No. 898,271.

C. N. SCOTT. PATENTED SEPT. 8, 1908.

INTERNAL COMBUSTION ENGINE.

APPLICATION FILED JAN. 23, 1905.

2 SHEETS—SHEET 1.

Fig. 1.

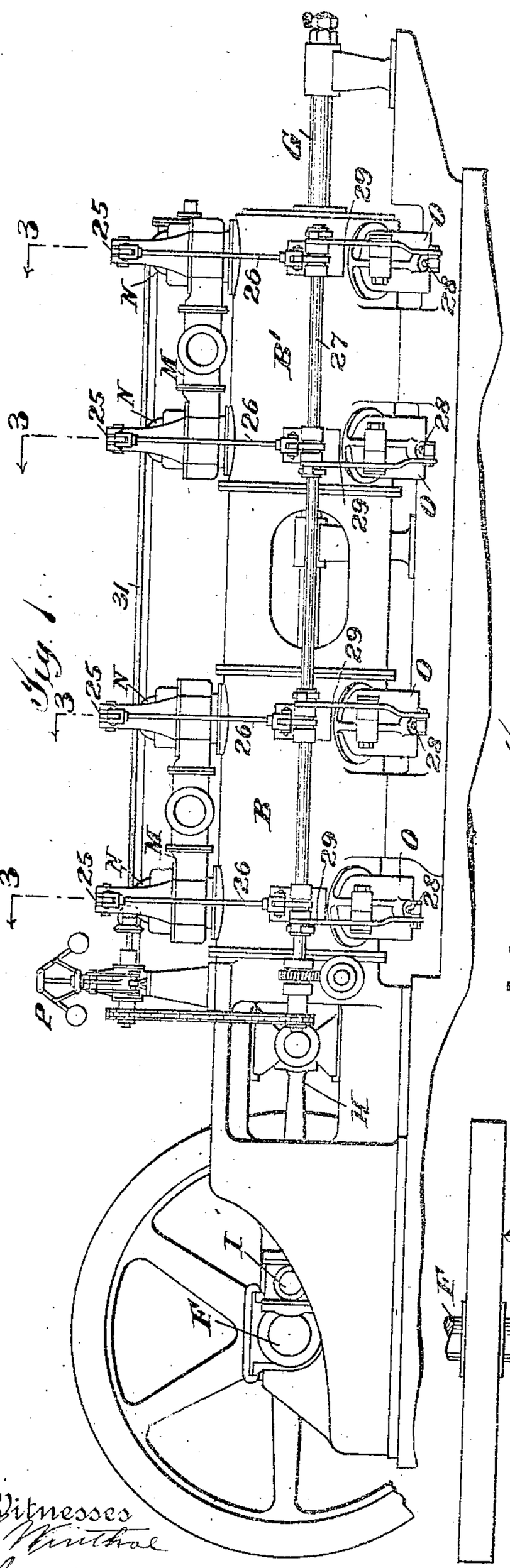
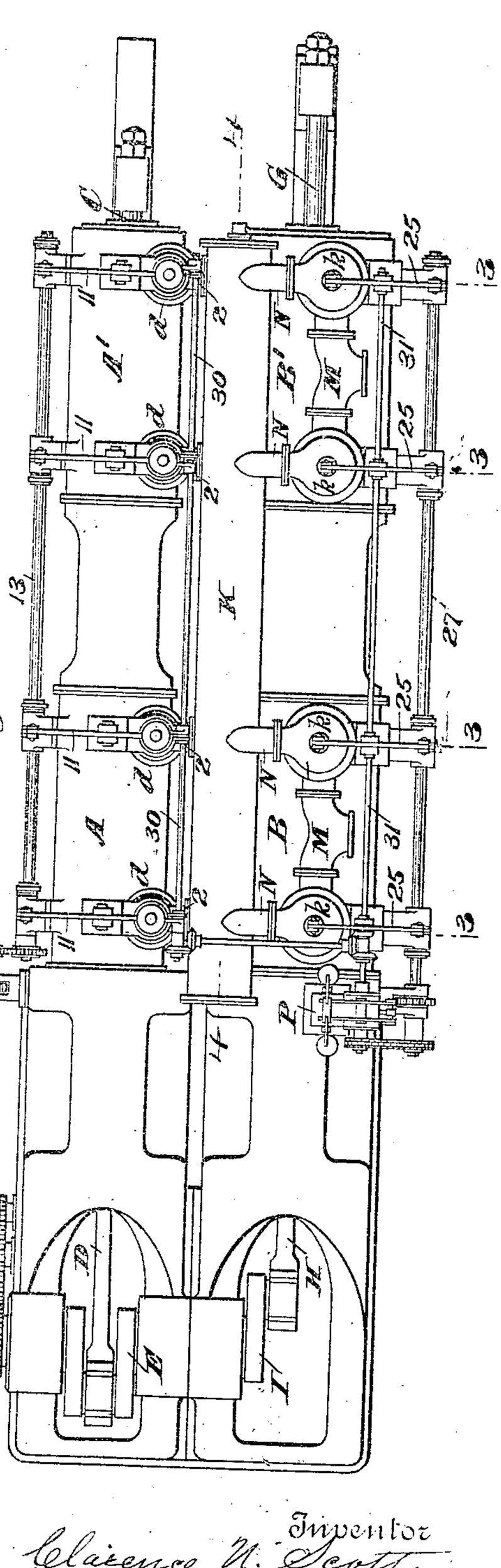


