j^2 the connecting-rods working on a common crank on the crank-shaft y. u is a crank-casing serving to compress the scavenging and working air, this air being admitted to the crank-casing past the valve s in the usual manner. The scavenging-air passes through the passage f to the air-inlet valve l immediately after the exhaust-valve a has been opened at the end of the working stroke by the rocker t', link t^2, and bell-crank lever t^3, actuated by the cam o, (which in this case opens the valve a once at each revolution of the crank-shaft y.) In this construction the gas is exhausted past the valve at the end of the working stroke, while air is forced through the passage f into the cylinder z^2, from which it streams into the cylinder z' through the passages m m, thus effectually scavenging both the cylinders. The gas is admitted to the charge-chamber r at the same time past the valve g, and during the compression-stroke the air is compressed in the cylinders z' z^2, while the gas is compressed in the charge-chamber r. Toward the end of the compression-stroke air is forced by the piston k^2 through the pipe q in order to form the auxiliary mixture at the top of the charge-chamber r, and as the pistons k' and k^2 begin to recede for the working stroke the auxiliary charge is exploded by the igniter y', thus forcing out the gas into the compressed air, and so making the working mixture, as before.

In all the constructions above described it will be understood that where gas is mentioned any vaporized fuel may be used in well-known manner. If liquid or solid fuels are to be injected, however, the construction of the engine will be slightly different.

Fig. 11 shows one construction for working with liquid or solid fuels. The piston k works in a horizontal cylinder z, provided with an air-valve l and exhaust-valve a, as before. The charge-chamber r has an extension r' for the auxiliary mixture, while the main charge of fuel is admitted to the chamber r by valve g and a subsidiary charge to the chamber r' by valve g'. The charges will be vaporized by the heat of the walls of the chambers r and r' in well-known manner. The auxiliary air is admitted to the chamber r' through the valve n. The auxiliary air mixing with the auxiliary fuel forms the explosive mixture in the chamber r', and this when exploded drives out the gasified fuel from the chamber r through a nozzle d into the air compressed in the space at the head of the cylinder z. A by-pass pipe w may be used to conduct some of the gases of the auxiliary explosion to a point close in front of the nozzle d in order that they may cross the main stream of combustible passing through said nozzle and may thus assist in breaking up the stream.

Instead of using two valves g and g' one valve may be arranged to serve the double purpose if a deflector x is provided below the valve, as shown in Fig. 12, to cause part of the fuel from valve g to pass along into the chamber r, while a small portion will fall into the chamber r'. The part of the fuel in the chamber r' forms the auxiliary mixture with the air entering through the valve n, and this when exploded drives out the fuel from chamber r into the cylinder z.

Finally, it is to be understood that the drawings are only intended to indicate in a general manner the method of applying this invention to certain standard types of internal-combustion engines, and it will be seen that a competent engineer can apply the invention to practically any type of internal-combustion engine without further instructions than are contained in the foregoing specification. Any convenient forms of valves, valve-operating mechanisms, &c., may be used, as the constructions of these parts form no feature of this invention. Throughout the specification it has been said generally for the sake of brevity that the air is compressed in the cylinders, while the gas is compressed in the charge-chambers. Of

course the plane of separation between the two will advance up the charge-chamber as the compression proceeds, as will be readily understood. In some cases—as, for instance, in Fig. 1—the positions of the air and the gas in the cylinder and charge-chamber may be reversed—that is to say, the air may be admitted by the valve *g*, while gas is admitted to the cylinder by the valve *l*. In this case the valve *n* would admit a small auxiliary amount of gas at the top of the charge-chamber for forming the auxiliary mixture, which when ignited would drive out the air from this chamber and mix it with the gas compressed in the cylinder-head. The arrangements previously described are, however, preferable. In any case it will be understood that the positions of the various valves may be varied somewhat and the construction of the various parts may be altered to suit particular circumstances without departing from the scope of this invention.

What I claim is—

1. In an internal-combustion engine, the combination with the working cylinder and piston of a charge-chamber open to the cylinder at one end, means for admitting working air and combustible, the one to the charge-chamber and the other to the cylinder, means for exhausting the waste gases, and further means for forming a separate and auxiliary mixture in the charge-chamber at the end thereof remote from the cylinder, the arrangement of the parts being such that by the explosion of the auxiliary mixture the separately-compressed air and combustible the one mainly in the cylinder and the other in the charge-chamber are mixed, substantially as described.

2. In an internal-combustion engine, the combination with the working cylinder and piston of a charge-chamber open to the cylinder at one end, means for admitting working air and combustible, the one to the charge-chamber and the other to the cylinder, means for exhausting the waste gases, further means for forming a separate and auxiliary mixture in the charge-chamber at the end thereof remote from the cylinder, and means for igniting said mixture, the arrangement of the parts being such that by the explosion of the auxiliary mixture the separately-compressed air and combustible, the one mainly in the cylinder and the other in the charge-chamber are mixed, substantially as described.

3. In an internal-combustion engine, the combination with the working cylinder and piston of a charge-chamber open to the cylinder at one end, means for admitting working air and combustible, the one to the charge-chamber and the other to the cylinder, means for exhausting the waste gases and further means for introducing to the charge-chamber at the end thereof remote from the cylinder a small quantity of a fluid such as will be capable of forming with a portion of the fluid already in said chamber separate and auxiliary explosive mixture, substantially as described.

