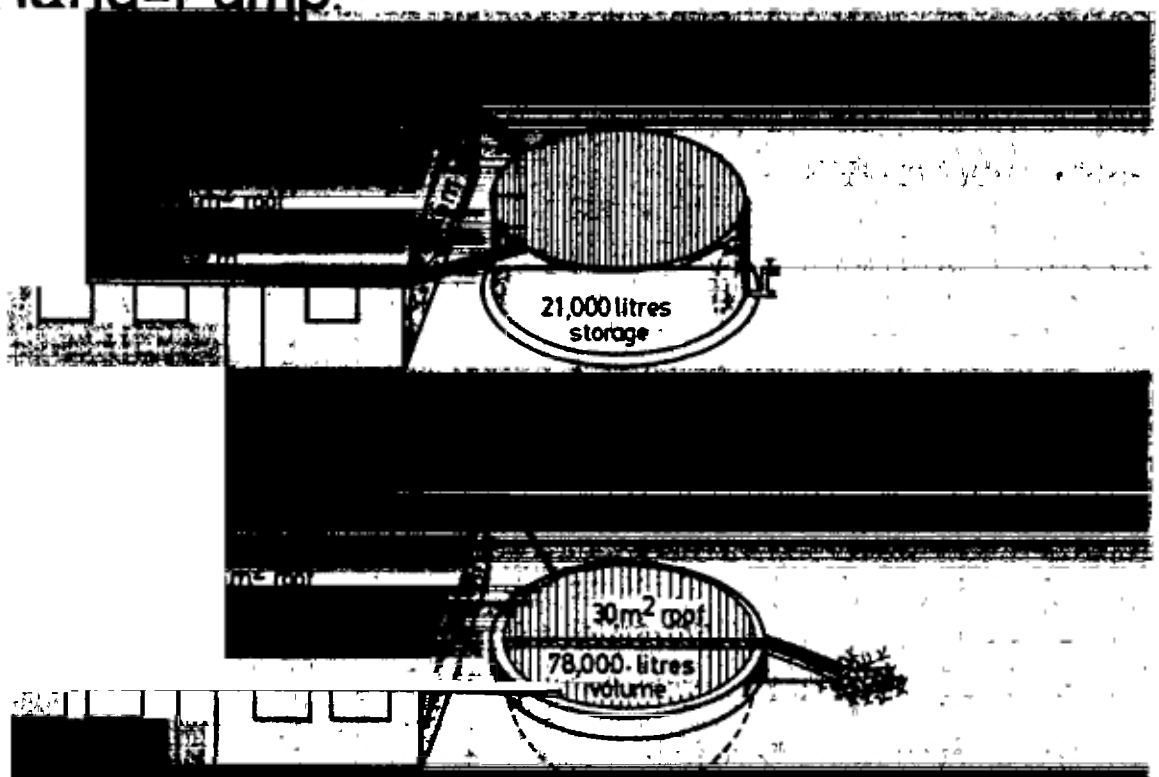
HARVESTING RAINWATER IN SEMI-ARID AFRICA

Study No. 1

Water Tanks with Guttering and Hand-Pump



Erik Nissen-Petersen, Dr. Michael Lee

Nairobi 1990

"Harvesting Rainwater in Semi-arid Africa" consists of 6 Manuals:

Manual No. 1. Water Tanks with Guttering and Hand-pump.

Manual No. 2. Small Earth Dam built by Animal Traction.

Manual No. 3. Rock Catchment Dam with self-closing Watertap.

Manual No. 4. Shallow Wells with Bucketlift.

Manual No. 5. Sub-surface and Sand-storage Dams.

Manual No. 6. Spring Protections.

Each Manual deals with siting criteria, standard designs and bills of quantities in a simple text and drawings.

The Manuals are based on practical experience gained by building some 700 water structures for rainwater harvesting in semi-arid Kenya over the last 14 years.

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ACKNOWLEDGMENT

The authors of these manuals are grateful for the grants given by Danida which made possible the compiling and publishing of their experience with rainwater harvesting for self-help groups in semi-arid areas of Africa.

Much gratitude is also due to the Ministry of Agriculture in Kenya, which together with Danida afforded the opportunity of developing low-technology and labour-intensive methods of harvesting rainwater and thereby enabling people and livestock in a semi-arid region of the country to have access to a steady water supply.

Thanks are also due to the local inhabitants with and for whom these techniques were developed and implemented. Their understandable skepticism in starting up these demanding activities gave the process a sound and realistic foundation on which to build.

Personal thanks are very much due to:

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Kim Nissen-Petersen for the many proof-readings and useful comments.

Erik Nissen-Petersen and Michael Lee

C O N T E N T S

SURVEYORS MANUAL

ON

WATER TANKS

1. Type of Tanks Described

This manual deals with two types of water tanks for roof catchments:

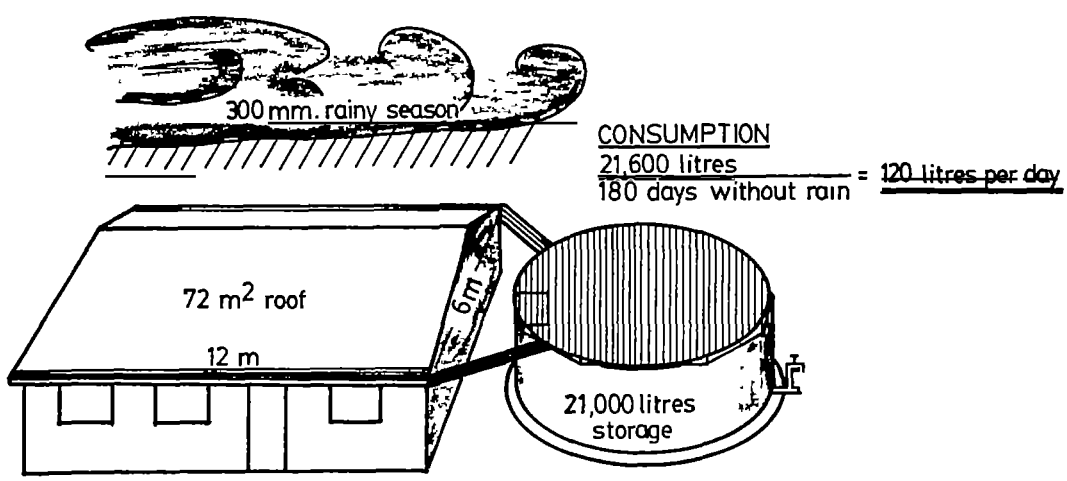
a. A cylindrical tank with a volume of 21,000 litres (21 cu.m.) made of ferro-cement and roofed with iron sheets. Water is drawn from the tank by gravity to a water tap placed at the floor of the tank.

This tank is most suited to smaller public buildings, larger private homes and for storage tanks for spring protections.

