TUBEWELLS AND BOREHOLES

Introduction

Depth for depth on any given site, hand-dug wells may yield more water than tubewells, but tubewells 100 or 150 mm diameter are usually quicker and cheaper to sink, need no dewatering during sinking, require less lining material, are safer in construction and use, and involve less maintenance. From a hygienic point of view, the fact that a pump is needed to lift water from a tubewell is an asset, not a liability.

These notes describe some features of tubewells which have handpumps, and two methods of sinking them in generally soft ground using only man-powered low technology equipment, namely, hand auguring using a Vonder rig, and sludging.

Salient features

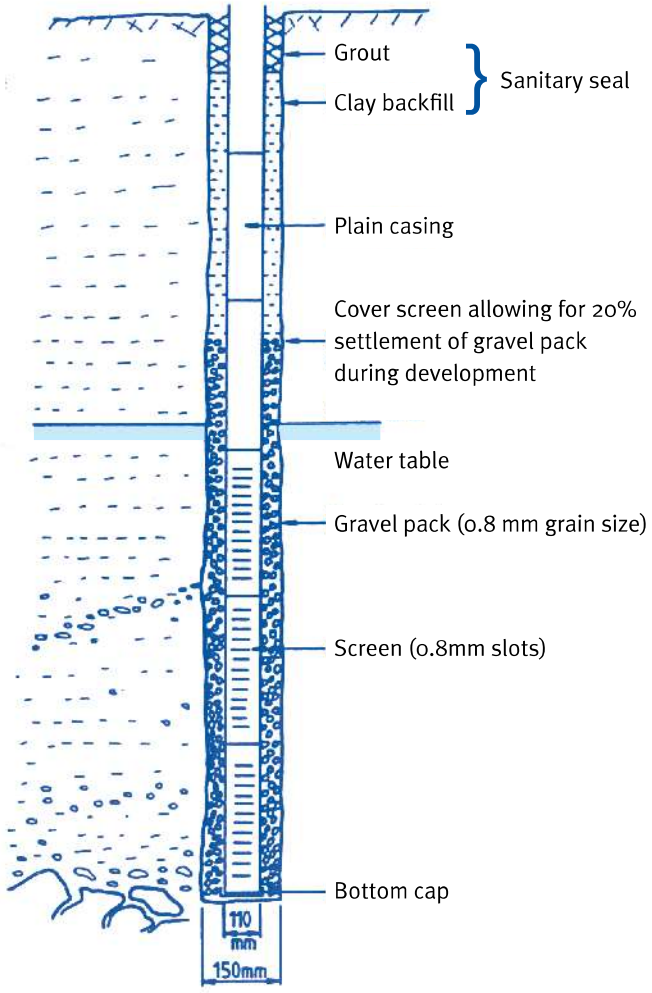
Some salient features of a simple tubewell are shown in the following diagram:

The casing – often in PVC, which is both cheap and inert – houses the inlet, cylinder, piston valves and rising main of a "down-the-hole" type handpump, which can be lifted out for maintenance or repair. Seepage down the tubewell bore is prevented by the sanitary seal. Seepage from the ground above the aquifer is excluded by the lengths of plain casing. Water to be pumped is admitted through slots in the lower lengths of casing. Casing to support the external surfaces of the borehole against collapse may be needed, either temporarily or permanently, but is not shown.

Water abstracted from aquifers in relatively soft ground usually contains sand or silt particles, which are liable to cause rapid wear to pump valves and cylinders (and dissatisfaction among consumers). Methods of preventing these particles from reaching the pump are of two general types:

- Screening: The drawing shows slots in the PVC casing which can be cut on site, using a hacksaw. More elaborate, and far more compact, screens are available commercially; some can be bolted on to pump inlets. Materials used include woven wire and man-made fabric; the latter can be wrapped around the pump inlet assembly.
- Sand/gravel packing: The drawing shows graded sand and gravel, which is placed from the top of the borehole. More compact, pre-bonded packs of sand and/or gravel are available commercially; some of these can also form part of the pump inlet assembly.

Screening is nearly always needed in some form. Sand and/or gravel packing is meant to eliminate particles from the water before they reach the screen and would otherwise have passed through the screen.



