Betty – London 2012
Olympic and Paralympic Cauldron

BREATHTAKING MOMENT: Once lit, the 204 individual copper petals rose to the vertical to form the cauldron bowl.

INCEPTION OF AN ICON
Projects are often driven by the creative objective of producing something that has never been seen before and for us, this often results in developing ‘never-been-done-before’ technology in order to deliver the creative vision. The London 2012 Olympic Cauldron certainly delivered the former, yet in bringing Thomas Heatherwick’s design to life, we employed many traditional, tried and tested engineering techniques.
ELEGANCE AND RELIABILITY
Code-named ‘Betty’, the cauldron was one of the most unusual and elegant devices we have ever built, comprising 204 individually designed copper petals with steel stems, arranged in ten concentric rings and attached to a five-tier ziggurat base. In its ‘down’ position, the design resembled a composite flower head, offering optimal spectator viewing from all angles – including from above. After the graceful, coordinated lifting of the stems and petals into the ‘closed’ position, the cauldron also provided what became one of the iconic images of the Games.

Heatherwick’s vision was the complete antithesis of all previous Olympic cauldrons and a radical contradiction of the original LOCOG brief. This brief had specified: ‘no moving parts’, yet Heatherwick’s design depended utterly upon the 204 stems rising gracefully from their lowered position to the vertical, the 204 petals coming together to form the cauldron bowl.

A SECRET VISION
Secrecy was a vital ingredient of both the design and the manufacture. Each petal, inscribed with the name of the participating nation, was to be carried into the stadium during the athletes’ parade by a representative of each team. The purpose of the petals was not disclosed before the show, indeed, the design of the cauldron was the most closely guarded secret of the whole Opening Ceremony. The cauldron reveal came only with the moment of lighting: the perimeter petals were lit by five young torch bearers and the flame appeared to be relayed around each tier in turn, before the stems rose to the vertical, bringing the 204 individual flames together to form a single, united, Olympic flame.

With the eyes of the world watching and waiting for this very moment, the need for reliability was absolute.
Over the last few years, investment in this CNC technology has seen us gain in certainty of production, as in this case, where all the CNC machines could be programmed from a single coherent drawing. The end result was a logical kit of parts that our teams could assemble for a test build and then later on site.

The CAD team modeled the cauldron’s components as well as the gas and electric feeds, with these models undergoing refinement as the project progressed. Each stem was attached to a system of components that formed the pivot, which in turn was attached to the tiered cauldron base. Originally much bulkier, these components are an example of the refinement process, not only from a mechanical design perspective but also from that of manufacture, where the original production time was reduced from 5 hours to 50 minutes.

The journey from model to reality began with Andrew Taylor’s 3D Rhino model which was exported as solid geometry to be used in our Autodesk Inventor software. This programme gives us the freedom to experiment: swapping materials with their different weights and strengths, to see what happens. It also means we can be precise regarding important factors such as material rigidity and other variables, whilst passing on exact information to our CNC machines for manufacture.

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THE PETALS
Thomas Heatherwick considered various materials and finishes for the petals, settling on copper which provided the necessary precious quality whilst giving an orange glow once the flames were lit, combining well with the blue finish of the steel stems.

Manufactured from thin copper sheet, each petal was unique, combining traditional craftsmanship and digital technology. They were, according to Piers Sheppherd, Opening Ceremony Technical Director: “A powerful symbol of the artisan skills that founded the Industrial Revolution” and were an important continuation of a major theme of the Opening Ceremony itself. Three sets were made: a rehearsal set, Olympic set and Paralympic set: a total of over 600 petals.

Not only was each petal different, but each one also had to interlock with its neighbours so that when closed, the petals formed the tight-fit bowl shape required. The array of stems was so tight, that just 1° of error would have resulted in a meshing of adjacent petals.

COPPER: This provided a precious quality, combining well with the dark blue stems and also the surprisingly blue London sky.
PETAL MANUFACTURE
The process of manufacturing the 600+ petals began with making the wooden plugs. These were built up from a series of contoured pieces, glued together then CNC’d into the exact form representing the negative form of each petal – similar to a traditional cobbler’s shoe last. Copper also had to be ordered to a very specific grade, weight and stiffness, with staged delivery over several months.

Working out the shape of the cut sheet of copper required for each petal was a tricky process and even once this was achieved, the final finished petal thickness was to have an average thickness of just 1mm. The petals were sent to Contour Autocraft in the East Midlands whose highly specialised, and increasingly rare, panel beating skills created petals of the correct thickness and with the hand beaten finish that Heatherwick Studios desired.

FAITHFUL TO THE DESIGN INTENT
This hand beaten look was an important part of the design integrity, a direct link with the Industrial Revolution theme of the Opening Ceremony.
A process called ‘spray transfer’ had been considered, whereby the copper would be spray-painted into shape, but this resulted in petals that were obviously machine made and not in keeping with the cauldron design or the sentiment of the Ceremony.