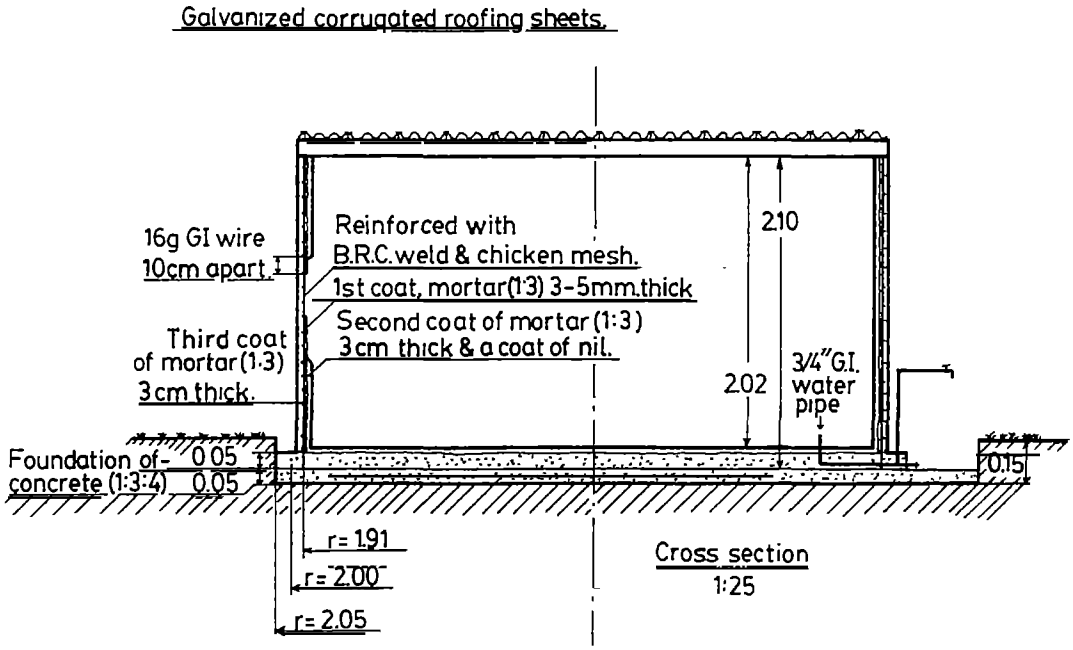
The tank is modified to cut construction costs to half that of a conventional tank with a volume of 21,000 litres. Not only is this method cheaper to build, a cylindrical ferrocement tank is also stronger and more durable than tanks made of bricks, blocks or galvanised iron.

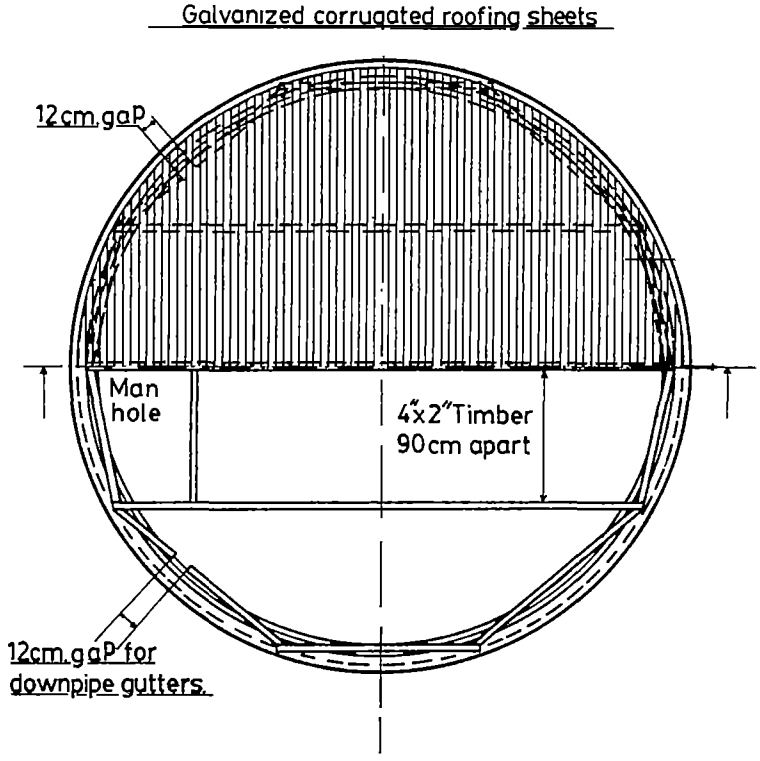
Because of the raised extension and the run-off from the rooftop the quality of the water is very high with little sediment and low levels of organic pollution.

If the tank is full at the start of a six month dry season it will provide 120 litres per day for the length of the dry period.