Developing the well

Over-pumping (that is, pumping at above the design-rate) before the well enters service can improve the efficiency of the packing by drawing further fine particles into it. Where the surrounding ground has many fine particles, the flow of water can be accelerated by back-flushing at a higher rate. This over-pumping and back-flushing is known as developing the tubewell.

Sinking tubewells

At least two experienced operators are required; communities will usually supply unskilled labour. Samples of the excavated material should be taken at regular intervals of depth (and also if the strata changes) and a borehole record should be kept.

Particular attention is needed to maintain verticality. A "down-the-hole" pump which has been installed out of the vertical may be hard to operate and subject to excessive wear.

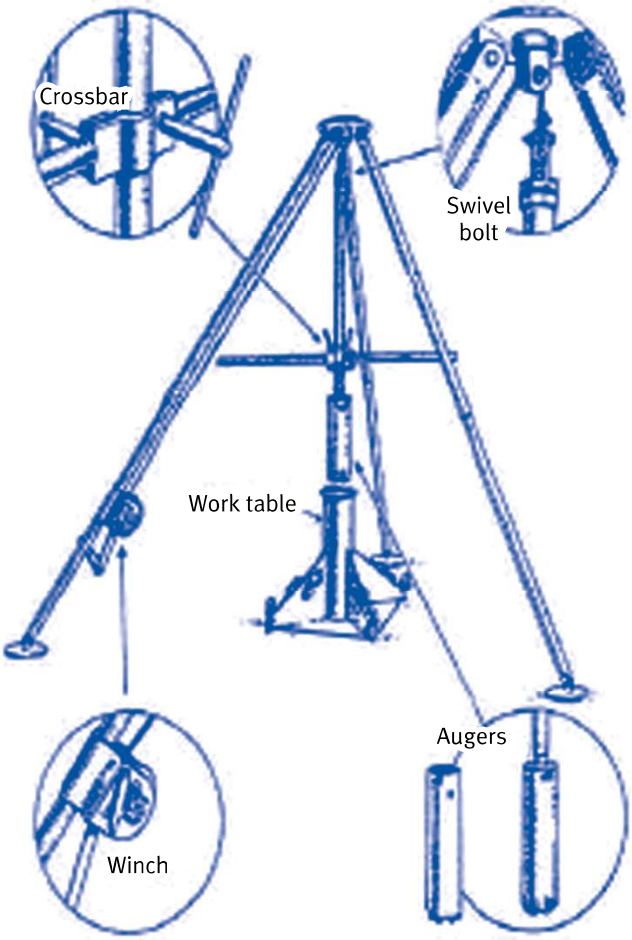
Auguring

Auguring cuts earth away by the rotation of a cylindrical tool with one or more cutting edges. The excavated earth feeds upwards inside the tool body, which needs lifting to the surface for emptying at intervals. This requires the whole auguring (drilling) train to be uncoupled and lifted; the weight involved can be considerable, and puts a limit to the depth of hand-operated auguring.

The next diagram shows hand-augering using a Vonder rig:

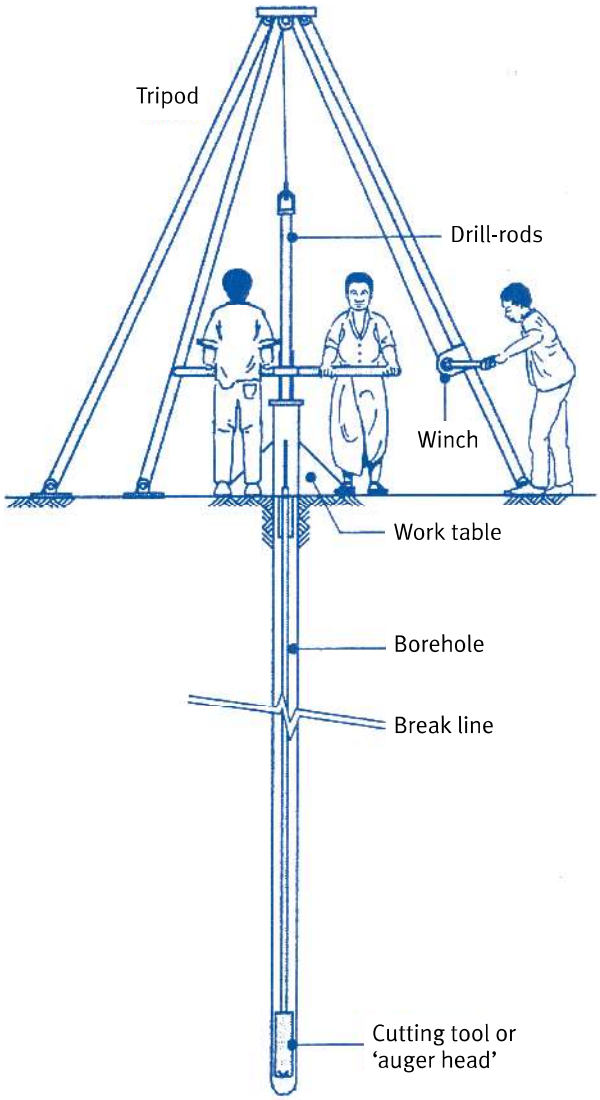
Auguring using the Vonder Rig

The Vonder Rig, manufactured in Zimbabwe and possibly elsewhere, can sink a tubewell hole up to 170mm in diameter and about 115m deep in about two days in ground which is predominantly soft. The drawing below shows its salient parts, all of which are made of mild steel and can be carried by hand between sites. The crossbar is friction-bolted to a stem, at a height suitable for pushing round by hand. Helpers can sit on it if auguring needs extra weight (or even if it doesn't). Additional stem sections are added as auguring proceeds. Several shapes and sizes of augerbit are provided, including a "hole-saw"; this is intended to tackle soft rock, but has rarely been successful. Thin layers of rock have been penetrated, however, by an improvised arrangement including a slow-speed diesel drive to the drilling train.



Hand-auger drilling

Method: The cutting tool (known as the auger head) is rotated to cut into the ground, and then withdrawn to remove excavated material. The procedure is repeated until the required depth is reached. Note: This method is only suitable for unconsolidated deposits.



Advantages of hand-auger drilling:

- Inexpensive.
- Simple to operate and maintain.

Disadvantages of hand-auger drilling:

- Slow, compared with other methods.
- Equipment can be heavy.
- Problems can occur with unstable rock formations.
- Water is needed for dry holes.

Useful contacts:

Van Reekum Materials b.v., 115 Kanaal Noord, PO Box 98, AB Apeldoorn, The Netherlands.
Tel: +31 55 335466 Fax: +31 55 313335

V & W Engineering Ltd. (Vonder Rig), PO Box 131, Harare, Zimbabwe. Tel: +263 4 64365/63417 Fax: +263 4 64365

Sludging

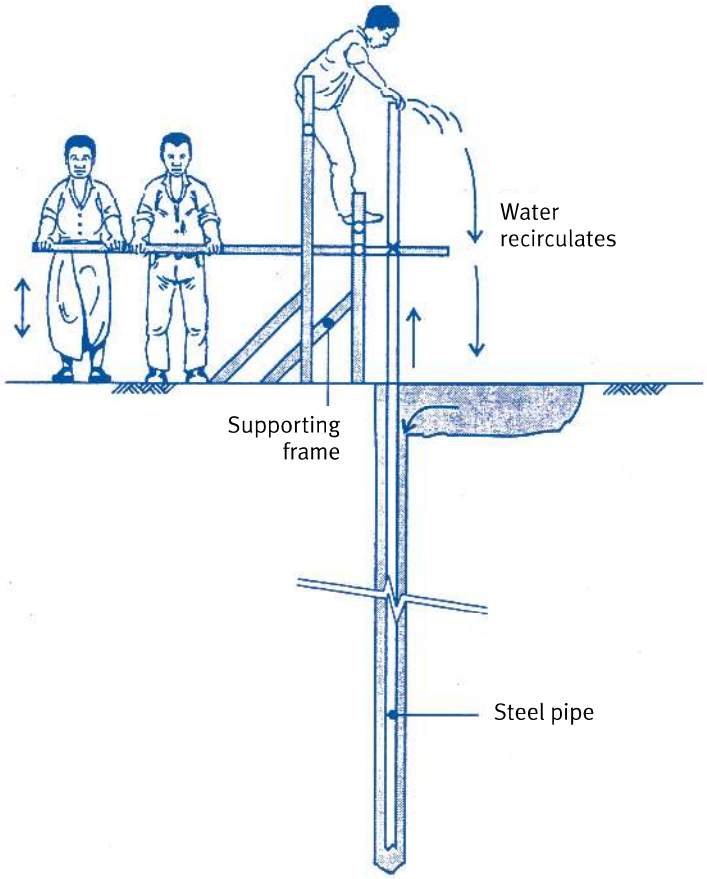
Sludging is a cheap but effective method of sinking small-diameter tubewells to a great depth in the water-logged silts and fine sands which underlie some flat river plains and deltas, notably those in the Indian subcontinent. Tubewells 25mm and upwards in diameter (the larger ones are able to accommodate a "down-the-hole" pump) are sunk to depths of 60m or more.