Fig. 2.



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2 SHEETS—SHEET 2.

Fig. 3.

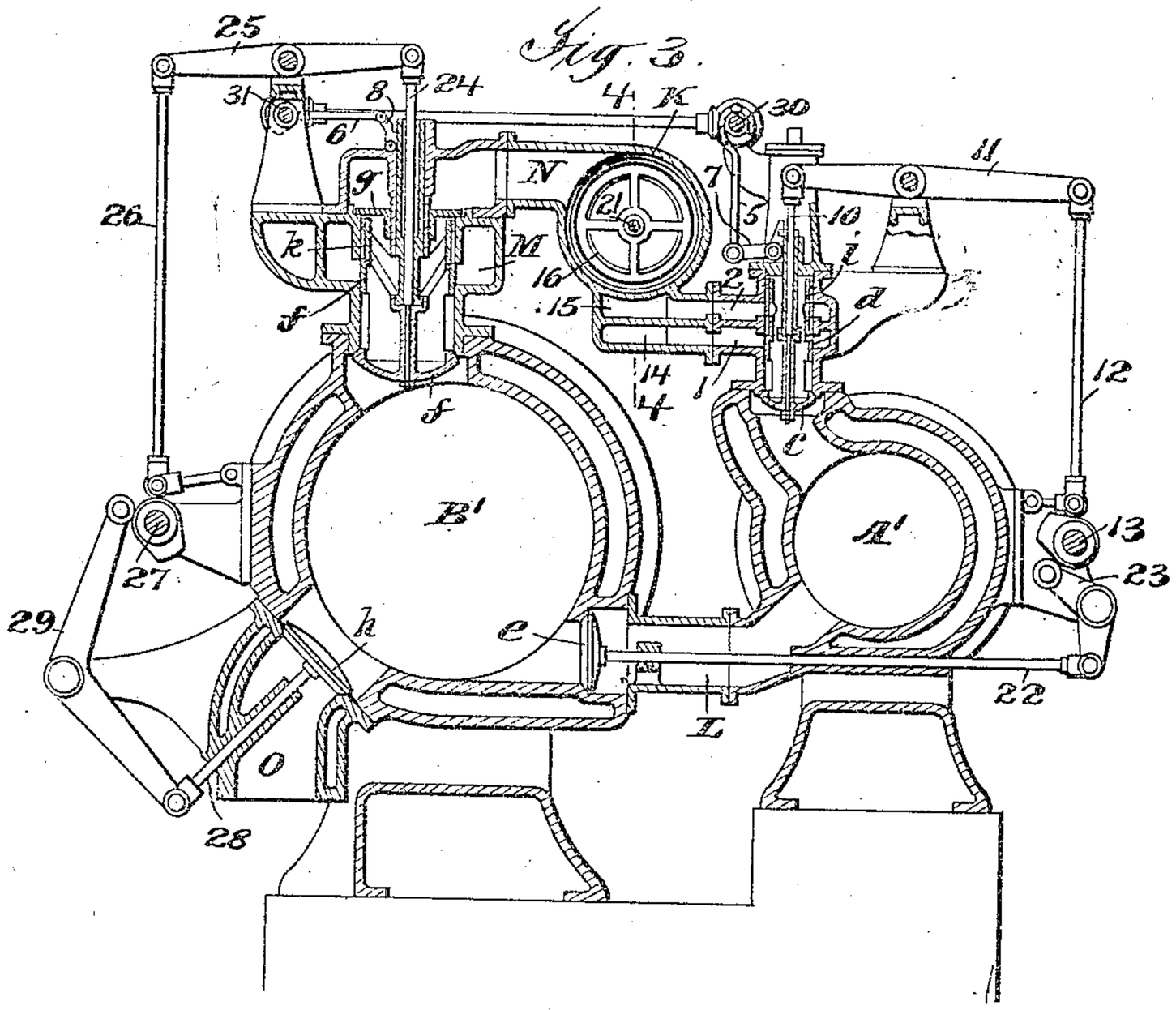


