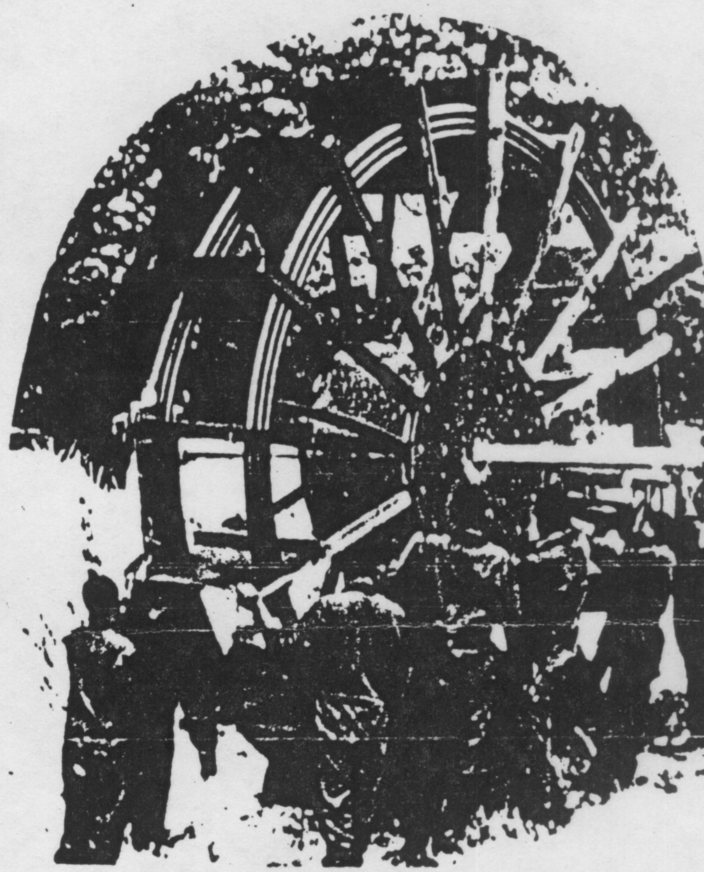
BLAIR RESEARCH BULLETIN

NO.

Blair Research Laboratory
Ministry of Health
P.O. Box 8105, Causeway
Harare, Zimbabwe

A SPIRAL TUBE WATER WHEEL PUMP



A 4 Metre Water Wheel under construction at Mazowe.

The spiral tube water wheel pump was designed by laboratory staff in 1979 specifically to use energy flowing in canal water to pump water under pressure to a higher point where it could be used for domestic use. Blair Research Staff have subsequently built wheels ranging in size from 0.5 m in diameter to 4 metres in diameter. The photo shows a 4 m diameter wheel being constructed. Although this pump was specfically designed to work in irrigation canals, waterwheels of this type have been constructed in riverine conditions.

Wheels of this type have now been in operation in Zimbabwe for 5 years and have provided very reliable service. The water pump itself consists of a spiral tube designed without valves. The 4 metre diameter wheel shown in the picture was fitted at Mazowe in 1979 into the main irrigation canal supplying the Citrus Estate. Readings taken in October 1979 showed that the wheel pumped 3697 litres of water per hour to a height of 8 metres above the canal (88 cu.m. per day). The canal width was 1.93 metres and the water flow rate in the canal was 1m/sec. The wheel was made with 16 paddles each being 600 mm x 600 mm in area. Two coil pumps were mounted on the wheel in horizontally opposed positions. Each pump consisted of 3 coils of 50 mm diameter pipe. The wheel performed 3.21 revs. per minute whilst pumping water to 8 metres. The output of the same wheel was remeasured in 1983 and remained unchanged.