A boring pipe, usually a galvanised mild steel tube fitted with a case-hardened open socket at its base, moves vertically under the action of a bamboo lever pivoted on an H-frame. The boring pipe rests initially in a shallow pit filled with a water/ cow-dung mixture, which acts as a drilling mud and helps to stabilise the walls of the bored hole during drilling (thrusting would be a better word). Using a lever, two men raise and drop the pipe successively. For the duration of each upstroke, another man seals the open top of the pipe with his hand, creating a partial vacuum inside it, so that the water within the pipe rises with it. He removes his hand for the downstroke, during which the pipe drops faster than the water inside it. As this hand-on / hand-off cycle repeats, water starts to gush from the top of the pipe and the whole assembly begins to work as an elementary force pump. Soil, fluidised by repeated strokes of the case-hardened socket, is entrained into the upward flow of the water and the boring pipe sinks further into the ground with each stroke. Boring rates of 20m per hour have been achieved. Additional lengths of boring pipe are attached successively until the required depth is reached. The whole pipe is then withdrawn and replaced by a PVC rising main (for a suction pump) or PVC casing (for "down-the-hole" pumps).

The process of sludging is illustrated in the next diagram:

Sludging (reverse jetting)

Method: This method has been developed and used extensively in Bangladesh. A hollow pipe of bamboo or steel is moved up and down in the borehole while a one-way valve – your hand can be used to improvise successfully – provides a pumping action. Water flows down the borehole annulus (ring) and back up the drill-pipe, bringing debris with it. A small reservoir is needed at the top of the borehole for recirculation. Simple teeth at the bottom of the drill-pipe, preferably made of metal, help cutting efficiency.



Advantages of sludging:

- The equipment can be made from local, low-cost materials, and is simple to use.

Disadvantages of sludging:

- Water is required for pumping.
- Suitable for unconsolidated rocks only.
- Boulders can prevent further drilling.

Anything that may be termed 'rock' is rarely met within these types of strata, but isolated stones, or groups of them, do occur occasionally. They totally inhibit sludging operations as just described, but a technique has been evolved which will usually deal with them.

On being stopped by a stone, the sludger boring pipe (with its open socket end) is withdrawn and replaced by a butt-jointed 'hammering pipe' which is fitted, at its base, with a cone of the same diameter as the open socket. The latter can be used to protect the top end of the hammering pipe, which is driven down by a two-man operated weighted sleeve driver. When the stone has been successfully broken and passed, the hammering pipe is winched or jacked out, the sludge boring pipe with its open socket replaced, and normal sludging operations re-started.