Fig. 4.

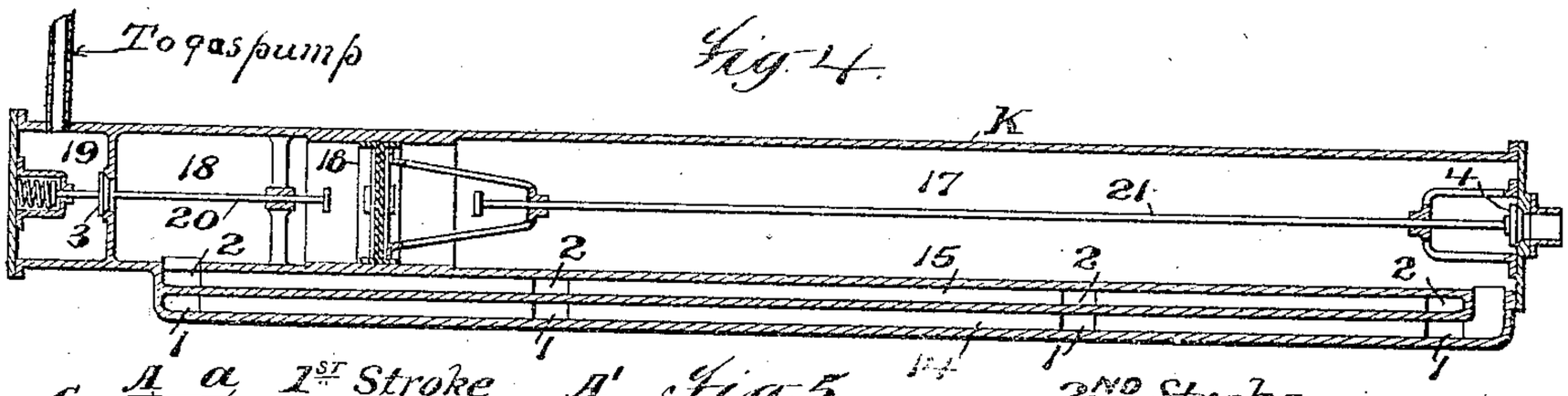
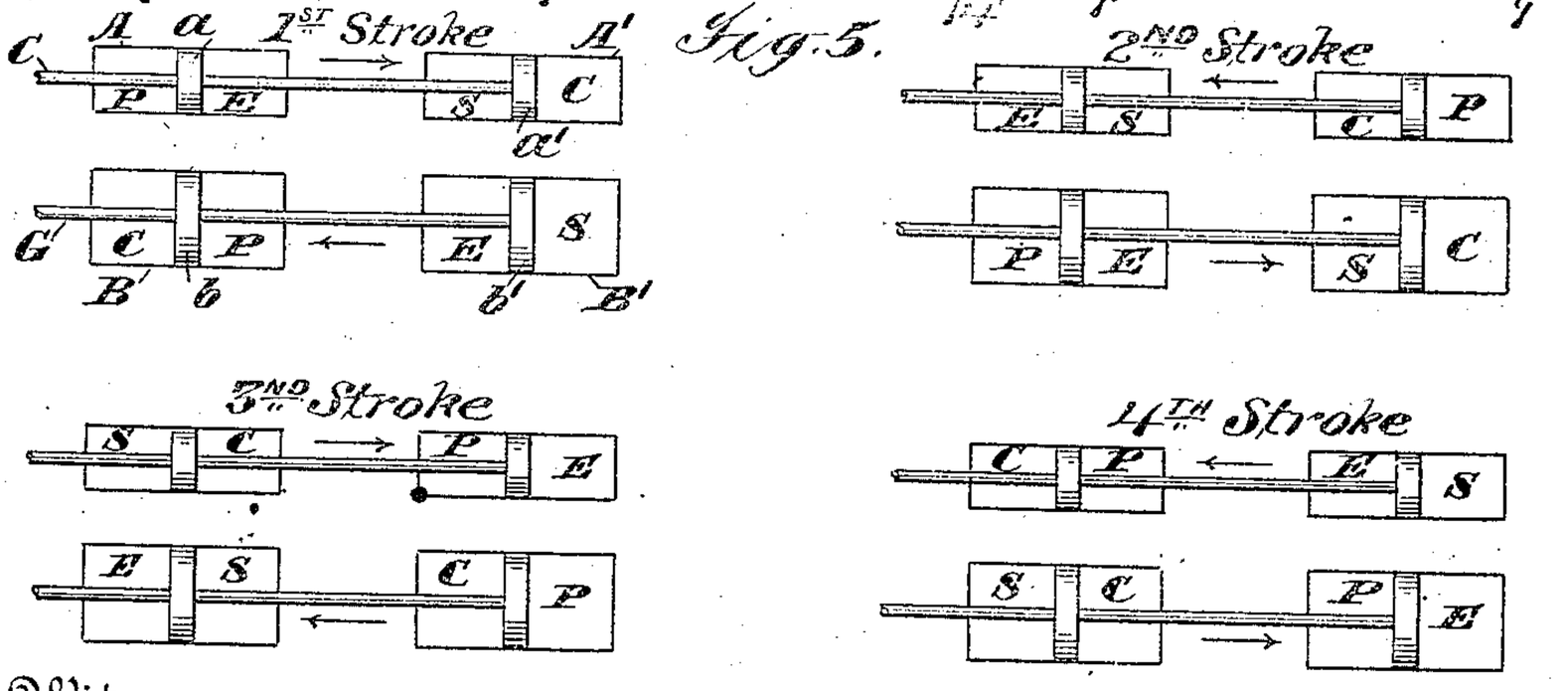


