WALSH RIVER MICRO-HYDRO
TURBINE CONTRUCTION GUIDE

These notes are intended as a guide to those wishing the construct a Banki-crossflow turbine like that used in the Walsh River Micro-Hydro Systems. The focus of the notes is on construction details, rather than design. The companion document ***Banki-Crossflow Systems Design Guide*** at http://www.planetarypower.com.au/info/microhydro/crossflow_design.pdf and the ***WalshHydro*** Excel spreadsheet at http://www.planetarypower.com.au/info/microhydro/WalshHydro.xls cover design issues and performance estimates.

The Walsh River Micro-Hydro System derives its name from the Walsh River in Far North Queensland, where the prototype system was installed. The system concept was developed and prototyped in 1991 by Jerry Jeffress and features the integration of custom made Banki-crossflow turbines, with Baldor DC generators and AERL Hydromax DC:DC step down controllers. It can also be used to pump water, indeed it has been used to pump water and generate electricity simultaneously.

These systems provide cost effective and environmentally friendly micro-hydro power for low head sites, ranging from less than 1 metre up to 8 metres.

1. GENERAL DESCRIPTION & LAYOUT

1.1 General Description

The turbine is of the Banki-crossflow type consisting of a cylindrical, horizontal axis 18 blade runner, intake nozzle, exit draft tube and housing. The turbine is made in two sizes:

LH6-180 has a runner 265mm dia. and 180mm wide

LH6-300 has a runner 265mm dia. and 300mm wide

For the **LH6-180** turbine, the maximum flow possible is 18.5 litre/sec for a head of 1 metre, rising to 26 litre/sec for 2 metres head and 32 litre/sec for a 3 metre head. For the **LH6-300** turbine the corresponding values are: 31 litre/sec, 43 litre/sec and 53 litre/sec.

The turbines have an adjustable nozzle to accommodate variable flow rates. The flow can drop to as little as one third of the maximum flow rate with little reduction in efficiency. This is a feature for which Banki-crossflow turbines are noted.

In normal operation the turbine sits just above the tail pond into which the water is discharged. The water exits via an optional draft tube, which descends into the tail pond itself.

The turbine needs to be anchored in a protected part of the stream bed. Usually it is bolted to concrete footings. The generator and/or pump is mounted, either above the turbine on a 1.2m high tower, or separately on the stream bank. Power is transmitted from the turbine to the generator/pump using a cog belt and pulleys.

If rising water levels submerge the turbine, no harm results. The turbine will continue to operate when partially submerged, although it may stop when completely submerged, automatically restarting when the water level drops.

A more complete general description can be found at http://www.planetarypower.com.au/banki.htm