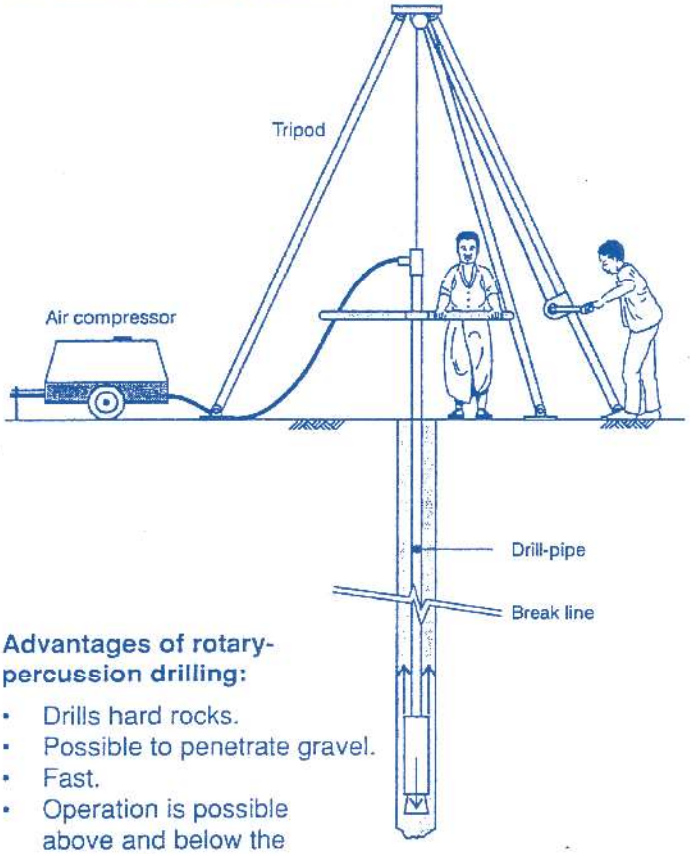
Other methods of drilling

WaterAid prefers the simplest methods of drilling, particularly those which can be operated by villagers themselves. However, there are several other, more complicated, techniques which can be used and the next few diagrams illustrate the following methods:

- Percussion drilling
- Rotary percussion drilling
- Rotary drilling with flush
- Jetting

Rotary-percussion drilling

Method: In very hard rocks, such as granite, the only way to drill a hole is to pulverize the rock, using a rapid-action pneumatic hammer, often known as a 'down-the-hole hammer' (DTH). Compressed air is needed to drive this tool. The air also flushes the cuttings and dust from the borehole. Rotation of 10-30 rpm ensures that the borehole is straight, and circular in cross-section.



Advantages of rotary-percussion drilling:

- Drills hard rocks.
- Possible to penetrate gravel.
- Fast.
- Operation is possible above and below the water-table.

Disadvantages of rotary-percussion drilling:

- Higher tool cost than other tools illustrated here.
- Air compressor required.
- Requires experience to operate and maintain.

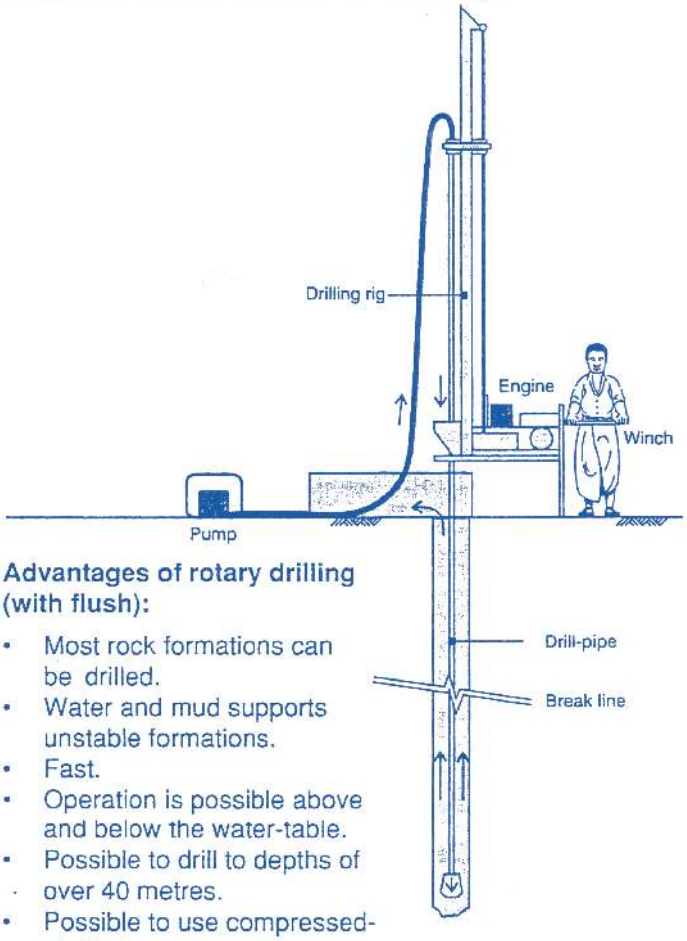
Useful contacts:

Consallen Group Sales Ltd., 23 Oakwood Hill Industrial Estate, Loughton, Essex, IG10 3TZ, UK. Tel/Fax: +44 81 508 5006

Eureka UK Ltd., 11 The Quadrant, Hassocks, West Sussex BN6 8BP, UK. Tel: +44 273 846333 Fax: +44 273 846332

Rotary drilling with flush

Method: A drill-pipe and bit are rotated to cut the rock. Air, water, or drilling mud is pumped down the drill-pipe to flush out the debris. The velocity of the flush in the borehole annulus must be sufficient to lift the cuttings.



Advantages of rotary drilling (with flush):

- Most rock formations can be drilled.
- Water and mud supports unstable formations.
- Fast.
- Operation is possible above and below the water-table.
- Possible to drill to depths of over 40 metres.
- Possible to use compressed-air flush.

Disadvantages of rotary drilling (with flush):

- Requires capital expenditure in equipment.
- Water is required for pumping.
- There can be problems with boulders.
- Rig requires careful operation and maintenance.

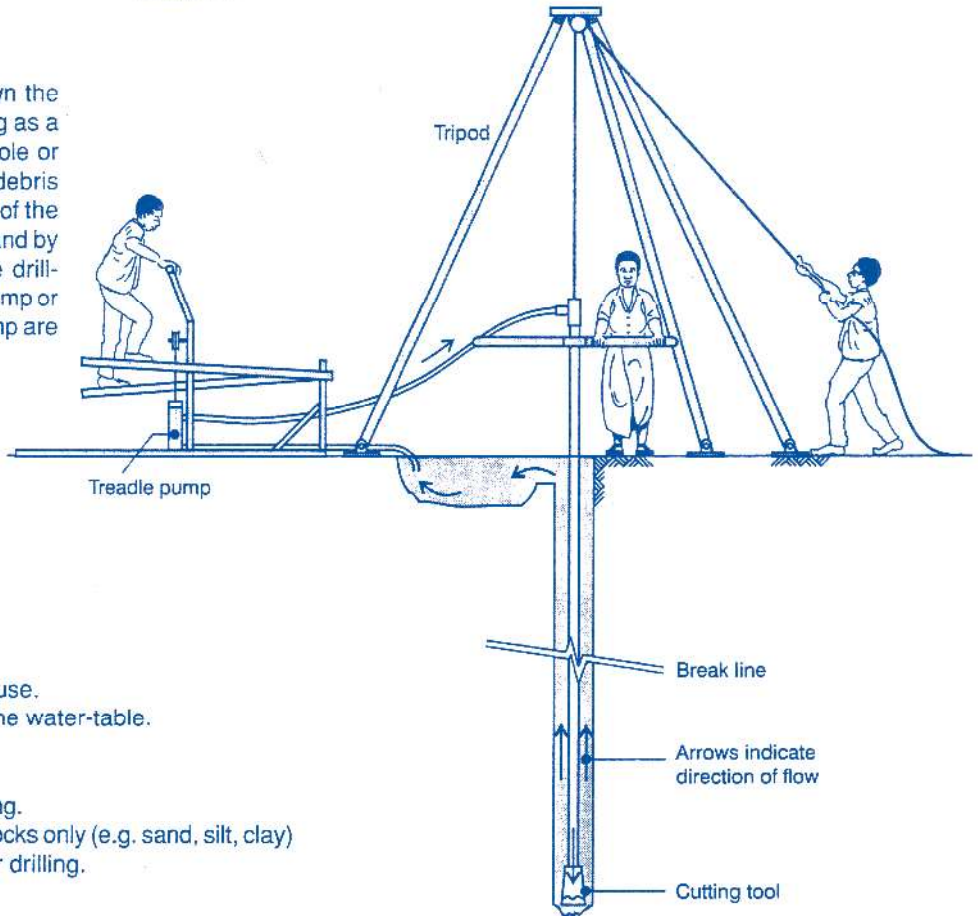
Useful contacts:

Eureka UK Ltd., 11 The Quadrant, Hassocks, West Sussex BN6 8BP, UK. Tel: +44 273 846333 Fax: +44 273 846332

PAT Co. Ltd., 1016 Taskin Road, Thonburi, Bangkok, Thailand. Tel: +66 2 476 1845 Fax: +66 2 476 5316

Jetting

Method: Water is pumped down the centre of the drill-rods, emerging as a jet. It then returns up the borehole or drill-pipe bringing cuttings and debris with it. The washing and cutting of the formation is helped by rotation and by the up-and-down motion of the drill-string. A foot-powered treadle pump or a small internal-combustion pump are equally suitable.



