

The Zimbabwe Bush Pump

by Dr Peter Morgan

Developed under actual field conditions to be almost indestructible, Zimbabwe's Bush Pump has been in service since 1933, with modifications and improvements. It is easy to build, requires almost no maintenance and is ideally suited to local conditions.

WHILE IT IS almost unknown internationally, Zimbabwe's Bush Pump can boast of over half a century of successful operation in conditions that would have placed many other models on the scrap heap. When first seen most Bush Pumps give the impression of being a crude assembly of metal parts — ideally suited for a museum of past relics. The facts show however that this remarkable pump is a masterpiece of endurance, and can ably perform when its parts are badly worn out or even missing altogether.

The Bush Pump is wholly Zimbabwean. It was first designed, in 1933, by Tommy Murgatroyd, a government Water Supply Officer operating in the Plumtree District of Matabeleland, in western Zimbabwe. Its success can be judged by the fact that no other pump, save the bucket and windlass, is more common in the rural areas of Zimbabwe. It has remained the pump of choice for all heavy duty and all deep well and borehole settings throughout the country ever since.

History of development

Following its birth, the design of the 'Murgatroyd Pump' remained almost unchanged for about 40 years, and many of these early models, dating back to the mid-1930s are still operating today. The original pump had been designed in a blacksmithing era, when standard pipe and plate were bolted together. The first major design change took place in the mid-1970s when Cecil Anderson, an engineer working with the Ministry of Water, redesigned it, replacing the bolted structure with components that were welded together. He used a successful

method of bolting the pump stand directly to the borehole casing and called it the 'Bush Pump'. This became the national standard handpump, and most Bush Pumps in existence today are of this type.

The period after 1980 saw a proliferation of Bush Pump models, many being inferior in design to the original. As a result the government decided to introduce new standards in 1987. The 'Model B' Bush Pump, designed by government staff as a result of a national co-ordinated initiative, is the current standard.

Description

The hardwood block, which operates as a bearing-and-lever system is without a doubt the key feature of all Bush Pumps. It was Murgatroyd who introduced this piece of genius. The teak or mopane block is robust, durable, and self-lubricating and still operates when old and badly worn. It has a life expectancy of at least one decade and usually two. Such features have enabled this pump to outlast and outperform most of its rivals.

Pump Head Most Bush Pumps

installed in recent years consist of a steel pump stand bolted to the upper end of a steel borehole casing. The original Murgatroyd pump was set into a concrete base, and some later models also had this feature. The latest standard models are designed to bolt on to a 150mm-diameter steel borehole casing, which makes total replacement of the pump head easy. Where the pump is fitted to a well, a length of borehole casing is cast into the concrete well cover. The use of 16mm U-bolts which clamp the pump to the casing, introduced by Cecil Anderson, is a very successful technique.

The wooden block, usually made of teak, is cut, drilled and then boiled in oil for two or three hours, then allowed to cool overnight. This treatment expels air from the timber, and oil is sucked in during the cooling phase. This treatment provides the block with self-lubricating properties, which are ideal in situations where regular pump maintenance cannot be guaranteed. Mopane hardwood blocks are now being introduced, as an alternative to teak, as the natural reserves of teak are being reduced.

The wooden block rotates around a steel bolt which is supported by steel brackets welded to the upper end of the pump stand. In older designs the wooden block rotated around a length of 25mm steel pipe (pivot tube) which was clamped within a U-shaped bracket and held by a nut and bolt. In the latest standard pump, this is a 35mm-diameter solid bright mild steel bolt equipped with a squared head to avoid rotation. The bolt is kept tight with a single nut held against a spring



Many Bush Pumps are found in very remote places.

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washer. Earlier head bolt systems which were fitted with a lock nut (and not a spring washer) had a tendency to come loose. The handle of all Bush Pumps is made from standard steel water piping attached to the wooden block with U-bolts.

The same arrangement of nut-and-bolt system is used to support the linkage between the block and pump rod at the front end of the pump head. On the current standard the link is made directly through a U-bracket.