Figure 1   general view of prototype turbine

Figure 2   top detail, showing generator and pump

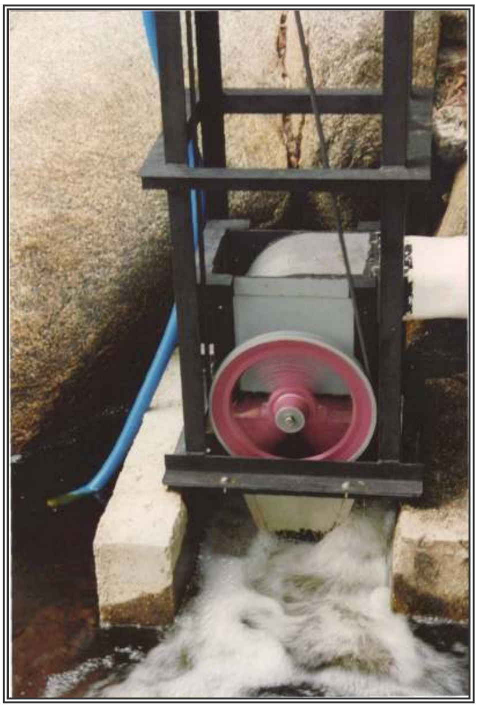

Figure 3   showing housing, lower pulley & draft tube descending into tail pond

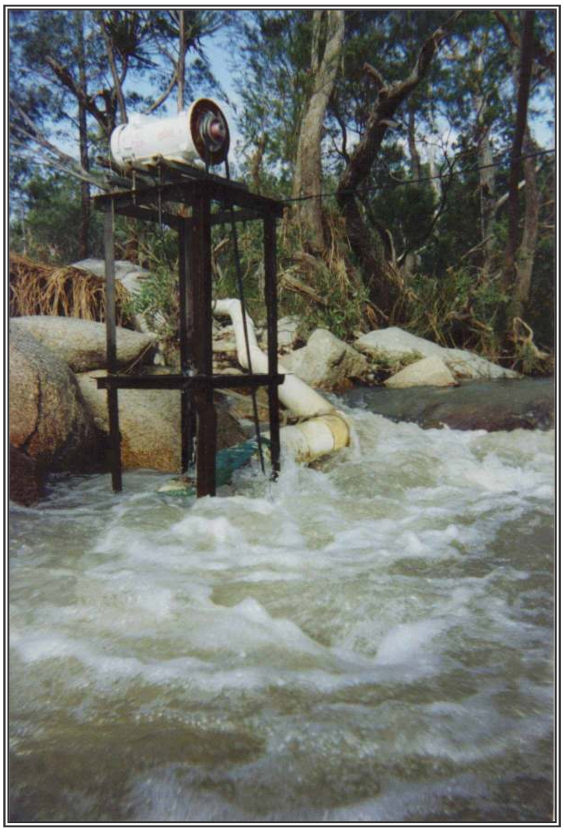

Figure 4   partially submerged, but still operating

Figures 1 to 4 show various views of the prototype LH-180 turbine. Figure 3 shows the original housing with draft tube attached. Subsequently it was found that the turbine was better able to handle flooding (figure 4) if the draft tube was removed. In figure 1, the draft tube is no longer present. The lower section of the 150mm dia. penstock can be seen in figure 4.

Figures 1 & 2 show the turbine in operation pumping water and generating electricity simultaneously.

