

# In Search of the Perfect Wave

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## INTRODUCTION

Please allow me to introduce myself. I've been an active surfer since my teens, but I'm also a professional physicist and a successful engineer directly responsible for designing commercial products having an annual turnover in excess of £20 million and which have been awarded three Queen's Awards for Industry. May I describe my recent quest to create the perfect wave?

Though learning to surf in Cornwall, most of my early surfing experience came from much nearer home, the beaches of Anglesey and the Lleyn Peninsula in north Wales.

Now, this part of the Irish Sea, lying to the west of Wales, is almost completely land-locked. Only to the south west does the St George's Channel allow Atlantic swells to penetrate, and occasionally, north Wales is blessed with smooth and glassy waves.

This was in the days before webcams or wave buoys, so we learned to be adept at reading the weather forecasts towards the end of every week.



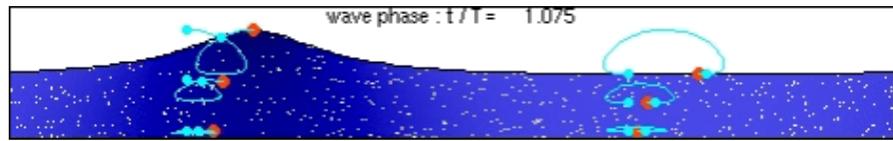
**A GOOD EXAMPLE OF A 'GLASSY' LAMINAR FLOW WAVE**

I still have fond memories of those faraway days, and the beauty of those glassy waves still fascinates me, it starting me dreaming about how to recreate those perfect glassy smooth waves in an artificial wave pool, dreams that led me eventually to the Wave-Master system.

## FLUID DYNAMICS

Fluid dynamics is the branch of physics that tells me that the water movements in those desirable and glassy-

smooth waves exhibit what is known as 'laminar flow', where the particles of water move in smooth, rhythmical and repetitive motions as each wave passes.



**WATER PARTICLE MOVEMENTS IN A LAMINAR FLOW WAVE**

Then, as every surfer knows, waves break as they move into shallower water, the water movement then becoming turbulent and chaotic.

## BASIC REQUIREMENTS

From this, I reasoned that for surfing, I would need to generate, on demand, single extremely smooth and laminar unbroken waves.

I also realised that in order to be viable for use in surfing pools, waves would have to be generated at high repetition rates and in a highly energy efficient way.

### BASIC REQUIREMENTS

- Smooth Laminar Waves On-Demand
- High Wave Repetition Rate
- Highly Energy-Efficient
- Adaptable to Wave Pool Designs

Additionally, any wave generating mechanism would need to be adaptable to various surf pool sizes and shapes.

The first thing I had to do was to build a wave tank or flume. This transparent-sided five-metre tank or flume enabled me to test models of various wave generating mechanisms in order to examine generated waves and the way they break on an artificial beach.



**1/10<sup>TH</sup> SCALE WAVE FLUME**

### **WAVE GENERATOR DESIGN**

This was a very difficult and sometimes frustrating time as I built and tested various ideas for generating waves; each one being an improvement on the previous one.

Then, late in 2013, I arrived at the latest system which is now producing glassy smooth waves as required. I've called this electrically powered modular mechanism the "Wave-Master".



**WAVE-MASTER GENERATING 1/10<sup>TH</sup> SCALE LAMINAR WAVES**

In operation, Wave-Master generates waves by the horizontal movements of a piston that is suspended by an efficient pantograph mechanism for almost frictionless horizontal movement.

Wave-Master meets all of my requirements for laminar flow waves on demand, with high repetition rates, high energy efficiency and versatility.

Unlike *all* other existing and planned wave pools, the Wave-Master system has no compressed-air systems, hydraulics or pneumatics, no dangerous moving underwater profiles or expensive water jet systems. It's just a simple yet highly energy-efficient piston-type modular wave generator that exquisitely matches real-world ocean waves.

It can produce single waves on demand, or new waves every fifteen seconds. It is this repetition rate that is head and shoulders above the competition.

- WAVE-MASTER FEATURES**
- No Hydraulics or Pneumatics
  - No Dangerous Underwater Profiles
  - No Pumps or Water Jets
  - Modular Wave System
  - High Power Efficiency
  - Real-World Ocean Waves

**DESIGN OF A SURF POOL USING BASIC PHYSICS**

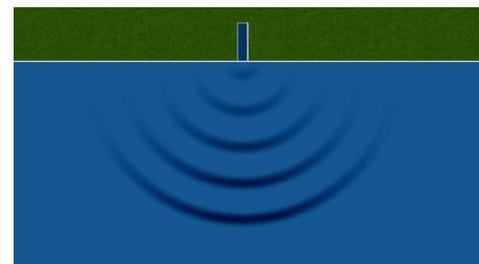
The Wave-Master has proved to be a very neat and highly effective means of generating waves, especially as it can be configured as an array. Therefore I resolved to continue in my efforts and see where applying this blend of surfing and science would take me.