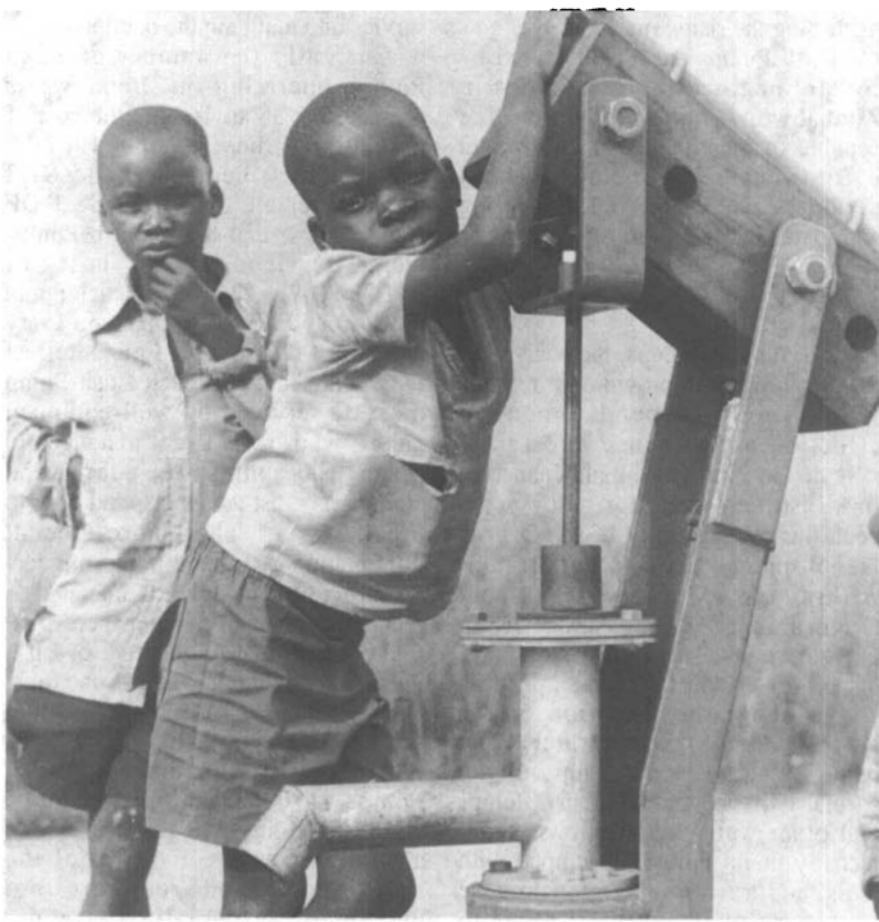
The latest Model B Bush Pump, retains all the best features of earlier models and these include the hardwood block, steel pump stand, U-bolt clamping system and solid pin-head bolts. This model has few wearing parts, and unlike its predecessors, has a direct link between the rod and the block.

In this model the rod passes through a 'floating washer' system which is able to accommodate all movement of the rod, both forward and back and from side to side. Two washers are used, the upper to support the rod (through a rubber buffer), the lower to form a hygienic seal. The main wearing parts in the head are reduced to the washers themselves, and the wooden block, the wear on the latter being minimal. The washers are 100mm-diameter discs of 6mm steel plate which should ideally be replaced every two years, although the pump will operate effectively even if these parts are excessively worn. Two spare washers are provided with each pump together with two spanners.

The Model B Bush Pump has been designed to operate (albeit less effectively) when most of its bolts have been removed, while other parts can be substituted with wire, steel pipe or non-standard parts. These features become all-important in the real world where pumps are just expected to work with minimal assistance from outside.