The Waterwheel

Waterwheels have been used to raise water since ancient times. The great Roman wheels built in Hama in Syria were built over 1000 years ago and some were 30 metres in diameter - they still work today. These great wheels lifted water in buckets on the rim to spill into troughs - the diameter of the wheel had to be equal to or more than the desired pumping head. Many subsequent attempts to use the power the wheel, but also its dependability. The pump described in this bulletin is little more than a coiled pipe - open at both ends and has proved - so far - that in simplicity and elegance, it is a perfect match for the wheel.

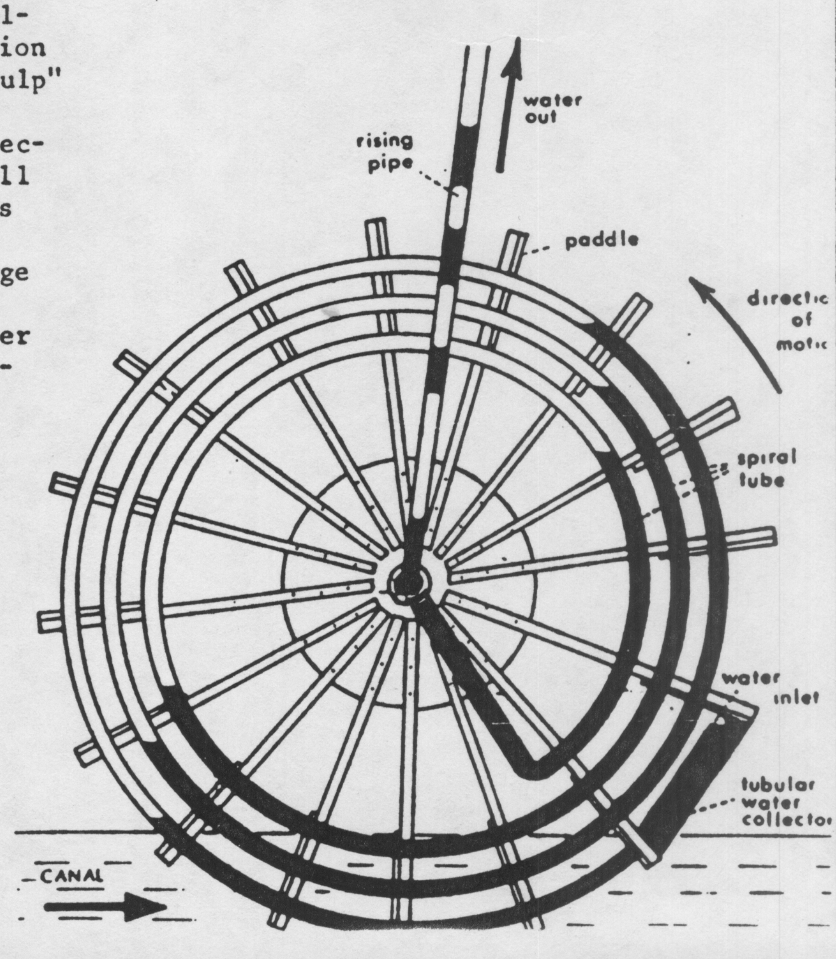
Basic Design

The waterwheel itself is very simple consisting of a series of paddle wheels attached through spokes to a central hub mounted on a central hollow steel axle. The axle is supported on either side of the canal through a brick built pillar. Wheels have been made of steel, hardwood and aluminium depending on the availability of suitable materials. The number of paddle wheels is 16 - the arrangement of this number being particularly easy.

The water pump itself consists of a polypipe tube arranged so that it forms a spiral fixed either on the sides of the wheel or preferably so that it fits within the paddles of the wheel (see diagram). The latter arrangement gives the wheel great strength since the spiral tubes act as reinforcing struts supporting the spokes. In most operating wheels two spiral tube pumps are used, placed within the wheel in horizontally opposed positions. Water enters the spiral tube through an enlarged pipe which acts as a water collector. The collector picks up enough water to half fill one complete spiral of the pump. Thus a core of water is picked up followed by a core of air. Thus a series of "airlocks" is built up in the spiral tube. The innermost spiral of the tube delivers water into the axle of the wheel and there it is led through a simple water seal, made of neoprene, to a static rising waterpipe which delivers water to a header tank above the wheel.