Standard Design of 21 cu.m. Tank



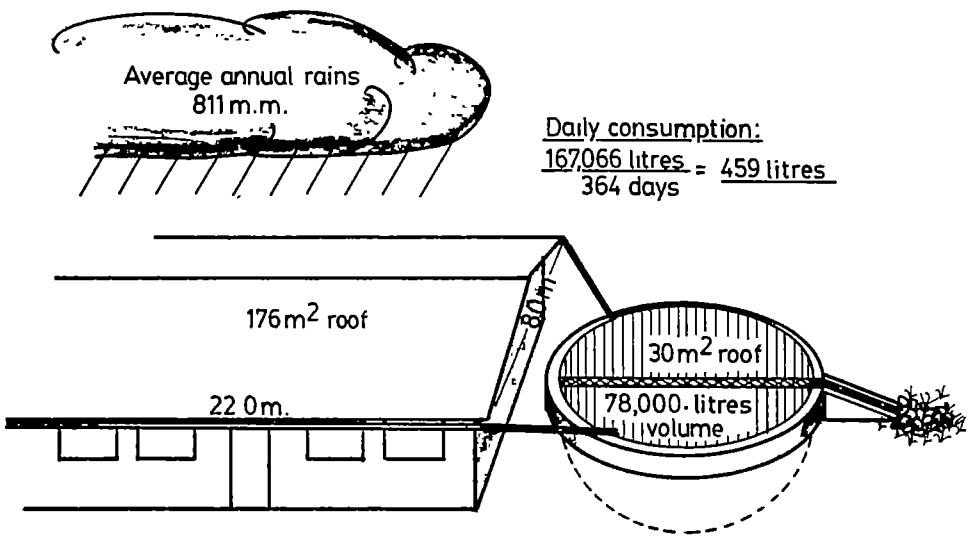


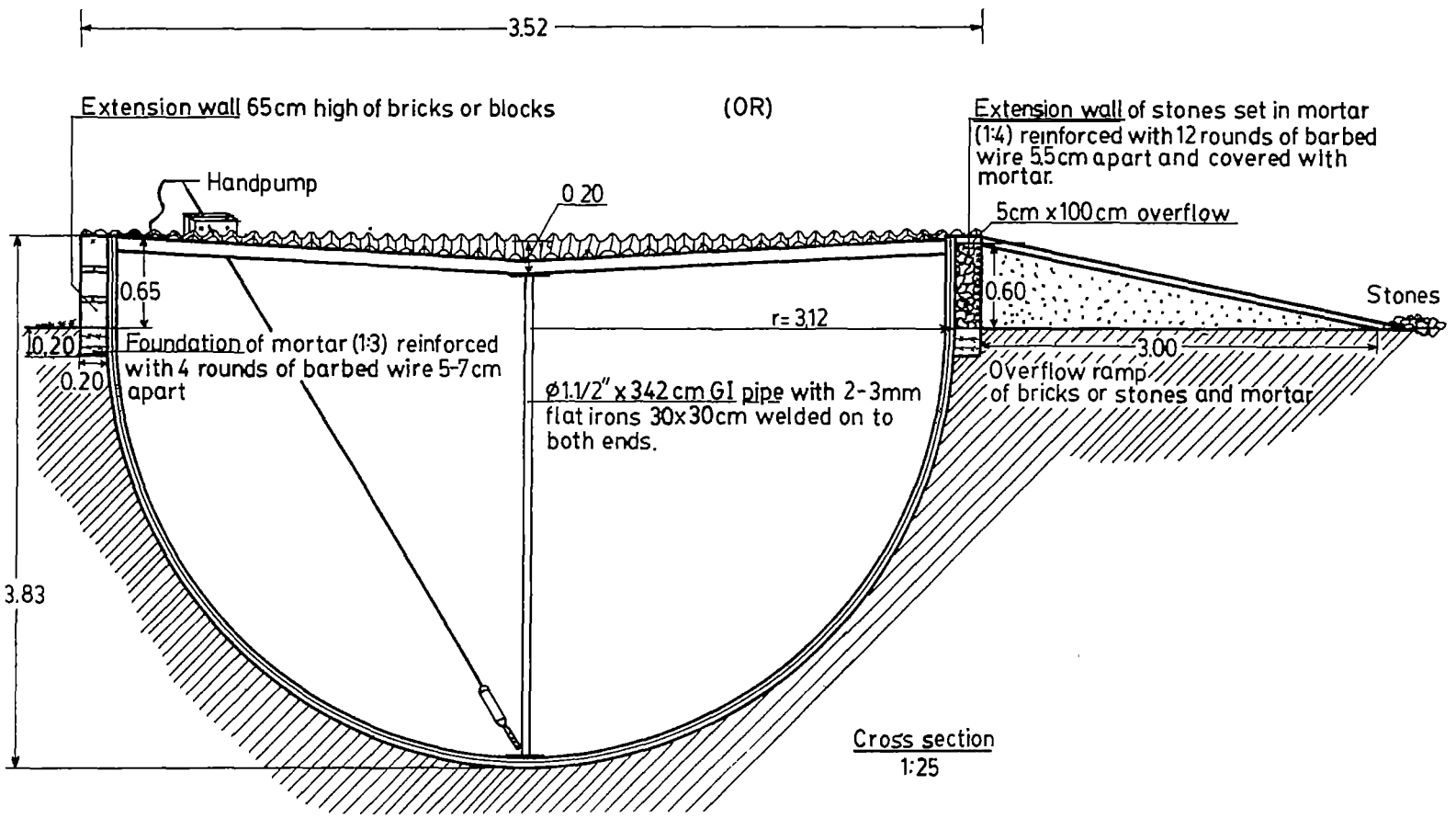
b. A hemi-spherical underground tank of ferro-cement which is extended above ground level with a cylindrical wall of either blocks or stone masonry and roofed with iron sheets. The total volume of the tank is 78,000 litres (78 cu.m.).

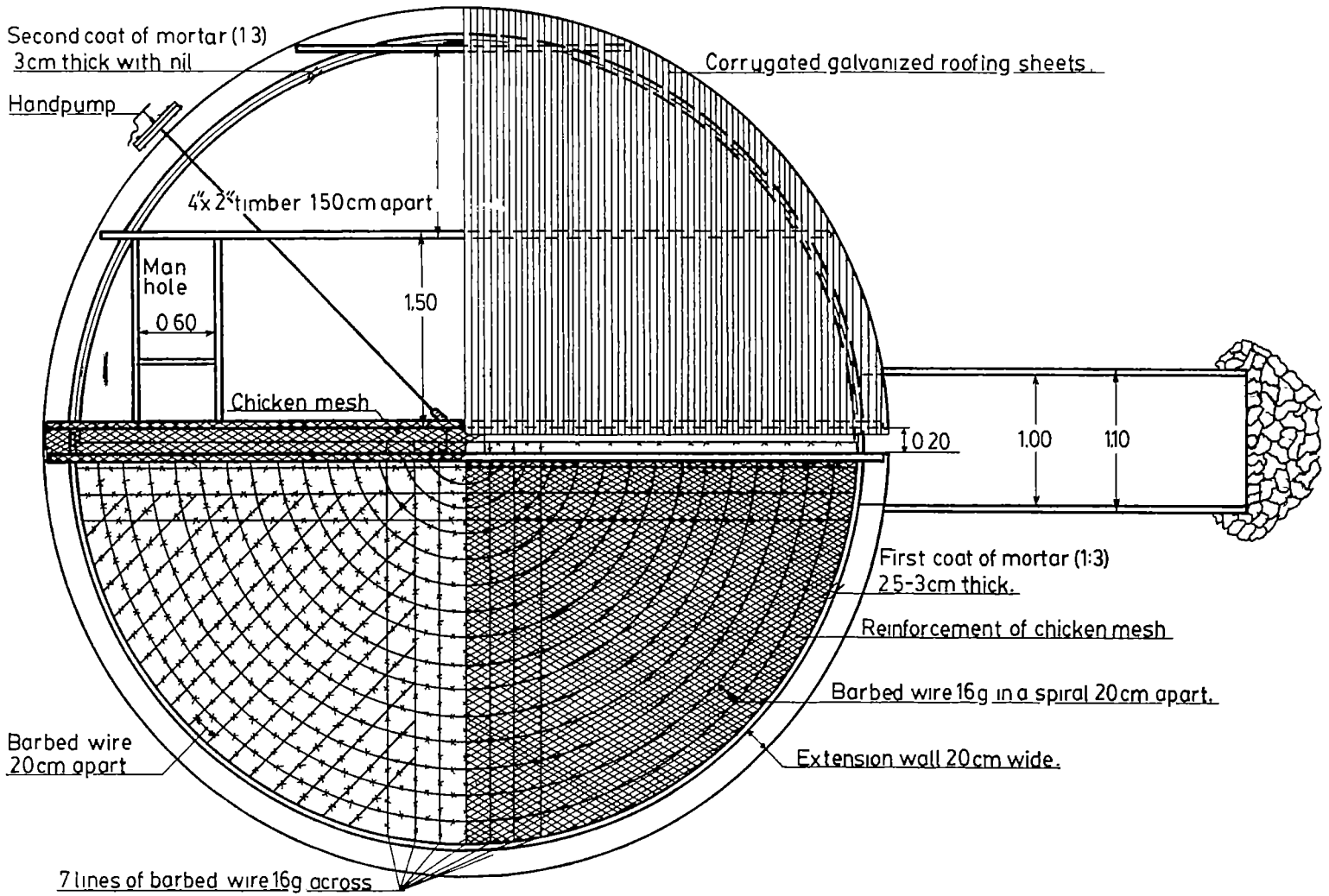
Water is drawn from the tank by either a hand-pump or buckets. Because water has to be lifted out of the tank by hand, there will occur little wastage and the consumption level will be lower than if water could flow freely from a tap. This type of tank is therefore well suited for schools where pupils might forget to close a water tap or play with freely running water from a tap.