1.2 Layout Detail

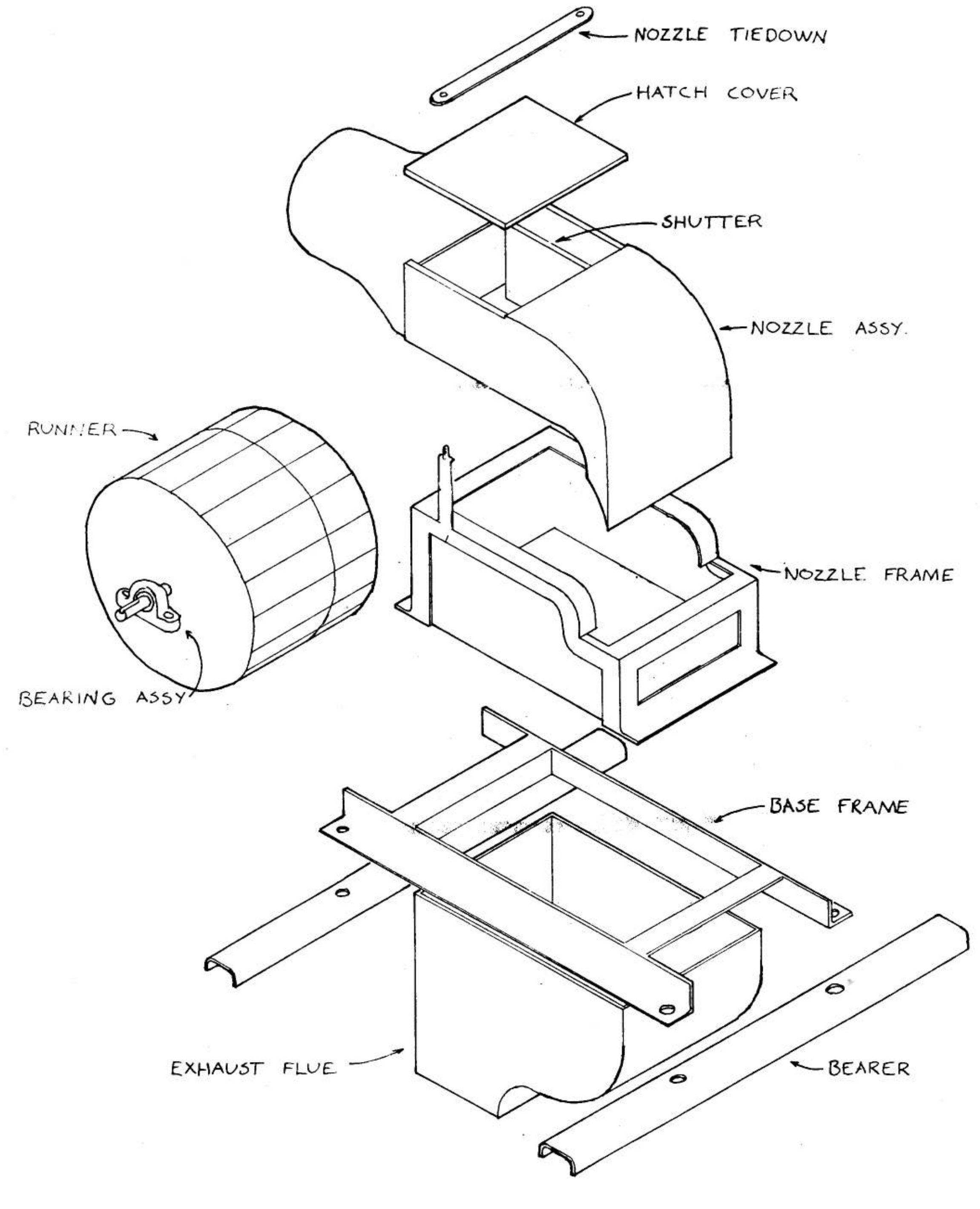

Figure 5 drawing showing frame, housing, nozzle assembly & runner

Figure 6   runner, housing and AERL Hydromax controller