It took six panel beaters an average of five hours to beat each petal into shape with hammers, the annealing process helping to ensure that the desired shape was achieved whilst maintaining accuracy to within 0.1mm. The rough beaten units were then returned to us to undergo the lengthy sequence of finishing processes. Each petal was washed with acid to remove tarnishing, then polished and buffed numerous times using various grades of coarse paper. A collar was then welded to each petal, to allow for easy attachment to the gas burner at the tip of each stem.
PETAL ATTACHMENT
The petals also had to be easy to fit to the stems, an operation that would be carried out in relatively cramped under stage conditions, during the Ceremony itself – complete with time pressures and a huge amount of noise. They attached using a bayonet light bulb-type connection with a visual and tactile clue giving confirmation as to whether the petal had fitted correctly. A red marker was hidden when the petal was correctly positioned and at the same time a bayonet locked over 1mm protruding steel balls to give a click-lock feel.

As the teams assembled, each petal was handed to a member of the Stage One team who then attached them in the correct order.

PETAL ETCHING
Each petal had a 30mm vertical edge around which the name of each nation was inscribed in Futura font. During etching, the font perspective had to be distorted – similar to cricket and rugby on-pitch advertising for television cameras - so that when the petal was viewed front-edge on, the scripted words would be clear and would appear to be consistent.

ACURATE DISTORTION
Mapping this distorted perspective was extremely time consuming: each nation’s name was a different length, as well as each petal being a different shape. The longest name was 37 characters and logic might dictate that this would be inscribed on the largest petal, however, the process was further complicated by the exact nature of the petal arrangement design and the fact that the petals were affixed to the stems in the exact order they emerged during the athlete’s parade. Late additions to the Paralympic nations added to the headache, especially as these petals affixed in reverse order, from the inner ring outwards.

Each individual petal had its own unique graphic template cut from self-adhesive vinyl, which was then applied to the petal lip, before going through multiple-stage etching baths to emboss the graphic to the petal. Each petal was then given a high level polished finish, the script being worn to a hallmark finish, in keeping with the hand-crafted look and feel of Thomas Heatherwick’s concept.
THE STEMS
For aesthetic purposes and the integrity of the design, Heatherwick Studios required the 204 tapered steel stems to be as thin as possible. Each stem, however, was a conduit for the gas feed as well as the electricity supply for an igniter and therefore the narrowness of the taper was limited.

We manufactured a series of components for each stem, with the main base component undergoing a tube reduction technique, enabling us to reduce the 80mm diameter to just 25mm along its 1.2m length. Each of these tapered base sections was then welded to the 25mm stem shaft and the whole tube was rotary polished and finished. In order to create the cauldron bowl when vertical, the completed stems varied in length, with the longest measuring 7m including the 0.5m pivot mechanism.

The zinc plating process for the stems, as with the panel beating of the petals, both involved fast-disappearing highly specialised skills and were some of the few processes that we were unable to carry out in-house. A company in Walthamstow carried out the zinc plating for us, after which the steel stems were dyed black and finished in ‘bad black’. This highly specific colour gave each stem the appearance of being even thinner than it actually was and, depending on the background and lighting at the time, the colour also helped create the impression of invisibility.

Hidden from view beneath the Opening Ceremony stage, alongside ‘Frank’, the huge stage lift that would discretely lift her into position at the correct moment, Betty was mounted on track and housed in an 18m long, 6m wide ‘garage’. In order to fit into this space, all the stems had to fold in a north-south orientation, only unfolding into their 18m diameter ‘open’ position, ready for the show start, once Betty was moved along the track and into her raising frame set within ‘Frank’.

Controlling the gas supply once the 204 petals were lit was an important consideration. The flame had to be at its highest in the centre of the cauldron bowl, where the stems were shortest and the petals at their lowest.
THE BASE
The design of the cauldron’s 6.5m diameter ziggurat base was another element that was developed in response to the aesthetic and technological demands of the project. Originally consisting of five individual concentric rings, this increased to five sets of two – one moving, one static - in order to facilitate the graceful and seemingly effortless transition of the stems and petals from the lowered open position, to the closed ‘bowl’ of the vertical.

Fitted at irregular intervals around the rings, the stems required a system of components based around a pushrod lever to elevate each one to the vertical. The pivot that articulated each stem consisted of a push rod pivot foot, push rod, pivot plate, pivot block, pivot pin and second pivot pin: all of which we manufactured in-house. With reliability such an essential factor, mechanical as opposed to hydraulic technology was chosen to manipulate the steel ziggurat and operate the pivots.

A POWERFUL REVEAL
In order to move Betty from her concealed position under the stage, we needed stage engineering capable of lifting all 16 tonnes of her to the stage surface. At 18m diameter and weighing 32 tonnes, stage lift ‘Frank’ was the largest lift we have ever built. ‘Frank’ was positioned snuggly within the frame of the 18.5m wide stage aperture, a total of eight rams supplying the power via eight lift towers to raise Betty the two metres to show position.
PETAL LEGACY
The generous rationale behind Thomas Heatherwick’s Olympic cauldron, with the 204 individual petals and flames coming together to form a united whole, was mirrored in the post Games legacy.

After the ceremonial lowering of the stems and extinguishing of the flame during the London 2012 Closing Ceremony, the petals were returned to us so we could carefully remove the oxidisation that had accumulated during the two weeks’ burn, mindful to retain the unique patina acquired whilst playing host to the Olympic flame. Each individual petal was then mounted on an engraved black gloss plinth and enclosed within a clear acrylic presentation box before being dispatched to the appropriate nation. This provided a beautiful and lasting memento, while scattering the London 2012 petals around the world.
TEAMWORK: Installing the cauldron and then moving it to its Games position in the stadium was a coordinated effort.