Because of the raised extension and the run-off from the rooftop, the quality of the water is very high with little sediment and low levels of organic pollution.

If the tank is full at the start of a six month dry season it will provide 459 litres per day with little loss to evaporation.




3.52
Extension wall 65cm high of bricks or blocks
(OR)
Extension wall of stones set in mortar (1:4) reinforced with 12 rounds of barbed wire 5.5cm apart and covered with mortar.
Handpump
0.20
5cm x 100cm overflow
0.65
0.60
Stones
r= 3.12
0.20
Foundation of mortar (1:3) reinforced with 4 rounds of barbed wire 5-7cm apart
3.00
Overflow ramp of bricks or stones and mortar
ø1.1/2" x 3.42 cm GI pipe with 2-3mm flat irons 30x30cm welded on to both ends.
3.83
Cross section
1:25


Second coat of mortar (1 3)
3cm thick with nil
Handpump
4"x 2"timber 150cm apart
Man hole
0 60
1.50
Chicken mesh
Corrugated galvanized roofing sheets.
0 20
1.00
1.10
First coat of mortar (1:3)
2.5-3cm thick.
Reinforcement of chicken mesh
Barbed wire 16g in a spiral 20cm apart.
Extension wall 20cm wide.
Barbed wire
20cm apart
7 lines of barbed wire 16g across

2. CALCULATING THE USERS WATER NEEDS

Calculating Demand

Calculating the water needs of the user is relatively easy and involves a simple formula which includes the average daily consumption of water from the tank per person (or livestock), the number of days in the dry season, and the numbers of people using the tank. Studies have shown that people with tanks next to their houses will often use from 20-40 litres of water per person per day. This is high compared to people who must walk long distances for water who may use less than 10 litres per family per day. As an average, assume that each person will take 20 litres per day if it is a household tank, and 5 litres per day if it is a school or health centre tank. The formula is;

Demand (in litres) = No. Dry Days x No. Litres Taken x No. People

For example, a household with six members will need the following amount of water for a 180 day dry period.

Demand = 180 dry x 20 litres x 6 people = 21,600 litres.

In this case a 21 cubic metre raised tank would be almost perfect for their needs. However, it might be that they could not afford a 21,000 litre tank but only a cheaper 7000 litre tank. The same formula could be rearranged to show them how much water such a tank could supply each family member each day during the dry season.

A private contractor must be able to understand these ideas of demand and supply and be able to calculate them. The tank owner must clearly understand how much water the family can expect to receive each season and how that compares to their needs.

Remember: if the consumption is higher than estimated, the tank will run dry before the next rainy season.

3. CALCULATING VOLUME OF RUN-OFF FROM ROOFS.

Two factors must be known for calculating the volume of run-off from roofs.

1. The area of the roof from where the run-off will be collected. This factor is found by multiplying the length of the roof with its width.

   Example:

   length of roof 12.85 m x width of roof 7.65 m = **98.3 sq.m.**

2. The annual rainfall from a year with poor rainy seasons. By using such a low figure the roof catchment system will supply sufficient water during years with poor rainfalls. The best way of calculating this figure is to deduct the average annual figure with 50%.

   Example:

   Average annual rainfall $\frac{620 \text{ mm} \times 50}{100}$ = 310 mm annual poor rainfall

The annual volume of run-off during a year with poor rainy seasons is found by multiplying the roof area (sq.m.) with the annual rainfall (mm).

Example:

Roof area 98.3 sq.m. x rainfall 310 mm = 30,473 litres = (30.5 cu.m.)

It is important to be fully conversant with the calculating of run-off from roofs, because by knowing this volume of water the right size of tank can be designed.

If the roof is too small for the size of tank wanted, the only solution is to extend the roof, or to expect a higher rainfall.

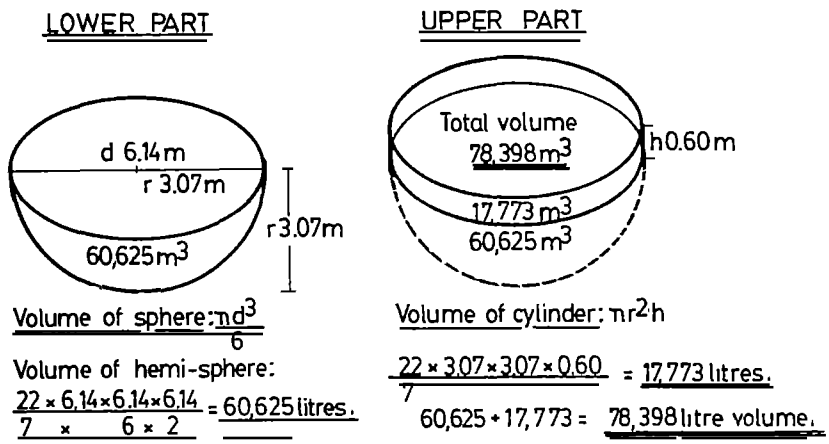
4. Calculating Volume of Water Tanks.

a. The volume of a cylindrical tank is calculated according to following formula:

$\pi \times r^2 \times h$ = volume. This means $\frac{22}{7}$ x (radius x radius) x height = volume

Example:

$\frac{22}{7}$ x (radius 1.87 m x radius 1.87 m) x height 1.90 m = **20,881 litres**



Calculation of Storage Volume.

b. The volume of a hemi-spherical tank is calculated according to two formulas:

1. The volume of a hemi-spherical form is:

$\frac{\pi \times d^3}{2 \times 6}$ = volume. This means $\frac{22}{7}$ x $\frac{(\text{diametre x diametre x diametre})}{2 \times 6}$ = volume

Example: $\frac{22}{7}$ x $\frac{(\text{diametre 6.14 m x diametre 6.14 m x diametre 6.14})}{2 \times 6}$ = **60,625 litres**

2. The volume of the cylindrical extension is calculated as:

$\pi \times r^2 \times h$ = volume, which is $\frac{22}{7}$ x (radius x radius) x height = volume

Example: $\frac{22}{7}$ x (radius 3.07 x radius 3.07) x height 0.60 = 17,773 litres

Grand volume of hemispherical tank 78,398 litre

5. Bills of Quantities

Cylindrical tank, 21,000 litres.

Bill of Quantity for items to be delivered by the donor/Ministry.

Skilled labour for 12 days x ..... 2 contractors x Shs ..... = Shs .....

Cement, 1,250 tonnes ..... 25 bags ..... x Shs ..... = Shs .....

B.R.C. mesh No. 65 or 66 ..... 1 roll ..... x Shs ..... = Shs .....

Chicken mesh, 1" x 3 ft. x 30 m ..... 2 rolls ..... x Shs ..... = Shs .....

Binding wire ..... 10 kg ..... x Shs ..... = Shs .....

Draw-off stand pipe and tap ..... 1 set ..... x Shs ..... = Shs .....