Most surfers have an intuitive understanding of the ocean and how waves behave and this helps me avoid using too much mathematics in my explanations. The Wave-Master is a piston type of wave generator, and our 1/10<sup>th</sup> scale model has proved to deliver quality waves in a simple flume.

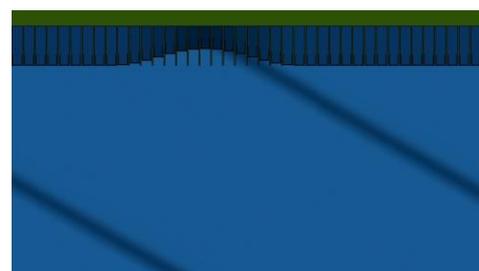
If a single Wave-Master module is operated in open water, the waves spread out like ripples in a pond and rapidly decrease in size.

What we really need are long, powerful and unbroken waves in a depth of about two metres of water. Waves such as these are easily generated by setting up an array of Wave-Master Modules side by side. The main advantage of using such an array of Wave-Master modules is that we can easily control the direction and shape of waves that are generated, by introducing small time delays between the activation of successive modules.

The use of an array in this way is extremely well understood and widely used in very many situations, such as wave paddles in marine research test tanks,



**WAVES SPREADING IN OPEN WATER FROM A SINGLE MODULE**



**DIRECTIONAL WAVES PRODUCED BY A PHASED ARRAY OF MODULES**



**DIRECTIONAL WAVES IN A COMMERCIAL TEST TANK**

loudspeaker arrays, electromagnetic arrays as used in radio telescopes and radar systems, and also in underwater acoustics, a technology I worked on for many years.

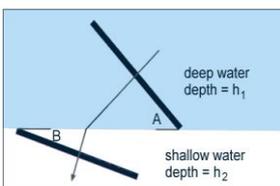
The width of the Wave-Master array is always going to be limited by the budget. To avoid the waves at the ends of an array from losing their size due to spreading, it is necessary to construct retaining walls on either side. As unbroken waves approach shallower water, they get steeper and steeper until they reach a point where they break, along their entire length. When waves break all at once in this way, surfers call it a “close-out” wave, meaning that it can no longer be surfed along its length.

The shape of the breaking waves also depends on the steepness of the sea bed. It must be neither too steep, nor too shallow. With the optimum conditions, the waves can be made to plunge, usually forming a hollow tube.

When unbroken waves approach the beach at an angle, they break first at the shallowest end. The critical point is where the wave is at its steepest and most powerful and is on the point of collapsing. This critical point progresses along the crest at a speed that depends on the peel angle. An ideal peel angle would be about 45 degrees.

The longest rides occur when the breaking crest progresses along the wave parallel to the beach. There are many such point breaks in the surfing world, at several locations in Hawaii, at Chicama in South America, Jeffrey’s Bay in South Africa and at Rincon in California

This refraction of waves around a point occurs because the waves slow down progressively along their length as they enter shallow water. It is entirely equivalent to



$$\frac{\sin(A)}{\sqrt{h_1}} = \frac{\sin(B)}{\sqrt{h_2}}$$

**SNELL'S LAW**

optical refraction, and Snell’s Law allows me to predict how the waves will behave as they approach the beach at an angle. In turn this allows me to design the profile of the pool bottom and the approach angle of the wave so that the peel angle is the desired 45 degrees.



**PARALLEL WAVES IN A BASIC WAVE POOL BREAKING ON A SHELVEING BEACCH**



**A HOLLOW WAVE PRODUCED BY THE OPTIMUM SLOPE OF THE SEA BED**



**ILLUSTRATING THE PEEL ANGLE OF A BREAKING WAVE**



**RINCON POINT IN CALIFORNIA SHOWING WAVE REFRACTION**

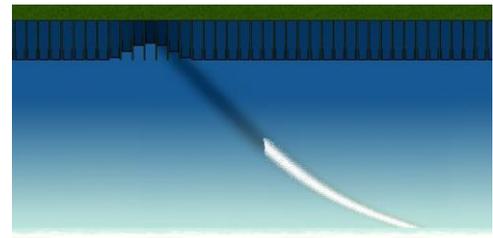
Surfers will instantly recognise the significance of the resultant wave shapes if we set up a long array of Wave-Master modules to direct waves at an angle of 45 degrees against a shelving beach.

With a limited size of array, we need to add walls on the left and right hand sides, in order to preserve the wave height against spreading. The walls should be at right angles to the path of the incoming waves, which explains their curved shape.

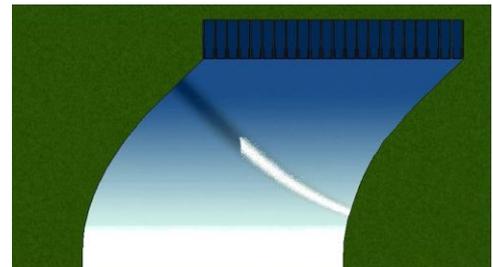
However, curving the left-hand wall in the opposite direction has several advantages. It allows the wave to peter out gently, giving a longer ride, and also provides a small family wave area beyond the surfing zone. By also curving the beach, this allows the surfer to complete his ride in safety as the wave dissipates. In summary, with a hundred metre Wave-Master array, this provides rides of longer than 100 metres, parallel to the beach, from the Take-off Zone to the Kick-out Zone. The speed of the break is 6.25 metres per second, or 14 miles per hour. A new wave can be provided every 15 seconds.