Down-the-hole components

The Bush Pump operates on a lift pump principle. The reciprocating action is transferred from the pump head to the cylinder through a series of galvanized steel pump rods running inside a steel rising main. Most rising mains are made from 50mm GI piping although 40mm is also used and even 25mm on occasions. Most rods are made of 16mm mild steel although 12mm is also used. Standard 3m lengths of pipe and rod are joined with threaded sockets or connectors. Pump cylinders are made of brass and are



The Model B Bush Pump.

either 50mm or 75mm in diameter, most being 75mm, these are locally manufactured. The pistons and foot-valves are also made of brass with most piston seals being made of leather. Standard foot-valves are very rugged and reliable, when the right model is chosen. Galvanized pipes and rods have been found to be durable in most Zimbabwean waters, and while corrosion problems do occur, they are much less intense than elsewhere in Africa.

Characteristics

Bush Pumps are installed in communal settings throughout Zimbabwe where they may serve several hundred people. In many cases they are expected to work for over 15 hours a day.

Bush Pumps can lift water from a depth of 100m, but most are installed to depths of about 40m. The pump is very flexible, however, and will also operate effectively on shallow wells. Most pumps are fitted with standard 75mm brass cylinders which enable them to deliver between 30 to 40 l/min. This discharge rate is reduced at greater depths and also when the leather seals are worn or the foot-valve leaks. 50mm cylinders deliver between 15 and 20 l/min. The stroke length is very variable, but normally lies

between 100mm and 200mm. The downstroke is cushioned by a rubber buffer. The upstroke is stopped when the steel handle hits the ground.

Several parts of the Bush Pump are subject to wear, especially in some older models. In the latest model, wearing components in the head are reduced to a minimum, as described earlier. In all cases the rate of wear of the underground parts depends on the amount of use the pump received and the quality of the water being pumped. Water containing sand or sediment leads to greater wear of the seals, which may need replacement every one or two years. Seals which are 75mm wear less rapidly than 50mm seals since they travel smaller distances for every litre of water pumped.

Steel rising mains and rods also break, wear and corrode for various reasons. Rod separation may result from unscrewing sockets or the rods snapping at the the threaded joint. Sixteen millimetre rods are preferred since they are about three times as strong as 12mm rods. Since both rods and rising main are taken apart each time the piston seals are replaced, the threading of the joints is also subject to wear or damage. For this reason more attention is being paid to fully extractable valve systems, where seal replacement can be done without

disturbing the rising main.

Bush Pumps are manufactured by several engineering companies in Zimbabwe. A mass-production line capable of manufacturing 200 Model B Bush Pumps per month has been established at V and W Engineering and Installations in Harare.

Maintenance

As with all handpumps, the success of the Bush Pump in providing a reliable water supply depends upon an effective maintenance and repair system. In Zimbabwe maintenance of the Bush Pump has for many years been the responsibility of the District Development Fund, a department within the Ministry of Local Government, Rural and Urban Development. The DDF operates at district level and employs pump-fitting gangs under the direction of the District Field Officer (Water). The pump-fitting gangs are equipped with special tools to maintain Bush Pumps and other water installations. More recently pump minders equipped with tools, and travelling by bicycle have been employed at Ward level to

service and maintain the handpumps.

Currently the number of Bush Pumps operating in Zimbabwe is estimated at about 16,000, the cost of maintaining these pumps (1987/88 DDF figures) being around Z\$1.3 million per annum (1987/88 DDF figures show that 8,391 Bush Pumps were serviced at a cost of Z\$1,296,067). On average each pump costs around Z\$150 to maintain every two years. These high figures reflect the simple fact that each Bush Pump must be serviced by well-equipped gangs, who travel great distances to reach the pumps. Under such conditions most gangs respond only to breakdowns. The more recent introduction of trained pump minders operating at ward level is intended to reduce the costs of maintenance. DDF figures show that 89 per cent of Bush Pumps are operational at any one time, although there is some variation from district to district.

Most visits are made to Bush Pumps to replace the piston seals, which have an average life span of around two years. Failures of the rising main and rods are not uncommon, especially in ageing

pumps. However confidence in steel components below ground remains high, because alternatives that operate well at the required depths are not available, and there is much expertise in handling of steel fittings which are available.