Fig. 5.



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UNITED STATES PATENT OFFICE.

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INTERNAL-COMBUSTION ENGINE.

No. 898,271. Specification of Letters Patent. Patented Sept. 8, 1908.

Application filed January 23, 1905. Serial No. 242,280.

To all whom it may concern:

Be it known that I, CLARENCE N. SCOTT, a subject of Great Britain, residing at Buffalo, county of Erie, and State of New York, have invented certain new and useful Improvements in Internal-Combustion Engines, fully described and represented in the following specification, and the accompanying drawings, forming a part of the same.

This invention relates to an improvement in compound internal combustion reciprocating engines of that class known as four cycle engines in which the piston makes one power or working stroke in two revolutions, the object being to provide an efficient and economical compound engine of this class, and further to provide for the use of light transmission parts fully utilized in transmitting the net load.

The invention consists in novel combinations and arrangements of cylinders in a compound four cycle internal combustion engine, as fully described and claimed.

In the accompanying drawings forming a part of this specification, the invention is shown as applied in a preferred form of engine.

Figure 1 is a side elevation of the low pressure side of the engine. Fig. 2 is a plan view of the engine. Fig. 3 is a cross section on any of the lines 3 of Figs. 1 and 2. Fig. 4 is a section of the air and gas tank and passages on line 4 of Figs. 2 and 3. Fig. 5 is a diagram of the cycle in the four cylinders.