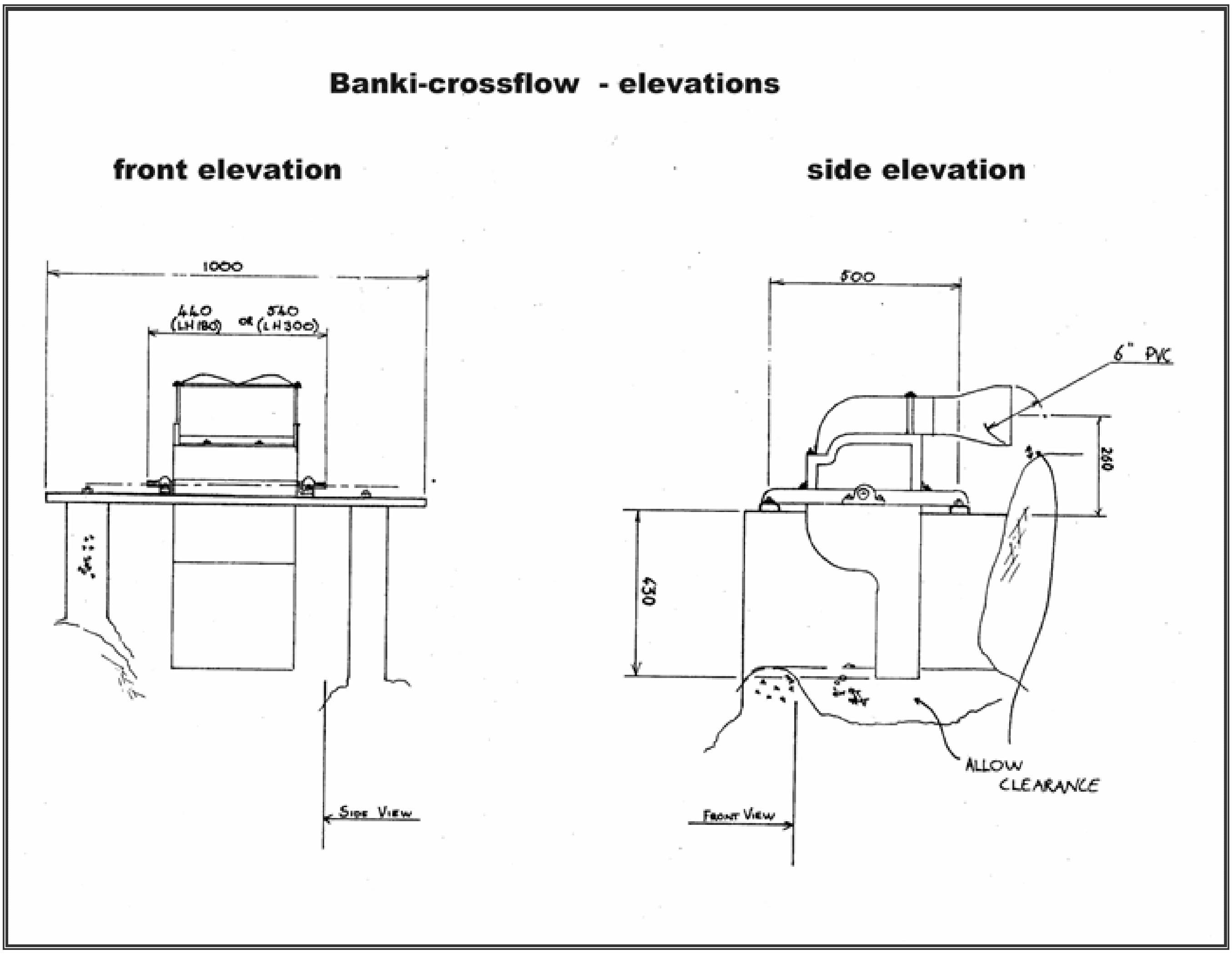

Figure 7   front & side elevations

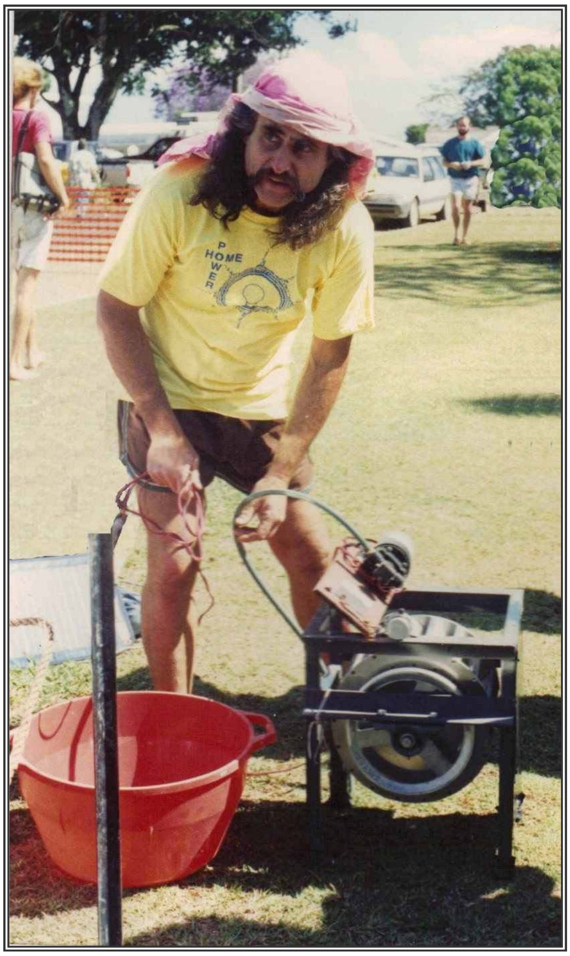

Figure 8

Figures 5, 6, 8 & 9 show how the individual components assemble to form the complete turbine.