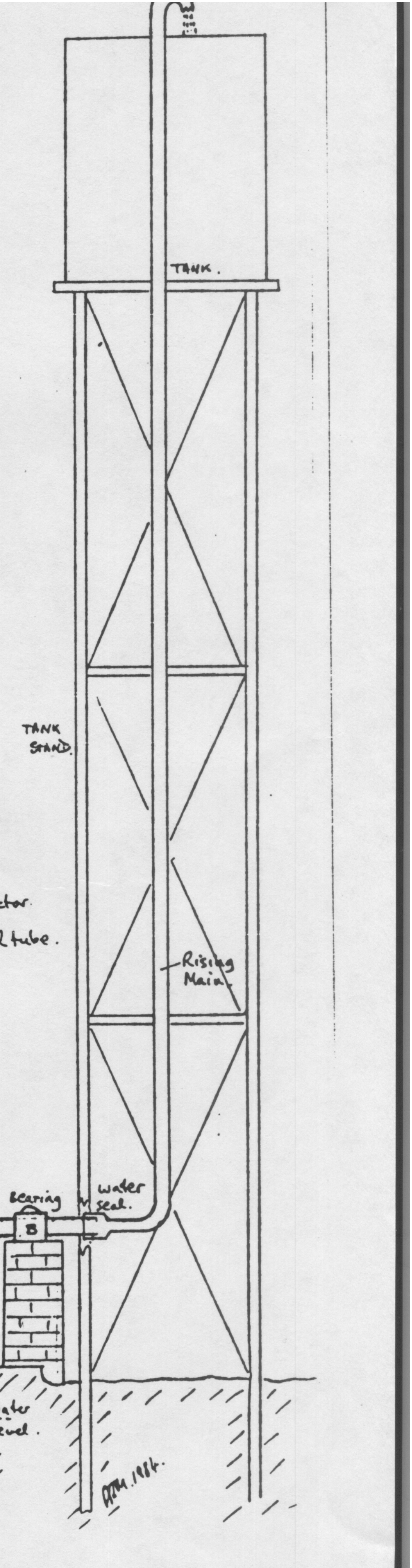
Operation

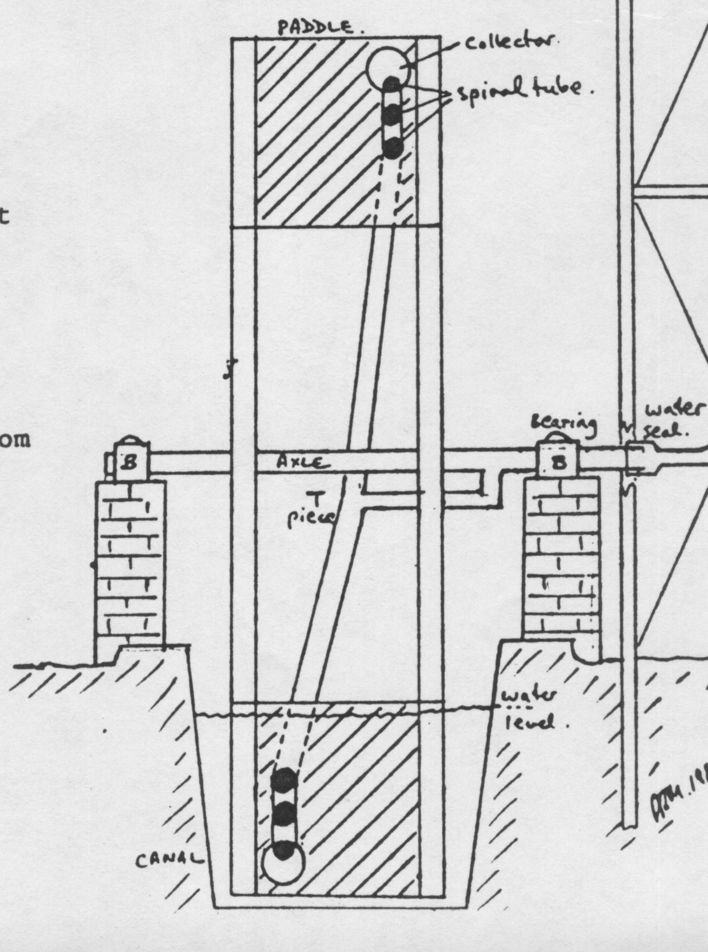
As the wheel revolves each paddle in turn becomes submerged in the water passing around it. Thus once per revolution each water collector also dips into the water. Just after the water collector passes the horizontal position and begins to rise, it takes in a "gulp" of water - expelling air previously contained within it. When the collector rises out of the canal it is full of water. This charge of water runs back into the first spiral of the tube pump and is followed by a charge of air. As it dips again into the water, the collector picks up another charge of water and the cycle is repeated. As the wheel revolves a pressure head develops within each coil of the spiral tube, water in the ascending coils being higher than in the descending coils (see diagram). Cores of water contained in the spiral compress air between them as they travel around the tube and both water and air are expelled under pressure into the hollow axle of the wheel. The water which is under pres-