Empty sugar sacks for supporting

plastering ..... 20 nos ..... x Shs ..... = Shs .....

Sisal twine thread for sugar sacks ..... 2 kg ..... x Shs ..... = Shs .....

Transport of 3 tonnes x ... km inclusive return trip ... x Shs ..... = Shs .....

Guttering not included

Total cost for project Shs

Bill of Quantity for items to be delivered free of charge by the self-help group.

Unskilled labour for 12 days x ..... 4 labourers .... x Shs ..... = Shs .....

Sand, clean and coarse 4 tonnes = 32 wheelbarrows ..... x Shs ..... = Shs .....

Ballast, 5 cm stones 2 tonnes = 16 wheelbarrows ..... x Shs ..... = Shs .....

Water ..... 2 tonnes = 10 drums ..... x Shs ..... = Shs .....

Transport by carts of 12 tonnes = 24 carts x ... km .... x Shs ..... = Shs .....

Total value of self-help Shs .....

Grand total cost and value of tank Shs .....

For converting tonnes into more understandable terms following formula can be used:

1 tonne of cement = 20 bags of cement.
1 tonne of sand = 8 wheelbarrows.
1 tonne of stones = 8 wheelbarrows.
1 tonne of water = 5 drums.

5. Bills of Quantities

Extended ground tank, 78,000 litres

Bill of Quantity for items to be delivered by the donor/Ministry

Skilled labour for 15 days x	2 contractors x Shs	= Shs .....
Cement 2.4 tonnes = ...	48 bags ..... x Shs	= Shs .....
Chicken mesh, 1" x 3 ft. x 30 m	3 rolls ..... x Shs	= Shs .....
Barbed wire, gauge 16	3 rolls ..... x Shs	= Shs .....
Nails, 2 1/2"	20 kg ..... x Shs	= Shs .....
Thin polythene sheeting for curing	30 metres .... x Shs	= Shs .....
Galvanized pipe, 1 1/2" with flat irons	3.25 metres . x Shs	= Shs .....
Timber, 4" x 2"	77 metres .....x Shs	= Shs .....
Corrugated roofing sheets, gauge 30, 3m	15 sheets .....x Shs	= Shs .....
Nails for roofing, 4"	5 kg .....x Shs	= Shs .....
Roofing nails	8 kg .....x Shs	= Shs .....
Gutters, triangular, 20cm overlap, g 26	56 metres .....x Shs	= Shs .....
Splash guards for gutters, 20cm overlap g 26 ...	50 metres .....x Shs	= Shs .....
Gutter hangers for triangular gutters, 3 mm	80 nos .....x Shs	= Shs .....
Clot nails for fixing downpipes	1 kg .....x Shs	= Shs .....
Bitumen paste for sealing overlaps	2 kg .....x Shs	= Shs .....
Transport of 5 tonnes x ..... km	inclusive return ....x Shs	= Shs .....

Guttering included

Total cost for project Shs

Bill of Quality for items to be delivered free of charge by the self-help group

Unskilled labour for 25 days x	4 labourers ..x Shs	= Shs .....
Sand, clean and coarse, ...	14 tonnes .....x Shs	= Shs .....
Stones, cleaned	6 tonnes .....x Shs	= Shs .....
Water	4 tonnes .....x Shs	= Shs .....
Transport by carts of 25 tonnes x ..... km	50 carts .....x Shs	= Shs .....

Total value of self-help Shs

Grand total cost and value of tank Shs .....

For converting tonnes into more understandable terms following formula can be used.

1 tonne of cement = 20 bags of cement.
1 tonne of sand = 8 wheelbarrows.
1 tonne of stones = 8 wheelbarrows.
1 tonne of water = 5 drums.

6. Quality Control and Maintenance

It is of great importance that the first, second and final coat of plaster be completed within one day and that the plaster mix ratios and reinforcement be the same as those listed in the building instructions. If the proportion of cement in the mix has been reduced, either through a false attempt at economy or through cheating then the wall will be crumbly and flake after wetting. If the reinforcement has been improperly made, large cracks will appear. If the curing has not been carried out effectively and for long enough, large numbers of small cracks will appear. All these faults are due to incorrect following of the building instructions given. If the instructions are followed closely then there should be no problems.

If the roofing on the tank has not been constructed so that they drain towards the centre of the tank and the gap, then water will not fill the tank properly and may even flow outside of the tank.

If the gutters have not been hung properly on the roof edge so that they slope gradually down towards the tank then the water running off the roof will not flow properly into the tank. Instead it may just build-up in the gutter and overflow onto the ground alongside the house.

If cracks do appear in the tank then depending on the seriousness of the cracking, several actions can be taken.

Is the lining of the tank crumbling off the wall?

If it is the mortar needs to be removed and the lining begun again from the beginning.

Is the surface covered with small cracks but still solid?

If it is then it dried too quickly and a third coat of plaster can be applied with a second waterproofing. Curing should be done properly this time.

Are there one or two large cracks in the tank through which water leaks out?

If there are then these need to be chiseled out and the leakage blocked. The best method is to chisel away 3-6 cm either side of the crack so that the barbed wire and chicken mesh is exposed. New strands of wire should be knitted into the wire to form a tighter mesh and mortar should be packed in once the surface has been wetted and dusted with cement. A smooth and complete coat of plaster should be applied over the crack and onto the wall of the tank around the crack. Single small cracks can be painted with bitumen paste.

Does water collect in the gutters but fail to flow freely towards the tank?

If this is the case, the hangers need to be suspended at an increasingly lower level towards the tank end of the roof.

Does water drain away from the opening into the tank once it flows onto the roof?

If the tank roofing does not drain towards the centre of the tank it needs to be removed and repositioned so that it does. This should not happen if the correct height of wall and correct length of galvanised support pipe has been used.

9.3.6 Maintaining and Improving Water Quality

There are several actions that can be taken to improve water quality. Firstly, the water quality is already improved over natural depressions because water is washed from a relatively clean roof into a covered tank, reducing the pollutants washed into the water and the number of insects that breed in the tank.

To maintain this water quality, the gutters and the roof should be cleaned periodically, especially just before the onset of the rainy season to prevent leaves, dust and dead animals and insects washing into the tank.

If the tank is not already empty at the end of dry season it should be emptied and any silt collected in the bottom should be removed. The interior of the tank should be cleaned with a brush.

