# Various types of pop-pop engines

By Jean-Yves

The first engine of the family was patented by Désiré Piot in 1891. Consisting in an evaporator connected to a single pipe it was silent. Later (1924), McHugh added a diaphragm which gave the sound, the name and the celebrity of this little engine. In order to ease its filling with water the single pipe was replaced by two parallel pipes. Then, somebody deleted the drum. However, in order to keep a reasonable size, and in order to heat enough pipe volume to ensure the evaporator role, a certain length of pipe was coiled. The coil or spiral engine –the simplest one- was born.

What are the common points and the differences between these engines? Our purpose is neither to argue about the pipe diameter or length, nor about the existence and the shape of possible nozzles, but only to compare principles.

## A) What differs between engines ?

- Diaphragm or no
- Evaporator shape
- Evaporator size
- Number of pipes
- Materials

### 1) Diaphragm or no ?

It seems also stabilizing the engine running. In particular, a diaphragm engine withstands a bigger heating power than the same engine without diaphragm.

It decreases the performance (efficiency, thrust and frequency). This is justified by the energy it uses at the wrong moments of the cycle. When the diaphragm is bulging outward it reduces the effect of the pressure increase. When it moves inward it diminishes the effect of the pressure decrease.

### 2) Evaporator shape

Everything has more or less been made. Specialists in boilers built good looking evaporators of smoke pipe type (ex on side picture) which improved slightly the efficiency (which however remained pathetic). Various shapes of evaporators were seen : quasi spherical ones, cylindrical ones, flat ones…

With flat or long evaporators various orientations were seen from horizontal to vertical. Pipe connections were seen mostly on the bottom wall, but some were on the top or by the sides. Some were nearly vertical. Others were very inclined.

In any case some engines were running good. Complementary information: Engines with any possible kind of evaporator were seen running. But this doesn't mean that whatever the engine it works. There are other parameters to tune.

3) Evaporator size

Its heated and heating surface allows to transferring energy from outside to inside.

Its volume acts on the resonance frequency, hence on the thrust. One must not confuse the physical evaporator with the real one. What is important is the mean gas volume (steam primarily. This gas (which is a spring) gives elasticity at the resonator of which the second main component (the mass) is the liquid water inside the pipes. When the evaporator volume increases the frequency decreases. There is limit to the volume decrease which is got when only the pipes are remaining. This is typically the case of coil engines, but we also built engines with straight pipes. A simple pipe closed at its upper end can work as a pop-pop engine.

4) Number of pipes

Engines with multiples pipes (more than 2) are rare and we have no experience of such engines to talk about. On the opposite, on many occasions we performed measurements on engines provided with two pipes. An unexpected experience of dissymmetry is reported in "Pulsed waterjet or pump?". The dissymmetry, though minor, set as evident a thrust reduction, and sometimes the engine refused to pulsate.

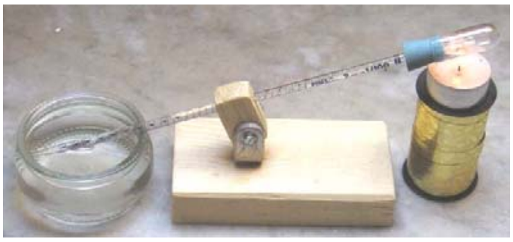
Seen from the point of view of vibration mechanics, a symmetrical engine has a node in its axis; i.e. it behaves exactly as would do two half motors. When there is a diaphragm the practical building of half an engine is not possible, but in the other cases (drum or coil) it is very easy. The picture hereunder shows on the test bench in front a 7 turn coil engine, and behind it, a 3 turn engine with single pipe. The thrusts measured at the end of each one of the 3 pipes were nearly equal.

Note:

- The 7 turn engine is for test bench use only. It is obvious that the opposite thrusts would cancel each other on a boat.
- Filling up the 3 turn engine requires the use of a flexible capillary tube and a syringe.
- The heating is here done by means of electricity in order to control the power. During the tests, the whole coil is thermally isolated.
- The heating power used with the 3 turn engine was roughly half the one used with the 7 turn engine (=> 3 turns pop-pop give the same thrust as at the end of one pipe of a 7 pipes pop-pop which have a double heating power)

5) Materials

Everyone thinks his engine is "the best" and we don't pretend to know a secret or the truth. We must admit that with different materials there are good working engines. Common extremes are on one side the whole copper engine and on the other side the glass engine (side example). In between one find mainly the brass engine, the steel engine and composite engines. Example: evaporator made of aluminum and pipes made of plastic.



## B) What are the common points between engines ?

- They all transform thermal energy into mechanical energy.
- They need hot source and a cold source.
- They run in diphasic mode (steam and liquid water coexist).
- They oscillate at a frequency which is roughly depending on the gas volume (stem and others, especially $N_2$ and $0_2$) and on the mean water mass into the pipes. (The frequency is slightly lower for diaphragm engines, but this is justified by the softness and hysteresis brought by the diaphragm).
- They propel the boat according to the pulsed waterjet principle.

We got the opportunity to observe what happened inside some more or less transparent engines specially built for this purpose.

In the engines built with a solid copper evaporator and an isolating pipe (plastic), the whole copper is heated by the hot source while the cold source is far downstream. Result: The evaporator is entirely overheated and the (oscillating) steam/water interface is located further down in the pipe.

In coil engines made of isolating material (glass), the interface is located somewhere between the heated place and the cold source.

In the engines having on one hand an evaporator flat and good thermal conductor, and on the other hand copper pipes, the hot source is located where the flame leaks the metal while the cold one climbs up to the top of the pipes. Result: everything occurs inside the evaporator. The steam bubble is created above the flame and its size varies with the same frequency as the pop-pops. However, by bringing more heat to this type of engine we succeeded to do t run dry; i.e. the interface stayed inside the pipes.

Wit glass engines filled with methyl alcohol a good running could be observed with a hot source of only approx 65°C. At the opposite, with whole copper engines we overheated the evaporators up to approx 800°C.

Whatever the engine, there is an oscillation around a mean location which depends mainly on the size, on the materials, and on the heating power.

An engine with a large evaporator provided with a very small diaphragm runs practically as the same engine without diaphragm. To end up, let's say that we installed a small diaphragm on a coil engine in order to measure the frequency.

The other engine is a model of simplicity. It is made of a copper pipe 8x1 (the heated part) prolonged by a brass pipe 6x0.5. This engine worked for hours.

**Conclusion:** There is no boarder between one type of engine and another type. In spite of apparent differences, either with overheated steam or not, all these engines without exception are using the same laws of physics and thermodynamics.