Advantages of jetting:

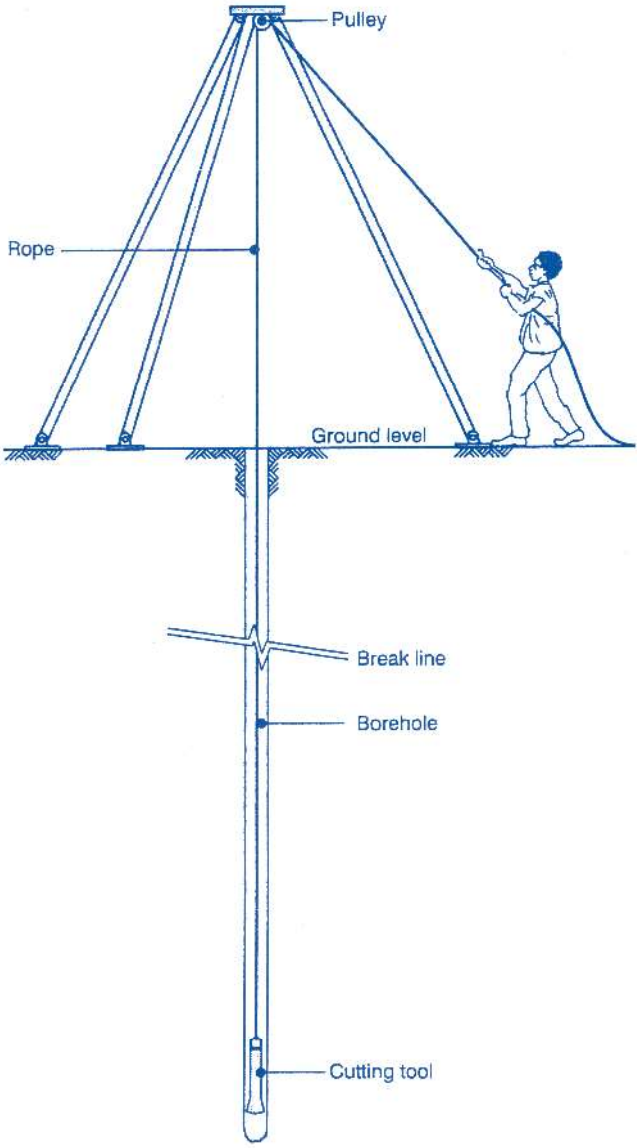
- The equipment is simple to use.
- Possible above and below the water-table.

Disadvantages of jetting:

- Water is required for pumping.
- Suitable for unconsolidated rocks only (e.g. sand, silt, clay)
- Boulders can prevent further drilling.

Percussion drilling

Method: The lifting and dropping of a heavy (50kg+) cutting tool will chip and excavate material from a hole. This drilling method has been used in China for over 3000 years. The tool can be fixed to rigid drill-rods, or to a rope or cable. With a mechanical winch, depths of hundreds of metres can be reached.



Advantages of percussion drilling:

- Simple to operate and maintain.
- Suitable for a wide variety of rocks.
- Operation is possible above and below the water-table.
- It is possible to drill to considerable depths.

Disadvantages of percussion drilling:

- Slow, compared with other methods.
- Equipment can be heavy.
- Problems can occur with unstable rock formations.
- Water is needed for dry holes to help remove cuttings.

REFERENCES

1 **Stapleton C K** (July 1983) *Tubewells and their construction* Waterlines, Vol 2, No 1 IT Publications

2 *The Vonder Rig: Instructions for use* V & W Engineering Ltd, PO Box 131, Harare, Zimbabwe

3 **Whiteside G F J and Trace S** (January 1993) *The use of Sludger and Well-pointing Techniques,* Waterlines, Vol 11, No 3 IT Publications