In the drawings, A, A′ are two double acting high pressure cylinders and B, B′ two double acting low pressure cylinders, the two high pressure cylinders being arranged tandem on one side of the engine with their pistons *a*, *a′* connected by piston rod C and connecting rod D to the crank E on the engine shaft F, and the two low pressure cylinders B, B′ being arranged tandem alongside the respective high pressure cylinders, with their pistons *b*, *b′* connected by the piston rod G and connecting rod H to crank I on shaft F, the two cranks E, I being located in the direction of rotation at approximately 180° from each other. A horizontal engine is shown, but the invention is applicable also to vertical engines.

The high pressure cylinders are provided at each end with inlet valves *c*, which are shown as valves of common form operated by valve stems 10, levers 11 and cam rods 12 from suitable cams on cam shaft 13, the charge being admitted to the chamber above the inlet valves *c* through a mixing valve *d* of any common or suitable form to which the air and gas pass from air passages 1 and gas passages 2, connecting with the air and gas tank K through air and gas passages 14, 15, extending along the tank. The gas tank K, in the form shown, consists of a circular tank mounted between and above the engine cylinders, and divided by a pressure equalizing piston 16 into air and gas chambers 17, 18, the passage 14 connecting with the former and the passage 15 with the latter. The gas chamber 18 is connected with a gas chamber 19 through valve 3, in which chamber 19 gas is maintained at a pressure higher than the maximum pressure required in the chamber 18 by an attached or independent gas pump and regulators of any common or suitable form. This valve 3 is opened by the piston 16 engaging rod 20 when the piston is moved to the left sufficiently, so as to admit gas from the chamber 19 to the chamber 18 when required, and thus maintain the desired equilibrium of air and gas pressure in the chambers 17, 18. An air release valve 4 operated by the piston 16 through rod 21 is shown for limiting the volume and pressure of air in chamber 17.

Each end of the high pressure cylinders exhausts into the corresponding end of the adjacent low pressure cylinder through passages L which thus act as exhaust passages for the high pressure cylinders and inlet passages for the low pressure cylinders, and these passages L are shown as controlled by valves *e* actuated by rods 22 and levers 23 from suitable cams on cam shaft 13.

Each end of each low pressure cylinder acts alternately as a pump to compress air into the tank K, and as a working cylinder with the piston actuated by the exhaus from its high pressure cylinder. Air is admitted to the low pressure cylinders through air passages M, communicating with the atmosphere, and shown as controlled by the inlet valves *f*, operated by valve rods 24, levers 25 and cam rods 26 from suitable cams on the cam shaft 27. Air is delivered from the low pressure cylinders to the tank K through passages N controlled by automatic valves *g*, which valves open when the pressure in the cylinder exceeds that in the tank, as usual in such automatic valve constructions.

The low pressure cylinders exhaust through

passages O to the atmosphere or otherwise, these passages being shown as controlled by exhaust valves *h* operated by stems 28 and levers 29 from suitable cams on the cam shaft 27.

It is desirable that some form of governor control be used on the high and low pressure cylinders to maintain a constant speed with varying load or to maintain constant the work done per revolution with varying speeds. In the drawings a governor control by separate cut off valves is indicated, the high pressure cylinders being provided with cut off valves *i* which close at some point in the high pressure suction stroke and prevent further mixing and admission of mixture during the remainder of the high pressure suction stroke, and the low pressure cylinders being provided with air cut off valves *k*, which, when the air required for the combustion of the gases has been admitted, close and prevent admission of air to the low pressure cylinders during the remainder of the low pressure suction stroke, these valves being actuated independently of the main valves by suitable connections from a governor of any desired form. As shown, the governor P actuates cam shafts 30, 31, which control the valves *i*, *k* through cam rods 5, 6, and trip levers 7, 8. Any other suitable form of governor control may be used, however, as well as any other form of valves and valve actuating devices, these forming no part of the present invention, the form shown being selected only for purpose of illustration and as one form of many suitable for use in an engine embodying the invention. The illustration of the valves is largely diagrammatic, actuating springs being omitted, as such main and cut off valve constructions are well-known. Igniting devices of any suitable form may be used, or combustion secured in any manner desired.