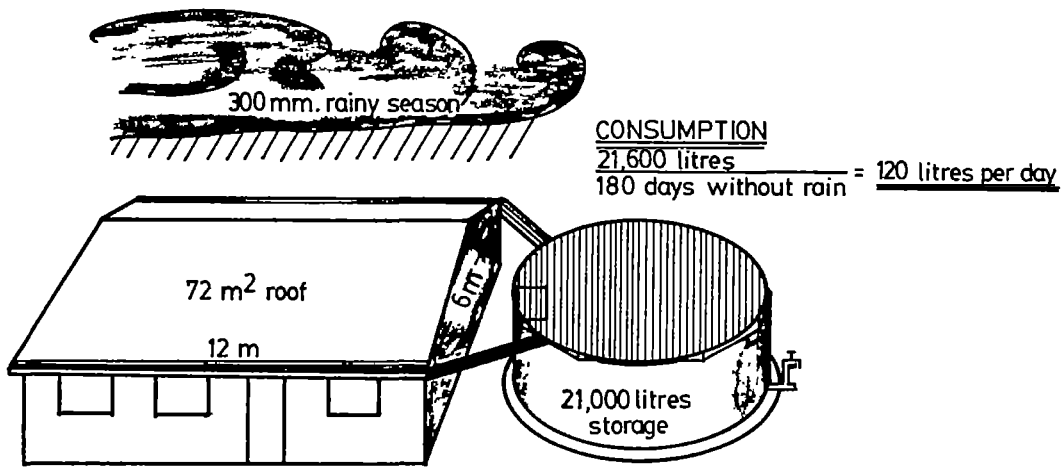
The gap between the roof and the extension wall should be closed with stones and mortar to keep out wind-blown material, lizards, birds and insects. This will also minimize evaporation losses. The chicken wire filter can be improved by attaching a length of screen-mesh across it allowing water through but keeping insects out.

A clean and efficient method of drawing water from the tank can be adopted, the best being a hand-pump fixed next to the extension wall with its suction pipe fixed just above the bed of the tank. Below the hand-pump a 120 cm square platform of stones should be laid to prevent the ground from getting swampy from any spilled water. The hand-pump should be locked with a padlock to prevent children playing with it or unauthorised use and it should be kept in good order with periodic greasing.

CONTRACTORS MANUAL ON WATER TANKS

C O N T E N T S

21 CUBIC METRE RAISED TANK



1. Site Preparation

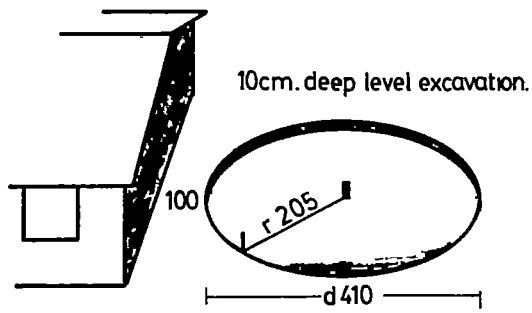
1.1 Positioning the Tank

a. The tank should be sited next to the house. Measure 3.05 metres from the wall and hammer a wooden peg into the ground.

b. Tie a wire to the peg and make a small loop 205 cm from the peg cutting off the extra wire. Put a long nail through the loop.

c. Using the nail, scratch a circle on the cleared ground around the peg using the wire radius of 205 cm. This circle of diametre 410 is the outline of the tank foundation.

d. Dig the soil out from inside the circle to a depth of 15 cm using a long spirit level to make sure the floor of the excavation is horizontal and even.



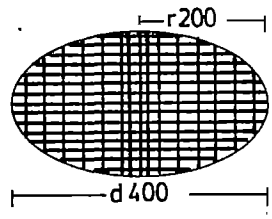
2. Building Instructions

2.1 Preparing the B.R.C. Weld Mesh Frame

a. Cut two lengths of 200 cm long and 210 cm wide B.R.C. weld mesh. Place them next to each other with an overlap of 10 cm so that the square of weld mesh is 200 x 200 cm.

b. Ram a peg into the centre of the square piece of weld mesh. Tie a string to the peg and draw a circle on the weld mesh that has a radius of 200 cm.

c. Cut the weld mesh along the drawn circle line using a hammer and a chisel on hard stone. This sheet of weld mesh will be used for the foundation of the water tank.

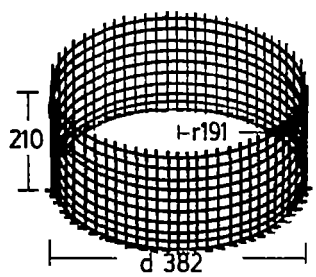


d. Cut one length of B.R.C. weld mesh 1250 cm long to be used for the wall.

e. With a string draw a circle on the ground away from the foundation that has a radius of 191 cm

f. Place the 1250 cm long weld mesh upright as a cylinder on the drawn circle with a radius of 191 cm and tie it together with wire.

g. Bend the lower ends of weld mesh's vertical ends outwards.



2.2 Concreting the Foundation

This work must be completed in one day.

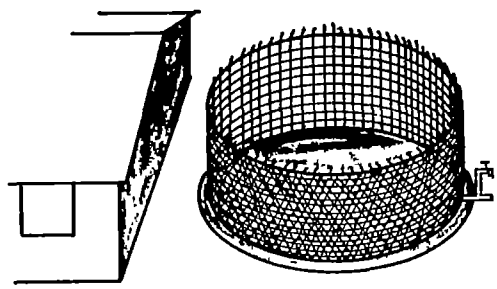
a. Mix concrete made of 1 portion of cement to 3 portions of clean, coarse sand and thereafter add 4 portions of ballast (approximately 5 cm diametre stones) (1:3:4) and add water.

b. Pour a 5 cm thick concrete mix into the excavation foundation and compact it well.

c. Place the circular sheet of weld mesh on top of the moist concrete.

d. Place the cylindrical sheet of weld mesh on top of the circular sheet of weld mesh and tie them together with binding wire in 30 places.

e. Tie the water pipe made from galvanised iron pipe onto the circular weld mesh and the wall.



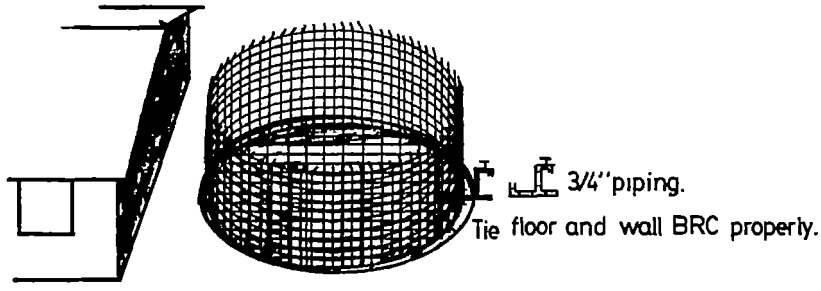
f. Mix concrete (1:3:4) and pour it in a 5 cm thick layer onto the first layer of concrete in the foundation. Compact this second layer well to ensure that it has a good bond with the weld mesh underneath.

g. Keep the concrete moist and covered for proper curing.

2.3 Lining the Tank With the First Coat of Plaster

a. Roll one layer of 2.5 cm chicken mesh, around the outside of the cylindrical weld mesh as tightly as possible. Overlapping of the chicken mesh should be at least 15 cm.

b. Roll loops of gauge 16 galvanised wire around the chicken mesh as tightly as possible. These loops of wire should be spaced 10 cm apart.