Some pumps break down simply because the down-the-hole components fall apart — a symptom of poor assembly by less-experienced pump maintenance staff. In recent years, however, pump minders and pump fitters have undergone far more training and have more educational literature available to them. It is hoped this will reduce the number of visits made to pumps that literally fall apart.

Village-level maintenance

Villagers and pump caretakers have an important role to play in the maintenance of the Bush Pump by ensuring that the nuts and bolts on the pump head are tight. Modern pumps are sold together with simple tools, which can be used on the pump head. The spanners are usually left with the pump caretaker or chairman of the village water committee. Villagers are also responsible for keeping the headworks (apron and water run-off area) clean.

Village maintenance of down-the-hole components is not easy with the Bush Pump, however, and is rarely practised. This is partly because pumps have always been considered government property, and partly because the pipes are heavy to lift, especially from the deeper boreholes, where special equipment is required. When the pumps are sited on remote boreholes where no alternative sources of water are available, however, villagers actively support the maintenance teams. Lifting equipment in the form of mopane poles fitted permanently in place above the pump. The mopane poles are common in drier parts of the country, and this reduces the amount of equipment which must be moved to service the pump. Community participation in maintenance is less common in areas where alternative sources of water are close to the surface and where river or well water may be freely available.

Bush Pump research

The relatively high cost of maintaining Bush Pumps is mainly due to high costs of conveying trained staff and equipment to the remote sites where pumps are often located. While the pump head can be adequately serviced

Table 1. Frequency analysis of breakdowns and repairs carried out by DDF handpump maintenance teams on Bush Pumps 1987-8

<i>A. Down-the-hole components</i>		
<i>Part</i>	<i>No. repairs</i>	<i>%Total</i>
Leathers	2,291	23
Pipes	1,313	13
Rods	1,065	11
Foot-valve	748	8
Cylinder	600	6
Other	232	2
Subtotal		63%
<i>B. Pump head (old standard model)</i>		
<i>Part</i>	<i>No. Repairs</i>	<i>% Total</i>
M24 bolts	587	6
Tee piece	350	4
M12 bolts	296	3
Guide pipe	279	3
Link arm	278	3
Base plate	262	3
M16 Bolts	227	2
Sleeve pipe	216	2
Block	204	2
Stand	146	1
Other	814	8
Subtotal		37%
Overall total		100%

Note: Data from DDF. Many of the parts of the old standard Bush Pump have been dispensed with in the later Model B Bush Pump. This move took note of the old saying, 'The designer knows he has reached perfection, not when there is no longer anything to add, but when there is no longer anything to take away'.

by keeping bolts tight, a task which can be performed by the local pump committee, repairs and maintenance of down-the-hole components is not so easy.

Since 1985 government staff have been actively involved with a research programme aimed at simplifying Bush Pump maintenance, especially of the down-the-hole components. This is an ongoing programme, which takes time to fulfil since faulty concepts and inadequate design in handpumps often take years to reveal themselves.

Three main avenues have been tried to date, these are:

- 50mm extractable brass foot and piston valve with 50mm GI rising main;
- 65mm extractable piston valve with 65mm GI rising main;
- 40mm and 50mm polyethylene rising main with 50mm and 75mm cylinders;

The more recent tests are being carried out on the Model B head, which can be adapted to suit a number of rising main and rod types.

The extractable piston and foot-valve system was developed by V and W Engineering in 1986. In this system both the piston and foot-valve can be extracted through a standard 50mm steel rising main with the pump rods. Both 12mm and 16mm mild steel pump rods can be used, and these are threaded together. A female acme thread has been introduced into the lower inner surface of the piston valve and a matching male thread fitted to the upper end of the foot-valve. The foot-valve press fits into the base of the cylinder. The piston seals are made of neoprene. The piston valve can be extracted directly by hand through the rising main. The foot-valve is lifted by screwing the piston valve down on to the foot-valve and using the leverage of the pump to extract it.