It will be understood that high pressure inlet valves *c* are open during the suction stroke of the high pressure pistons and closed during the rest of the cycle; the combined exhaust and inlet valves *e* are open during the exhaust stroke of the high pressure pistons and the corresponding working stroke of the low pressure cylinders and closed during the rest of the cycle; the low pressure air inlet valves *f* are open during the suction stroke of the low pressure cylinders and remain open during the compression or delivery stroke and are closed during the rest of the cycle; and the exhaust valves *h* of the low pressure cylinders are open during the exhaust stroke of the low pressure cylinders and closed during the rest of the cycle.

The cycle on which this engine will preferably operate, is illustrated diagrammatically in Fig. 5, which shows the stroke in each end of each cylinder throughout the cycle. In this figure, the strokes are indicated by letters as follows:—P indicates the power stroke, obtained in the high pressure cylinders from the compressed charge and in the low pressure cylinders by further expansion of the exhaust from the high pressure cylinders. E indicates the exhaust stroke, that is, the exhaust of the high pressure cylinders to the low pressure cylinders and the exhaust of the low pressure cylinders to the atmosphere. S indicates the suction stroke during which the charge is admitted into the high pressure cylinders and air is drawn into the low pressure cylinders. C indicates the compression stroke by which the charge, already under considerable pressure, is further compressed in the high pressure cylinders and air is compressed from the low pressure cylinders into the tank K. From these diagrams of Fig. 5, it will be seen that there is one and only one power or impulse stroke on each crank at each stroke or movement of the pistons in either direction, and that the initial load on each high pressure stroke is directly resisted by the initial back pressure or expansion load on the same or a connected piston, so that the maximum load to be transmitted is only that due to the high pressure initial propulsion load minus the high pressure initial back pressure or expansion load. The results secured by these features of the cylinder arrangement and cycle described are very important in the construction and operation of the engine, as they enable the size and weight of the crank shaft and fly wheel, the parts transmitting the power from the pistons to the crank shaft, and the framing connecting the crank shaft journals with the power cylinders to be reduced. The size and weight of all these parts depend upon the maximum initial net propulsion load and the regularity of the turning moment, and with the cylinder arrangement and cycle above described, the total net initial load to be transmitted to the crank shaft on any stroke is reduced so far as possible without reducing the initial propulsion pressure, and the turning moment is regular on account of the relations of the power or impulse strokes throughout the cycle. The transmission parts, also, are fully utilized in transmitting, there being no idle strokes and the proper quota of work being done on each stroke.

An important result in compound internal combustion engines is secured, also, by an arrangement of high and low pressure cylinders, such that each high pressure cylinder lies alongside of the low pressure cylinder to which it exhausts, in that the ports or pipes through which the exhaust gases pass in expanding from a high pressure into a low pressure cylinder may be made direct and very short, so as to expose to the expanding gases the minimum of cooling surface and secure simplicity in the high pressure exhaust piping and valve mechanism. The arrange-

ment of cylinders shown and above described, with two high pressure cylinders on one side and two low pressure cylinders on the other side, is preferred for securing this result, as well as securing important results by the special cycle it permits, but this feature of arranging the cylinders of a four cycle compound engine with two cylinders tandem on each side and each high pressure cylinder placed alongside the low pressure cylinder to which it exhausts, forms a specific feature of the present invention, independently of the particular arrangement of cylinders or special cycle shown and described.

The cylinders will be so proportioned and such pressure in the tank K be maintained by the low pressure pistons, as to secure the initial and terminal pressures in the high pressure cylinders required for the effective operation of the low pressure cylinders by the exhaust from the high pressure cylinders, according to the running conditions of the engine.

It will be understood that the invention is not to be limited to an internal combustion engine of any special class or using a charge of fuel of any special character, or securing combustion in any special manner, but that the invention, as defined by the claims, is applicable generally in internal combustion engines.

What I claim is:—

1. A compound internal combustion four cycle reciprocating engine, having two double acting high pressure cylinders arranged tandem with their pistons on the same crank, in combination with two double acting low pressure cylinders arranged tandem and substantially parallel with and beside the high pressure cylinders with their pistons on a second crank on the same shaft and at approximately 180° from the high pressure crank.

