three main castings: the combustion chamber, the lower bend, and the water valve box. From the water valve box the discharge pipe leads to the elevated tank.

The supply or suction tank embraces the water valve box, giving free access of water to the valves. These valves open inwardly, being held on their seats by light springs. At the head of the combustion chamber are fitted the inlet valve for gas and air admission, the exhaust valve, and the air scavenger valve. A simple system of locking bolts is arranged between these valves so that when the inlet valve opens and closes it locks itself shut, and with the same movement unlocks the exhaust and scavenger valves and vice versa. Therefore at each suction period in the combustion chamber these valves open in rotation. Normally the exhaust valve has a tendency to remain open and the inlet valve to remain shut through the action of light springs fitted to them. As the scavenger valve is not essential to the working of the smaller pumps it will for the present be left out of consideration. Should, however, any member desire an explanation of the use and action of this valve I will be pleased to give one.

An indicator, fitted to a pump when working, and driven by clockwork at a uniform rate, would produce a diagram like that shown on Drawing B.

For starting the pump one of two methods may be used:

(1) By pumping an explosive mixture into the combustion chamber, and exploding same by hand operation of the ignition apparatus.

(2) By pumping air only into the combustion chamber until the water column is forced well down to the lower end of same. The exhaust valve is then opened by means of the hand lever shown on Drawing A.

Either of the above methods sets up a surging of the water column. At starting all valves are closed, the inlet valve being locked and the exhaust valve free. Combustion chamber, water valve box, and discharge pipe are full of water up to the level of the water in the supply tank.

We will suppose that a charge of explosive mixture has been ignited by hand operation of the ignition apparatus. All valves being shut when the explosion takes place, the resultant increase in pressure acting upon the surface of the water forces it downwards in the pump and sets the whole water column in motion. The column of water attains kinetic energy, so that when these gases reach atmospheric pressure the water column may be moving at the rate of, say, 6 feet per second. The motion of this column of water cannot be suddenly arrested, consequently the pressure in the combustion chamber falls below that of the atmosphere, the exhaust valve opens under its own weight, and the forward movement of the water continuing, the level of the water in the combustion chamber finally falls below that of the water in the supply tank, and water rushes in through the valves in the valve box.

When the kinetic energy of the moving water column becomes exhausted by forcing water into the elevated tank, the water column commences to flow back along the discharge pipe and gains velocity until, rising in the combustion chamber and driving the spent gases out through the exhaust valve, it reaches the exhaust valve, which it shuts by impact. The closing of the exhaust valve automatically locks itself and unlocks the inlet valve. Above this level a cushion of spent gas (highly diluted by air where a scavenging valve is used) is trapped, and is further compressed by the moving water column to a higher pressure than that due to the static head of water in the elevated tank. The column finally comes to rest. The pressure in the combustion chamber head is now sufficient to cause the water column to surge back again.

The water column attains considerable momentum, and the pressure in the combustion chamber head falls below atmospheric pressure. As the inlet valve is now unlocked and the exhaust locked, a charge of explosive mixture is drawn in through the inlet valve until the column comes to rest again. The water column commences to return. The pressure in the combustion chamber rises, allowing the inlet valve to close, automatically lock itself, and unlock the exhaust valve. All valves are now closed, and the water column expends its energy in compressing the new charge, which it fires automatically, thus starting a fresh cycle of operations. The ignition is timed by a small piece of apparatus which closes the electric circuit at the point of maximum compression, a small battery, coil, and sparking plug similar to those used in motor car work being employed. The pump has the advantage over the ordinary gas engine of expanding its exploded gases to atmospheric pressure in its combustion chamber.

Briefly the working cycle is: A long out stroke: Exploded charge expands to pressure below atmosphere; supply of water taken in (where used, scavenger valve admits air). A return stroke: Spent gases (highly diluted by air when scavenger valve in use) driven out through exhaust valve; exhaust valve shuts and unlocks inlet valve; further compression of balance of spent gas in combustion head. A short outstroke: Expansion of compressed spent gas; fresh explosive charge enters through inlet valve. Return stroke: Inlet valve closed and locked; exhaust valve unlocked; compression of explosive charge; ignition of same follows.

REFERRING TO THE DIAGRAM

A to B.—Explosive charge being compressed.

B.—Charge fired.

B to C.—Rise of pressure due to explosion of charge.

C to D.—Gases expanding and doing work upon water column.

D.—Exhaust valve opens.

D to F.—Pressure in pump chamber remains atmospheric; water supply taken through water valves; water column surging back drives spent gases through exhaust valve; closes water valves.

F.—Exhaust valve closed and locked; inlet valve unlocked.

F. to G.—Compression of cushion of spent gases in combustion chamber head.

G to H.—Cushion expanding causing outstroke of water column; pressure in combustion chamber falling slightly below atmosphere, the inlet valve opens and admits fresh charge.

J.—Inlet valve closes and locks; unlocks exhaust valve; water column returning compress explosive charge, which it fires at K, commencing fresh cycle of operations.