sure rises up the pipe and this process is assisted by the compressed air which lifts water above it in its attempt to escape through the pipe. The water is discharged into the header tank in a series of bursts - jets of water being followed by jets of compressed air.

The height to which water can be pumped depends on the number of coils in the spiral tube. As an example - a 2 metre diameter wheel can pump water up to approximately 8 metres with 6 complete coils, the same wheel being able to pump up to 6 metres with 4 complete coils and 4 metres with 2 complete coils. For larger wheels where the diameter of the coils is nearly the same as the diameter of the wheel an approximation can be made by multiplying the diameter of the wheel by the number of coils. A 4 metre diameter wheel with 3 coils should be able to pump water up to a height of 12 metres. The volume of water pumped depends on the capacity of the spiral tube pump. Naturally, the wheel will only pump water if there is sufficient energy in the canal to turn the wheel against the weight of water held in the rising spiral tube. The head of water in each spiral varies through a cycle, with optimum pressures being developed as the water load in the rising main reaches a maximum. The volume of water pumped also depends on the speed of the wheel as well as the capacity of the spiral tube. The wheel should not move too fast however, as the effects of centrifugal force will have an influence and may carry water over the head of the wheel, and break the essential air lock between each core of water. The wheel could not pump water at all through the spiral tube if the air locks did not exist. It is possible to fit a single collector pipe and connect this to the axle through a single spiral tube. More water can be pumped however, when two collectors are fitted to two spiral tubes. The exact arrangements may depend on whether more water is required at a small head or less water is required but but at a greater head.