The size of the wave pool would be about 2 Hectares excluding support facilities, and include a sandy beach, a grassed recreation areas and a family wave area beyond the surfing zone.

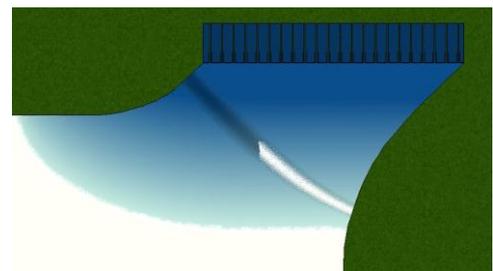
Allowing for an efficiency of 65%, the overall power consumption would be approximately 650 Kilowatts. This table below illustrates the approximate running costs of the Wave-Master, based on the typical costs of electricity in the UK and the USA.



**WAVE APPROACHING A SHELVING BEACH HAVING A 45 DEGREE PEEL ANGLE**



**LIMITED WAVE-MASTER ARRAY SIZE WITH WALLS TO PREVENT SPREADING**



**A PRACTICAL DESIGN OF WAVE POOL WITH CURVED BEACH FOR SAFETY**

	UK	USA
Cost per Wave	£0.33 per wave	\$0.33 per wave
Cost per Hour	£78 per hour	\$78 per hour
Cost of Electricity	£0.12 per kWh	\$0.12 per kWh

Costs based on 2011 prices, ShrinkThatFootprint.com Exchange rate \$1.68 = £1.00

**BASIC ELECTRICAL RUNNING COSTS**

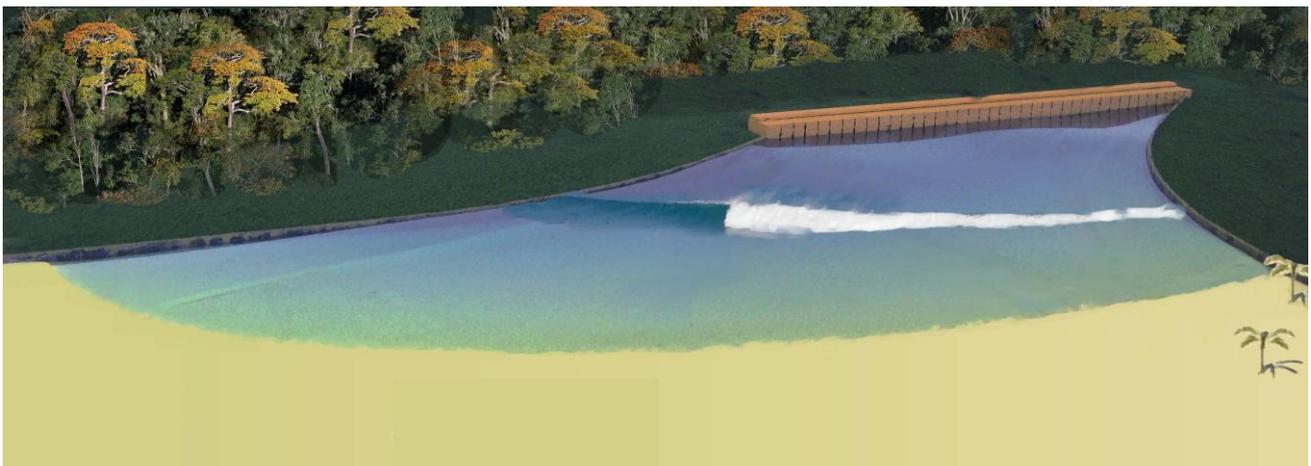
**SUMMARY**

Back in 2009, I set out to create the perfect wave without any clear indication it would lead anywhere. After all the late nights, building and testing exotic mechanisms, at my own expense, I now have the technology to facilitate the construction of a unique and novel design of wave pool.

Having kept a close eye on the competition I believe that none of them will be able to match the exciting opportunities presented by Wave-Master. The quality of the waves and especially the repetition rate along with the length and duration of the rides I believe will be a revelation to the surfing world.

To protect the design concept, I have registered the trade mark Wave-Master, and filed for a UK Patent. Also I have had lots of help and encouragements from friends, family, surfers and specialist engineers, all of whom would like to see this technology happen.

With over half a million active surfers in the UK alone, spending an estimated one point eight billion pounds annually on their sport, and a severe shortage of quality waves particularly during the summer months, there is a really exciting opportunity to be involved, and this represents a unique opportunity, as I am offering a licence for the use of the Wave-Master Technology!



**ARTISTS IMPRESSION (Temporary Draft)**

### FOR FURTHER INFORMATION

YouTube Video: [http://youtu.be/A\\_j0Kj5QSp8](http://youtu.be/A_j0Kj5QSp8)

WEB: [www.wave-master.org](http://www.wave-master.org)

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