Figure 6 shows one of the earliest turbines prior to installation, with a stainless steel runner and welded PVC housing and nozzle assembly. Note the removable hatch cover of the housing, to facilitate cleaning out the nozzle.

Figure 8 shows the author with a mock up demonstration on display at a Yungaburra Enviro Fair during the early 1990s, with a solar powered Flojet pump used to emulate the nozzle.

Figure 9 shows an installation using dual LH6-300 Banki-crossflow turbines, coupled to a single generator (not visible in the photos). It is fed by a penstock comprising 4 x 150mm diameter pipes. The housing and final section of the penstock of the right turbine have been removed to show the runner.

Figure 9 dual LH6-300 Banki-crossflow turbines, end view

2. FRAME & BEARERS

The frame is made by welding 40mm x 40mm x 3mm L- section mild steel, as per the design shown in figure 5 and rustproofed with a two part epoxy coating. The other parts of the turbine are built up from the frame and then anchored at the site as a pre-assembled unit.

The method of anchoring depends on the site and various arrangements are shown in the photos. A common method is to bolt the frame to steel or wooden bearers. The bearers in turn are anchored at each corner to concrete footings using 10mm dia. threaded stainless steel rod protruding vertically from the concrete.

At the prototype site the tower supporting the generator was secured to the anchors independently of the turbine, while in the example shown if figures 9 & 10 it can be seen that they are part of the same structure.

3. HOUSING & DRAFT TUBE

On our turbines, the housing is two parts, a top section comprising the intake & nozzle assembly and a bottom section being the draft tube (labelled exhaust flue in fig. 5). These are independently attached to the side members of the chassis, using stainless steel self-tappers.

The draft tube is optional - it is worth it if the runner is more than say 50cm above the level of the tail pond. If the turbine is likely to be operating submerged, i.e. the level of the tail pond is above the lowest point of the runner, the draft tube just hinders the flow of water away from the turbine and should be removed.

The housings of our turbines, including the nozzle assembly, were originally made from welded PVC. This is functional but not very attractive. Today we use welded sheet stainless steel.

Figure 10 LH6-180 with stainless steel housing & draft tube - note the T-piece arrangement of the penstock adjacent to the turbine to facilitate cleaning

If a draft tube is used, a suction effect is created and water can be lifted all the way up the tube into the runner chamber and interfere with the crossflow passage of the stream. In this case an adjustable air bleed point should be provided on one side of the housing. A 10mm hole fitted with an adjustable sliding cover will suffice – if needed the hole can always be made bigger. This allows the level of water in the tube to be adjusted to its optimum level, i.e. as high as possible so long as the crossflow stream can clear the runner without splashing back up to it.

3.1 Nozzle & intake

The intake of the LH6-180 is designed to accept water entering via a single 150mm dia. UPVC penstock (i.e. inlet pipe) as shown in figures 1, 3, 4, 6 & 10. The LH6-300 has a double entry, allowing a penstock made up of two pipes, side by side. (fig..9)

The intake functions like a throat, profiled to accept the150mm diameter pipe(s) at its upper end leading to the rectangular cross section of the nozzle at its lower end

The nozzle creates a stream of rectangular cross section, with a width equal to the runner width and a depth usually taken as 9.5% of the runner diameter. This is covered in detail in OSC Bulletin #25 referred to in Section 6.