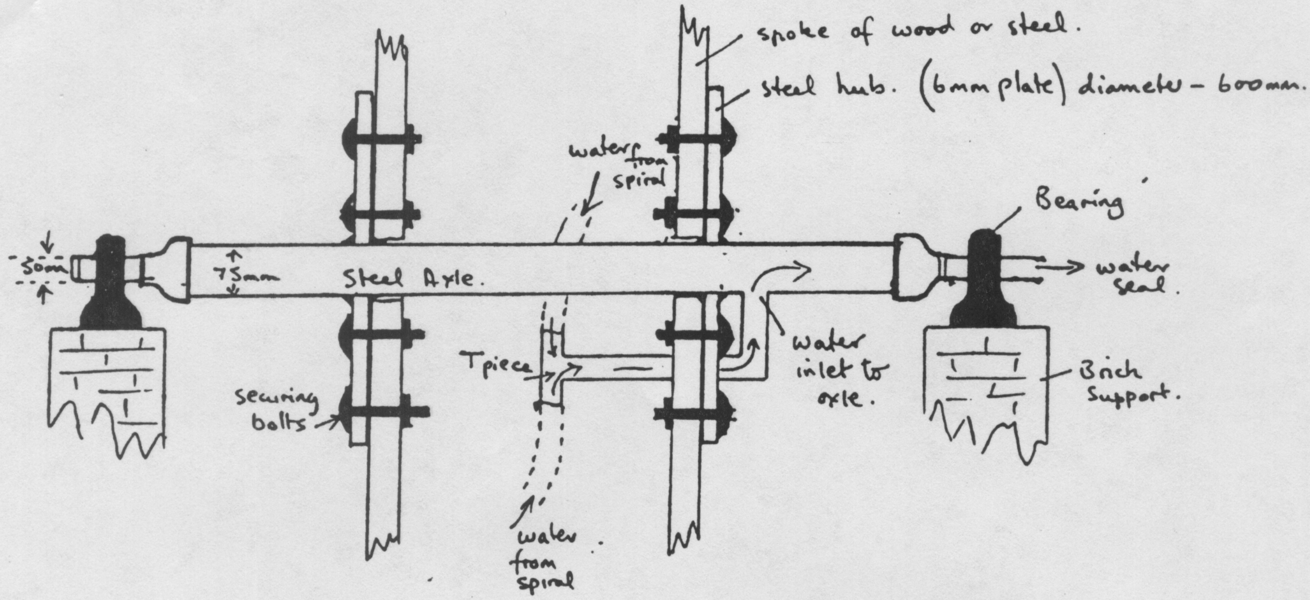


Constructional details

1. The Axle and Wheel

The axle is normally made from galvanised steel piping. For small wheels up to 2 metres in diameter a 25 mm or 32 mm diameter axle pipe is adequate but 40 mm pipe is preferable. Larger wheels should have a stouter axle- a 75 mm steel pipe being most suitable for 3 m and

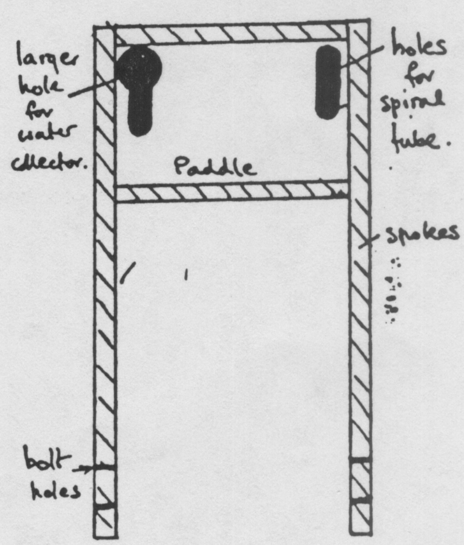
4 m diameter wheels. A 75 mm steel axle can be reduced in diameter to 50 mm at the point where it passes through the bearings. Unless the wheel is made of light material like aluminium it is best to weld in the water inlet to the axle, off-centre, which avoids making a weak point in the centre of the axle.



Large sealed bearings should be chosen on which to mount the axle, preferably pillar block type. Preferably two steel hubs at least 600 mm in diameter should be welded to the axle - so that the spokes can be bolted on at a later time. Heavy wooden discs can also be used to make the hub, which should be rigidly mounted. Paddles should be made to fit the canal - the hubs should be spaced apart the same width as the paddles - large wheels so far built have paddles which are 600 mm wide.