Another system uses extractable 65mm piston valves. This was developed by government staff to improve the water discharge rate and retain extractability. In this design a 65mm-nominal-bore brass cylinder is expanded and threaded above to fit a 65mm GI pipe, reduced in diameter and threaded below to fit a 50mm heavy-duty brass foot-valve. The piston is fully extractable, has larger parts and the seals wear out more slowly compared to the 50mm extractable type. In those pumps being used in trials standard 16mm mild

steel rods are used.

In this system the chosen foot-valve is a well-proven reliable design that is known to provide several years of service before attention is required. The delivery rate of this system is intermediate between the 50mm and 75mm cylinders and is about 30 l/min.

The 65mm GI pipe used in this system costs about 25 per cent more than 50mm pipe, and is heavier. Obviously specialized equipment is required to raise and lower rising mains of this type, but with the chosen foot-valve in place, lifting takes place very rarely and is part of the maintenance system that could be undertaken by district teams. The great advantage is that piston seal replacement, which is the most frequent service requirement, can be undertaken quickly and easily, by pump minders, which results in much reduced maintenance costs.

Model B Bush Pumps are also being tried with heavy-duty polyethylene rising mains equipped with flexible 12mm EN8 steel/steel rods. 40mm and 50mm pipes have been chosen for tests so far, fitted with 50mm and 75mm brass cylinders respectively.

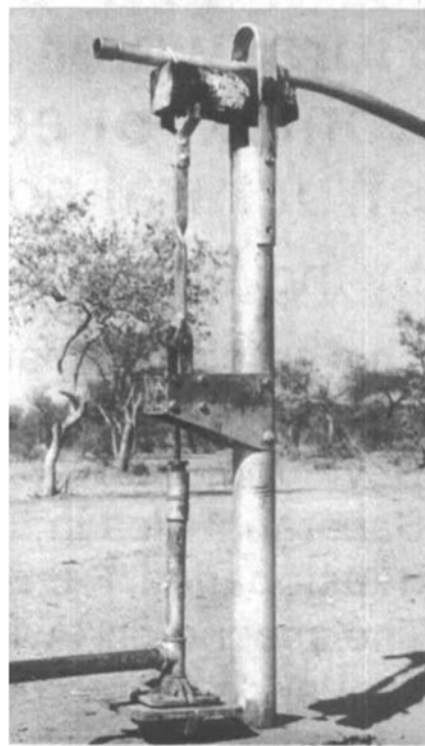
When the piston/cylinder/foot-valve assembly requires inspection, the whole rising main/rod system is pulled out at one time. So far this system has been tried satisfactorily to an 18m depth.

Traditionally leather seals are used in Zimbabwe, but neoprene seals are also being examined in combination with brass cylinders, and nitrile rubber seals are being examined in combination with stainless steel cylinders. Clearly there is an advantage in extending the working life of seals, as the frequency of visits and related costs will be reduced.

Requirements for programme success

If Zimbabwe's handpump programme is to succeed, some 40,000 Bush Pumps will be required together with an effective maintenance system to back them up. As the number of pumps increases, so does the pressure on staff and resources of the DDF who maintain them. Consequently it becomes increasingly essential that maintenance procedures should be simplified so that the users themselves can play a much more active role in maintenance, especially of the down-the-hole components.

While time-tested conventional down-the-hole components continue to



The early Murgatroyd pump.

be used, an ever-increasing number of pumps are fitted with easier to maintain systems. Only when these new systems are thoroughly tested and proven, will they begin to take precedence over more conventional practice. Great care and constraint is required however before dramatic change takes place, especially for deeper settings where alternative valves, rods and rising mains may fail.

Zimbabwe is fortunate in having chosen the handpump option long ago so there is much experience to draw on. Today this long experience is cautiously being combined with techniques of a more recent age. The Bush Pump is so firmly established in Zimbabwe, that it is unlikely to be replaced by any other model for the foreseeable future. As past history shows, Bush Pumps last for far too long for that to happen.

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