4. In an internal-combustion engine, the combination with the working cylinder and piston of a charge-chamber open to the working cylinder at one end, means for admitting working air and combustible, the one to the charge-chamber and the other to the cylinder, means for exhausting the waste gases, further means for introducing to the charge-chamber at the end thereof remote from the cylinder a small quantity of fluid such as will be capable of forming with a portion of the fluid already in said chamber, a separate and auxiliary explosive mixture and means for igniting said mixture, substantially as described.

5. In an internal-combustion engine, the combination with the working cylinder and piston of a charge-chamber, means for admitting working air and combustible, the one to the charge-chamber and the other to the cylinder, means for exhausting the waste gases, a displacing device and means operatively connecting said displacing device with the working piston, and a passage leading from said displacing device to the charge-chamber, the arrangement and proportions of the parts being such that the fluid displaced by the displacing device is injected into the charge-chamber in which it forms an auxiliary explosive mixture with a portion of the fluid already in said chamber, substantially as described.

6. In an internal-combustion engine, the combination with the working cylinder and piston of a charge-chamber, means for igniting the mixture in said chamber, means for admitting working air and combustible, the one to the charge-chamber and the other to the cylinder, means for exhausting the waste gases, a displacing device and means operatively connecting said displacing device with the working piston, and a passage leading from said displacing device to the charge-chamber, the arrangement and proportions of the parts being such that the fluid displaced by the displacing device is injected into the charge-chamber in which it forms an auxiliary explosive mixture with a portion of the fluid already in said chamber, substantially as described.

7. In an internal-combustion engine, the combination with the working cylinder and piston of a charge-chamber, means for admitting working air and combustible, the one to the charge-chamber and the other to the working cylinder, means for exhausting the waste gases, a second or displacing cylinder and means connecting same to the working cylinder aforesaid, a piston in said second cylinder and means operatively con-

necting said piston to the working piston aforesaid, and means of communication between said second cylinder and the charge-chamber, the arrangement and proportions of the parts being such that fluid displaced by the second piston is injected into the charge-chamber in which it forms an auxiliary explosive mixture with the fluid already in said chamber, substantially as described.

8. In an internal-combustion engine, the combination with the working cylinder and piston of a charge-chamber, means for igniting gases in said chamber, means for admitting working air and combustible the one to the charge-chamber and the other to the working cylinder, means for exhausting the waste gases, a second or displacing cylinder and means connecting same to the working cylinder aforesaid, a piston in said second cylinder and means operatively connecting said piston to the working piston aforesaid, and means of communication between said second cylinder and the charge-chamber, the arrangement and proportions of the parts being such that fluid displaced by the second piston is injected into the charge-chamber in which it forms an auxiliary explosive mixture with the fluid already in said chamber, substantially as described.

9. In an internal-combustion engine, the combination with the working cylinder and piston of a charge-chamber, means for admitting working air and combustible, the one to the charge-chamber and the other to the working cylinder, means for exhausting the waste gases, a second or displacing cylinder and means connecting same to the working cylinder aforesaid, a piston in said second cylinder and means operatively connecting said piston to the working piston aforesaid, and means of communication between said second cylinder and the charge-chamber, the arrangement and proportions of the parts being such that fluid displaced by the second piston is injected into the charge-chamber in which it forms an auxiliary explosive mixture with the fluid already in said chamber, and that the exhausting means is opened shortly before the end of the working stroke and the waste gases are expelled by air admitted through the air-valve, substantially as described.

10. In an internal-combustion engine, the combination with the working cylinder and piston of a charge-chamber, a second or displacing cylinder and two passages connecting said two cylinders near the top and near the bottom respectively, a piston in said second cylinder and means operatively connecting said piston to the working piston aforesaid, means of communication between the second cylinder and the charge-chamber an air-inlet valve on the second cylinder, a combustible-inlet valve on the charge-chamber, and an exhaust-valve on the first cylinder, the arrangement and proportions of the parts being such that air displaced by the second piston is injected into the charge-chamber in which it forms an auxiliary explosive mixture with the combustible already in said chamber, and that the two pistons uncover the second opening between their cylinders at the end of the working stroke, at which time the air-inlet valve and the exhaust are opened, substantially as and for the object hereinbefore described.

11. In an internal-combustion engine, the combination with the working cylinder and piston of a charge-chamber, a second or displacing cylinder and two passages connecting said two cylinders near the top and near the bottom respectively, a piston in said second cylinder and means operatively connecting said piston to the working piston aforesaid, means of communication between the second cylinder and the charge-chamber, an air-inlet valve on the second cylinder, a combustible-inlet valve on the charge-chamber, and an exhaust-valve on the first cylinder, and means for igniting the gases, the arrangement and proportions of the parts being such that air displaced by the second piston is injected into the charge-chamber in which it forms an auxiliary explosive mixture with the combustible already in said chamber, and that the two pistons uncover the second opening between their cylinders at the end of the working stroke, at which time the air-inlet valve and the exhaust are opened, substantially as and for the object hereinbefore described.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

FRIEDRICH AUGUST HASELWANDER.

Witnesses:

H. W. HARRIS,

CONRAD ZIMMER.