3.2 Nozzle adjustment

One of the nice things about the crossflow turbine is that it performs well on part flow, with little loss in efficiency down to one third of full flow. Flow is reduced by adjusting the nozzle and there are various ways of doing this.

The first crossflow turbine we built had a vertical dividing plate running down the inside of the nozzle (labelled shutter in fig. 5), so that the flow could be partitioned into a 1/3, 2/3 or full flow. When part of the flow was to be blocked off a profiled "mask" was inserted at the entrance to the nozzle. The mask was made from 10mm thick PVC to which was glued a rubber gasket [made from type inner tubing], and secured to the nozzle by bolts at each of the four corners.

It was a bit of work each time to insert or remove the mask as that part of the turbine had to be disassembled and reassembled each time. However this approach is simple and effective. If three flow settings are sufficient then this is the simplest way to go. Note that the ratio does not have to be 1/3, 2/3. My preference is for [1/τ], [1 - 1/ τ], where τ is the golden mean (1.618..). That way, the three possible flow rates are in divine proportion.

We have also built turbines with a hinged plate inside the nozzle. The hinge passes right through the entrance to the nozzle from left to right, aligned with the bottom surface. The plate can be raised [to reduce flow] or lowered [to increase flow] by means of levers mounted at the extremities of the hinge on each side. The levers are held secure in the desired position by means of locking pins. When full flow is required the plate lies flush with the bottom of the nozzle. This method also works well and has never given us any problems.

We now use a variation of this, where the hinged plate is held in position by means of one or two thumbscrews protruding through the underside of the nozzle. The plate rests against the thumbscrews being held in place by the pressure of the water. This approach allows adjustment of the plate, and hence flow rate, even while the turbine is operating.

4. RUNNER

The earlier runners used a stainless steel 15mm dia. shaft, 5mm PVC end plates and 1.2mm stainless steel blades all glued together. These generally worked well, however most eventually failed, with the most common cause of failure being due to stones or possibly sticks getting past the screen and jamming between the runner and the housing. This left nicks on the outer edge of several blades triggering creep fracture and eventual dislodgement of the blade.

We now make the runners out of all welded mild steel, which is then galvanised and these have been free of problems The shaft diameter is 1" [25mm], the end plates are 5mm thick and the blades are from 90mm dia. pipe, [about 3mm thick], cut lengthways into four.

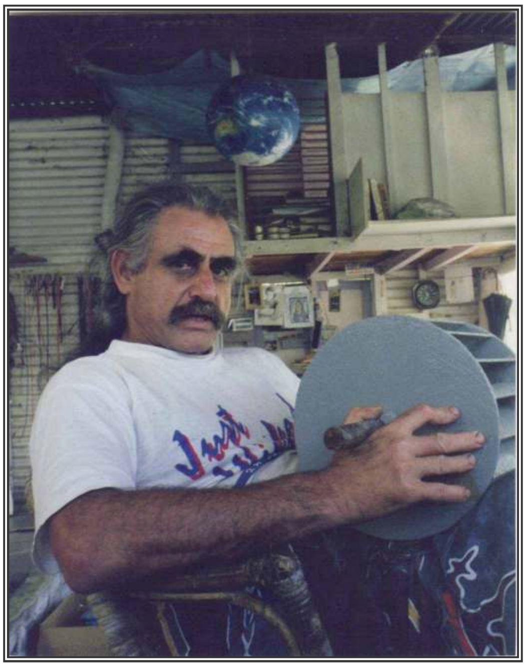

Figure 11 Author with welded steel runner

4.1 Runner blade dimensions

The optimum size and curvature of the blades is derived in OSC Bulletin #25 referred to in Section 6 and this is followed here.

Taking the outer radius as being one unit (A), the 18 blades are sections of a cylinder of radius 0.326 units (D). The centres of these cylindrical sections lie equally spaced on a circle of radius 0.736 units (B) and each section has its inner edge touching a circle with radius 0.66 units (C). A little trigonometry will establish that each blade section covers 73.6 degrees of an arc. Thus each blade can be obtained from pipe cut lengthways into four with a margin to spare.