2. In a compound internal combustion four cycle reciprocating engine, two double acting high pressure cylinders arranged tandem with their pistons on the same crank, in combination with two double acting low pressure cylinders arranged tandem and substantially parallel with and beside the high pressure cylinders with their pistons on a second crank on the same shaft and at approximately 180° from the high pressure crank, and suitable passages and mechanism for operating the high pressure pistons by the initial pressure of a charge and the low pressure pistons by the exhaust from the corresponding ends of the high pressure cylinders.

3. In a compound internal combustion four cycle reciprocating engine, two double acting high pressure cylinders arranged tandem with their pistons on the same crank, in combination with two double acting low pressure cylinders arranged tandem and substantially parallel with and beside the high pressure cylinders with their pistons on a second crank on the same shaft and at approximately 180° from the high pressure crank, and suitable passages and mechanism for operating the high pressure pistons by the initial pressure of a charge compressed by the low pressure pistons and further compressed on the high pressure compression stroke, and the low pressure pistons by exhaust from the high pressure cylinders.

4. In a compound internal combustion four cycle reciprocating engine, two double acting high pressure cylinders arranged tandem with their pistons on the same crank, in combination with two double acting low pressure cylinders arranged tandem and substantially parallel with and beside the high pressure cylinders with their pistons on a second crank on the same shaft and at approximately 180° from the high pressure crank, and suitable passages and mechanism for operating the high pressure pistons by the initial pressure of a charge and the low pressure pistons by the exhaust from the corresponding ends of the high pressure cylinders, and arranged to secure a high pressure power stroke in one end of one cylinder at each stroke and with each high pressure power stroke opposed by the back pressure of a high pressure exhaust stroke.

5. In a compound internal combustion four cycle reciprocating engine, two double acting high pressure cylinders arranged tandem with their pistons on the same crank, in combination with two double acting low pressure cylinders arranged tandem and substantially parallel with and beside the high pressure cylinders with their pistons on a second crank on the same shaft and at approximately 180° from the high pressure crank, and suitable passages and mechanism for operating the high pressure pistons by the initial pressure of a charge compressed by the low pressure pistons and further compressed on the high pressure compression stroke, and the low pressure pistons by exhaust from the high pressure cylinders, and having the strokes of the four cylinders throughout the cycle arranged substantially as herein shown and described.

6. A compound internal combustion four cycle reciprocating engine having two double acting high pressure cylinders and two double acting low pressure cylinders arranged with two cylinders tandem on each of two cranks substantially 180° apart on the same shaft, and with each high pressure cylinder placed substantially parallel with and beside the low pressure cylinder to which it exhausts, in combination with suitable passages and mechanism for operating the high pressure pistons by the initial pressure of a charge and the low pressure pistons by the exhaust from the adjacent ends of the high pressure cylinders.

7. A compound internal combustion four cycle reciprocating engine having two double acting high pressure cylinders and two double acting low pressure cylinders arranged with two cylinders tandem on each of two cranks substantially 180° apart on the same shaft, and with each high pressure cylinder placed substantially parallel with and beside the low pressure cylinder to which it exhausts, in combination with suitable passages and mechanism for operating the high pressure pistons by the initial pressure of a charge compressed by the low pressure pistons and further compressed on the high pressure compression stroke, and the low pressure pistons by the exhaust from the adjacent ends of the high pressure cylinders.

8. A compound internal combustion four cycle reciprocating engine having two double acting high pressure cylinders and two double acting low pressure cylinders arranged with two cylinders tandem on each of two cranks substantially 180° apart on the same shaft, and with each high pressure cylinder placed substantially parallel with and beside the low pressure cylinder to which it exhausts, in combination with an air receiver into which the air is compressed from each end of the low pressure cylinders on their compression stroke, means for supplying fuel under regulated pressure, and suitable passages and mechanism for mixing air from the receiver with fuel and charging the high pressure cylinders, delivering the exhaust from the high pressure cylinders to the low pressure cylinders, and compressing air from the low pressure cylinders to the receiver.

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

CLARENCE N. SCOTT.

Witnesses:

A. E. BALLIN,

S. B. DAUGHERTY.