2. The Paddles

16 paddles are made to the appropriate size as shown in the diagram. The spokes and frame for the paddle can be made of 75 mm x 50 mm hardwood or 40 mm steel angle iron. The paddles themselves can be made of quality plywood or thin steel plate. The spoke length is approximately ½ the diameter of the final wheel and the paddle width should be calculated to fit within the canal. If the spiral tube pump is to be fitted within the paddles, holes should be left within the paddle to accomodate the piping. If a single spiral tube is fitted, two of the 16 paddles should be made with holes large enough for the collector (see earlier picture). If two spiral tubes are to be fitted, 4 of the 16 paddles should have cut out sections large enough for the two collectors. The holes for the collectors and piping should be cut so that the inserted pipes fit tightly. Each collector



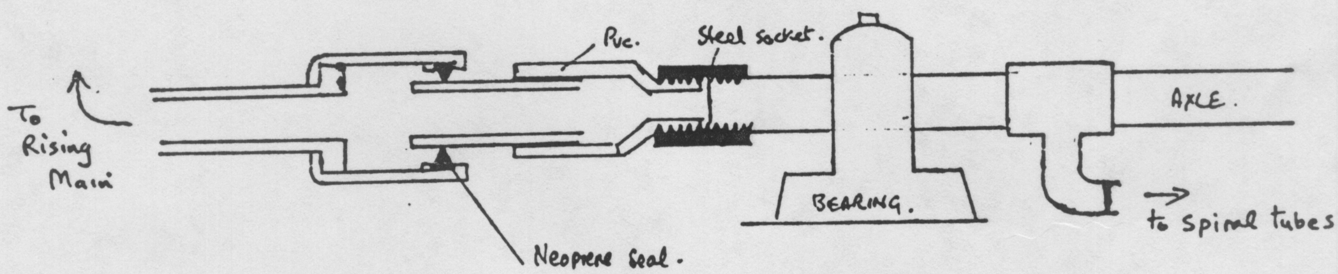
is held by two paddles. Bolt holes are made in the spokes to enable the spokes to be attached to the central hub. The wheel itself is complete once the spokes and paddles have been attached to the axle and hub.

3. The Spiral Tube and Collectors

On larger wheels, the spiral tube is made of 50 mm diameter polypipe tube; on smaller wheels it can be 25 mm, 32 mm, or 40 mm. Obviously larger diameters are also possible. In wheels so far constructed the collector for a 4 m diameter wheel has a length of mm and a diameter of mm. The collectors are attached to the appropriate paddles first. The length of flexible polypipe is then threaded through the holes made in the paddles so that it forms a spiral. It is best to start threading from the inside working outwards. The outermost end of the pipe is connected to the rear end of the collector. If three spirals have been chosen the polypipe is cut off after the third spiral and a polypipe 90° elbow added. The polypipe is then led to another elbow (if one spiral tube has been made) or to a polypipe T (if two spiral tubes have been made). The third arm of the T is led into the axle as shown in the diagram.

4. The Water Seal

There are a variety of ways of making this. Reinforced plastic pipe fitted over a plastic fitting such as a pipe to thread adaptor can be used. Seals can also be made from neoprene washers fitted around the PVC outlet pipe. What is important is that the axle section of the rising main is static.



5. Mounting the Wheel

Once the wheel has been finished and the spiral tube pump fitted, the wheel can be placed in the canal. Two brick pillars are built on either side of the canal at the correct height and distance apart so that the wheel will sit nicely on its bearings and well immersed in the flowing canal water. It is wise to have the water seal ready when the wheel is fitted because water will be delivered under pressure as soon as the wheel turns. Large wheels fitted to large canals cannot easily be stopped once they are revolving - in such conditions it is wise to lower the level of water in the canal temporarily whilst the wheel is being fitted.