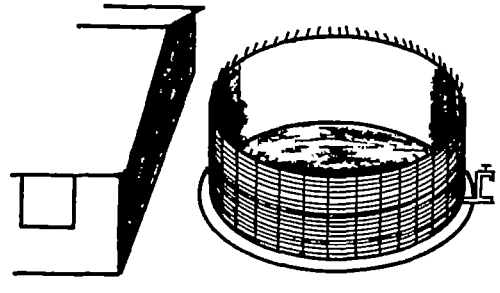
c. Cut open 20 empty sugar sacks. Sew them together to make a long blanket 200 cm wide.

d. Roll this blanket tightly around the weld mesh and the chicken mesh so that all of the outside of the tank is covered.

e. Tie 50 rounds of sisal string tightly around the blanket of sacks. Space the strings 4 to 5 cm apart.

f. Mix 1 portion of cement with 3 portion of clean, coarse sand (1:3) and water.

g. Smear this moist mixture onto the inside of the blanket with a trowel. This coat should be 3 to 5 cm thick and stick well to the chicken mesh all over. Leave this coat of mortar to harden for 12 hours.

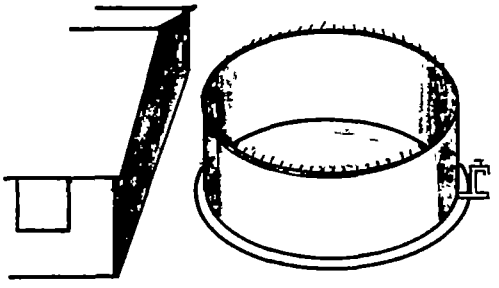


2.4 Lining the Tank With a Second Coat of Plaster

a. The following day, mix mortar (1:3) and apply it to the inside of the tank in a 3 cm thick coat. Smooth it evenly with a wooden float.

b. Clean the floor of tank. Pour a 2 cm thick layer of mortar (1:3) onto the clean, moist floor. Smooth it with a wooden float.

c. Mix cement with water and apply a thin coat of this cement slurry to the moist plaster on the inside of the tank wall and floor. Press the slurry into a plaster with a square steel trowel. This will ensure a watertight coat. The coats of plaster and cement slurry **must be completed in one day.**



2.3 Curing the Lining and Coating the Tank

a. On the following day after lining the inside, remove the sugar sack blanket from the outside of the tank, wet it and hang it on the inside of the tank for proper curing. Lay polythene sheeting on the floor of the tank and cover it with 3 cm of water.

b. Plaster the outside of the tank with a 3 cm thick coat of mortar (1:3) and smooth it with a wooden float.

c. Wrap the outside of the tank in a sheet of polythene sheeting and secure it with sisal strings.

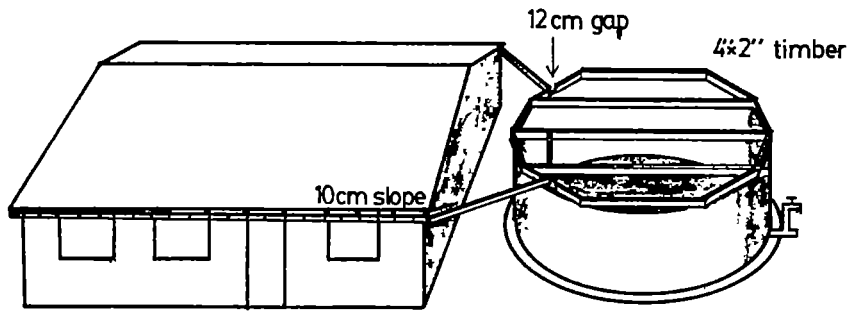
d. Keep the ferro-cement tank moist and covered for 3 weeks to ensure a good curing and a watertight tank.

2.5 Fixing the Roofing Timber

a. Water tanks should be roofed to reduce evaporation which can remove up to half the water in the tank (evaporation rates in ASAL regions are more than 2 metres annually which is equivalent to the height of this particular tank).

b. Place 5 lengths of timber, 10 cm x 5 cm (4" x 2") across the tank and space them 90 cm apart. The timber should have been treated with wood preservative prior to the construction to stop it rotting in the moist environment. In coastal areas this can be done by soaking the timber in sea water for one month. Tie the ends of these timbers to the upper part of the wall reinforcement with binding wire.

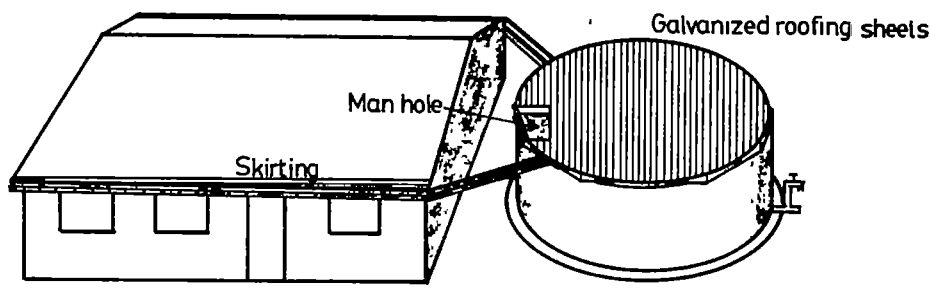
c. Place lengths of timber, 10 cm x 5 cm between the ends of the first 5 lengths of timber and nail them together with 10 cm (4") nails. Leave two gaps, 12 cm wide, for the intake of the downpipe gutters. Fix a length of timber and a frame for a man-hole in the roof structure.



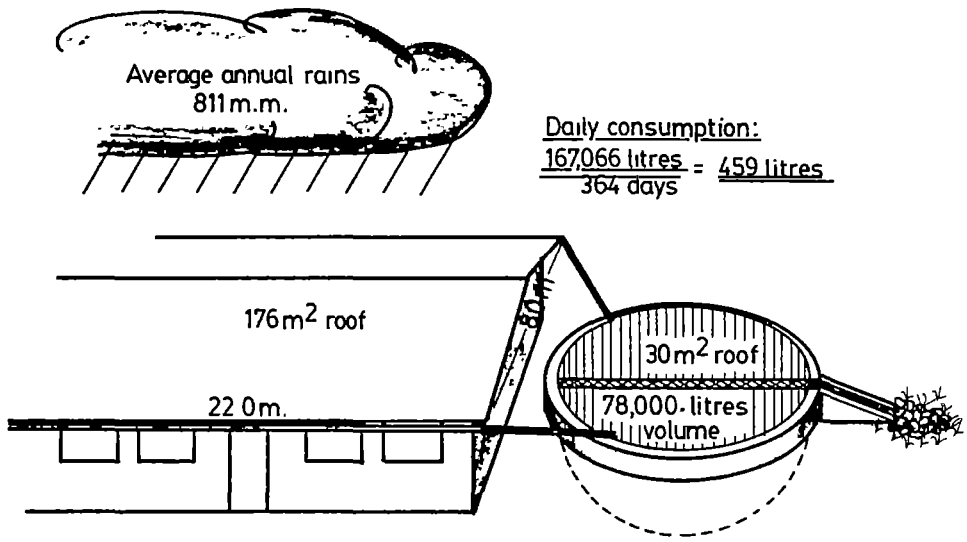
2.6 Constructing the Roof

a. Nail galvanized corrugated roofing sheets onto the timber structure. Trim the sheets that protrude over the edge of the tank wall. Roof the lid of the man-hole and attach two strips of metal to act as handles for the man-hole lid.

b. Close all openings between the iron sheets, the timbers and the edge of the tank with mortar (1:4) to keep lizards and insects out.