For the turbines manufactured by Planetary Power: A = 132.5mm, B = 97.5mm, C = 87.5mm, D = 43.2mm.

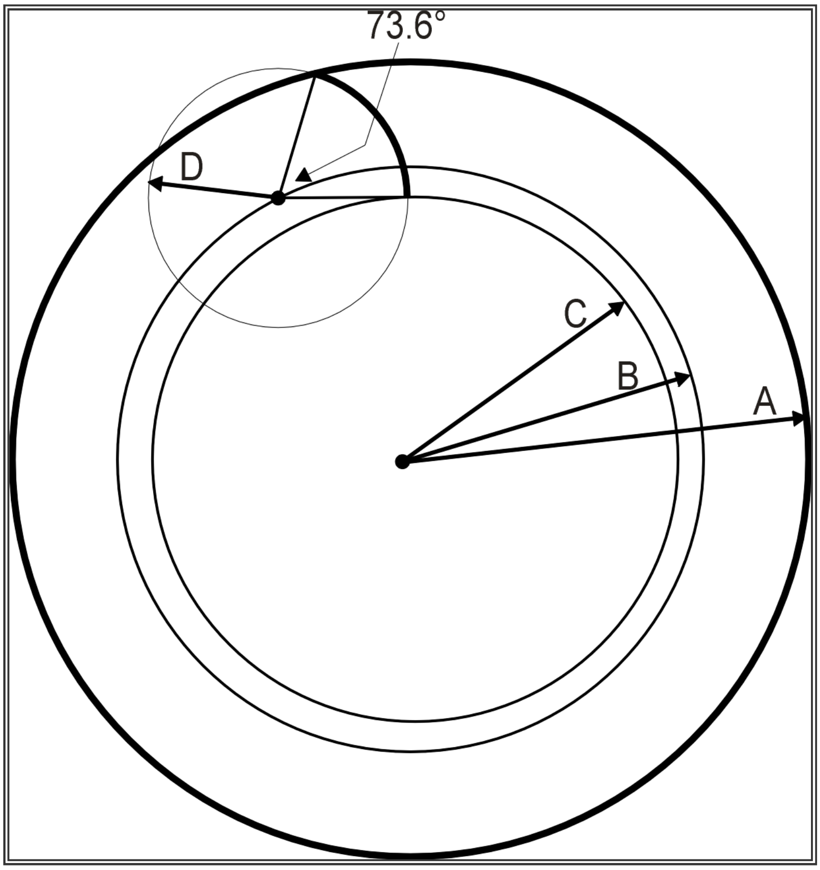

Figure 12 runner dimensions

5. BEARINGS & BEARING HOUSINGS

The runner shaft fits into a single bearing at each end. The bearing housing is bolted directly to the frame (ref. figures 6, 7 & 10). Standard UC200 type ball bearing units are used and these should be greased about once a month. At some sites it is hard to prevent bearings being constantly splashed with water and in these cases wooden bearings are an attractive alternative. Figure 13 shows a Banki-crossflow runner configured as a breast wheel used for pumping water with wooden bearings. The bearings are water lubricated and two small holes drilled from the top, directly above the shaft, to allow water to penetrate to the bearing surface are just visible in the photo.

Vertical alignment of the runner relative to the housing is critical:– too high and the runner will scrape against the top of the housing; too low and part of the stream will fly over the top of the runner with loss of efficiency. The use of shims between the bearing housing and the frame is a convenient way of adjusting height to obtain optimum alignment.

6. FURTHER READING

An excellent discussion of how the crossflow works is given on Joe Cole's website http://home.carolina.rr.com/unclejoe/ and from there you will be able to down OSC Bulletin #25 "The Banki Crossflow Turbine" Our design follows the principles set out in this bulletin.

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