6. The Rising Main and Storage Tank

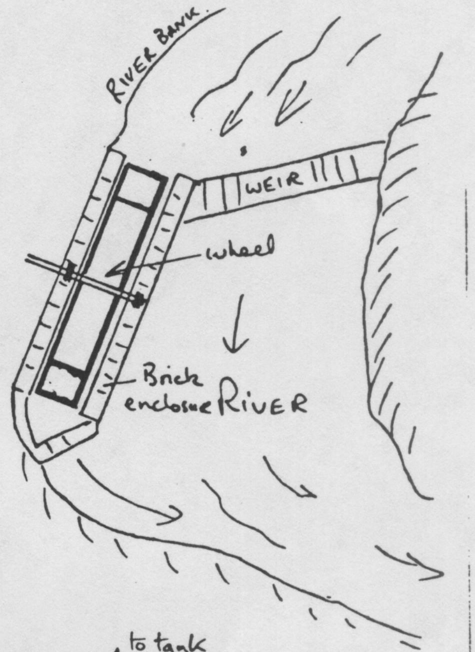
The rising main fitted to the axle pipe should rise vertically and be fitted with a curved pipe at its head so that water is led into the storage tank. Smaller wheels have rising mains made of 25 mm pipe, larger wheels with 50 mm pipe. A tank stand can be made of concrete or stout gumpoles or steel bolted together. Once the water has been delivered to the tank it can be reticulated to the domestic supply through some form of purification system.

7. Maintenance

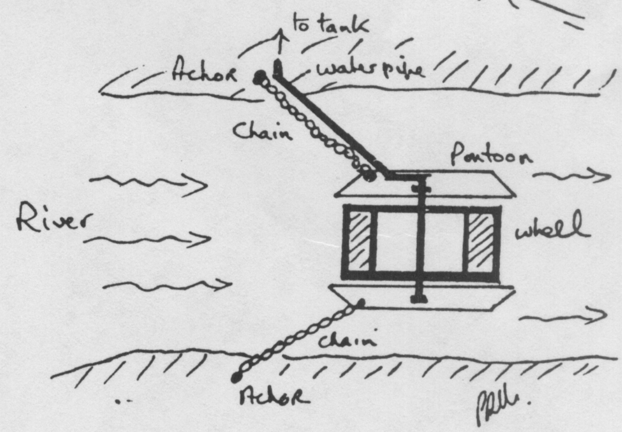
Provided the wheel has been made strongly and the bearings are lubricated, the wheel should provide long and trouble free service almost without being touched. The water seal may need tightening or replacing from time to time - but a well made seal should last for many years.

Alternative Arrangements

Fitting in the course of a river: it is possible to build a weir across a suitable part of a river or stream and build a brick wall on which to mount the wheel. Waste water can then be diverted back into the stream after it has been diverted from the main stream, through the brick "flume" and provided the wheel with energy. This arrangement is similar to many ancient wheels built in Syria. The great disadvantage of mounting wheels in rivers is the great variation in the height of the water in the river.



This disadvantage can be overcome in some cases and especially larger rivers by mounting the wheel on a floating pontoon which is anchored to the river banks. In this case the paddles should be broad and not so long-so as to catch most of their energy just underneath the water. The outlet water can be led down one of the chains used as an anchor. The arrangement should be protected against damage from large floating logs and other debris.



THE SPIRAL TUBE WATERWHEEL PUMP DESCRIBED HERE WAS DESIGNED IN ZIMBABWE IN 1979 WITHOUT REFERENCE TO EARLIER DESCRIPTIONS OR MATERIALS. LATER, IN 1981, EVIDENCE CAME TO LIGHT THAT THE FIRST SPIRAL PUMP HAD BEEN INVENTED BY H.A. WIRTZ IN ZURICH, SWITZERLAND IN 1746, AND HAD BEEN DESCRIBED BY THOMAS EWBANK IN ' A DESCRIPTIVE AND HISTORICAL ACCOUNT OF HYDRAULIC AND OTHER MACHINES FOR RAISING WATER ' IN 1849 (NEW YORK). SINCE THE ZIMBABWEAN MODEL DEVELOPED INDEPENDENTLY, IT HAS SEVERAL FEATURES NOT FOUND IN EARLIER DESCRIPTIONS.

Peter Morgan. March 1984