78 CUBIC METRE EXTENDED GROUND TANK



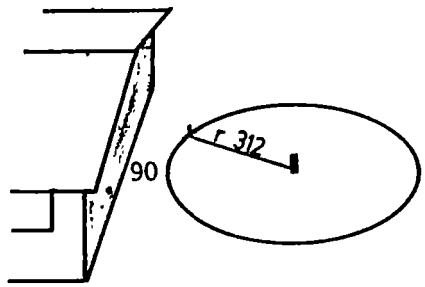
1. Site Preparation

1.1 Positioning the Tank

a. The tank should be sited next to the house. Measure 4 m from the wall and hammer a wooden peg into the ground.

b. Tie a wire to the peg, make a small loop 312 cm from the peg and cut off the extra wire. Put a long nail through the loop.

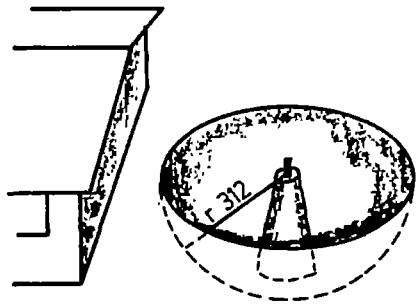
c. Using the nail, scratch a circle on the cleared ground using the wire radius of 312 cm around the wooden peg. This circle of diameter 624 cm is the outline of the tank excavation.



1.2 Excavating the Tank

a. Dig out the soil inside the circle leaving some soil remaining around the centre peg. Use the radius wire at all times to make the shape of the half-ball excavation. If large stones protrude out of the sides, they can be left as part of the tank wall but smaller stones should be removed.

b. After excavating all around the pillar with the centre peg, remove the pillar as the last part of the excavation.

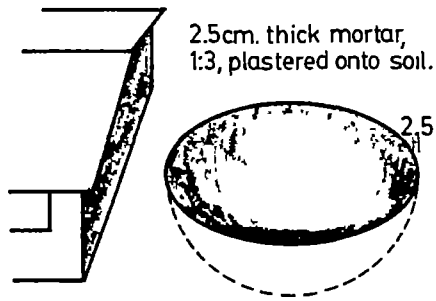


2. Building Instructions

2.1 Applying the First Coat of Plaster

a. Fill in any holes left by the stones removed during the excavation with smaller stones and mortar made from 1 portion of cement to 5 portions of sand (1:5).

b. Starting at the bottom of the tank, throw a coat of mortar, consisting of 1 portion of cement to 3 portions of coarse sand (1:3), onto the wall of soil. Continue until the plaster has reached a thickness of 2.5 to 3 cm. Leave the plaster with a rough surface as it makes a good bond for the next coat of plaster to follow in a couple of days. Keep the plaster moist and covered with a polythene sheeting.



1st Coat of Mortar.

2.2 Building the Tank Rim Beam

a. Dig a 20 cm wide and 20 cm. deep ditch along the edge of the tank wall.

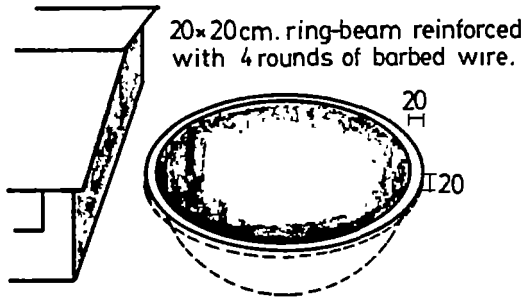
b. Fill the bottom of the ditch with a 5 to 7 cm layer of mortar (1:3). Place 2 rounds of barbed wire (gauge 16) on the mortar.

c. Pour a second layer of 5 to 7 cm of mortar over the barbed wire and compact it well.

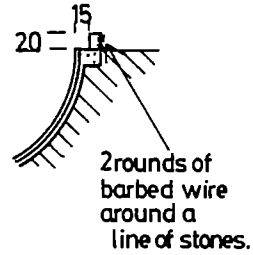
d. Place another 2 rounds of barbed wire (gauge 16) on the mortar so that all together there are 4 rounds of uncut wire in the ring beam. Cut the barbed wire free from its roll.

e. Fill up the ditch with mortar (1:3) and compact it well. Level the top of the beam by placing stones set in mortar.

f. Keep the ring beam moist and under shade for proper curing either with polythene sheets or sackcloth.



Ring-beam.



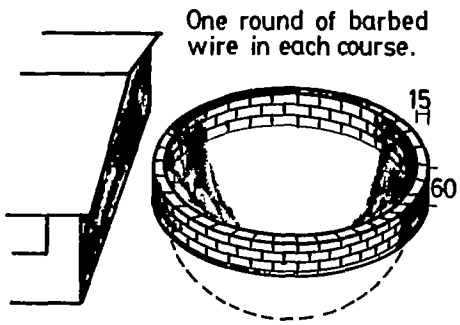
2.3 Extension of the Tank Wall

a. The extension wall, 65 cm high, is built onto the ring beam.

b. A gap 100 cm wide and 5 cm deep should be left at the side furthest away from the building to allow overflow water out.

c. The wall can be built of stones set in mortar (1:4). Twelve rounds of barbed wire are drawn tightly around the wall as reinforcement and covered with mortar/plaster (1:4).

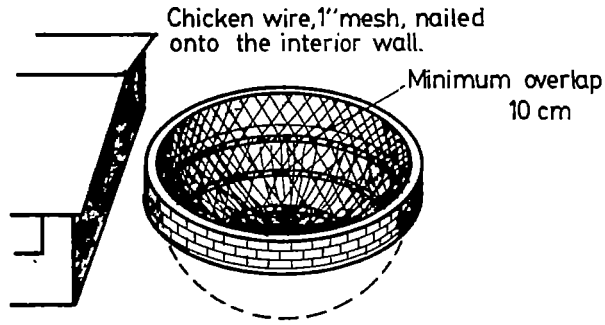
d. Alternatively, bricks or blocks with a ring of barbed wire in each course can be used.



Extension of wall.

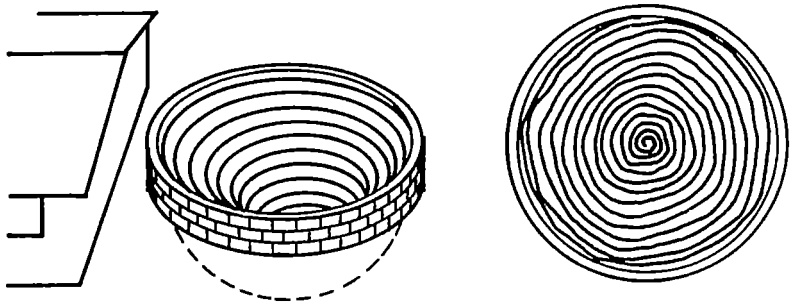
2.4 Reinforcement of the Tank

a. Nail chicken mesh with 2.5 cm nails onto the plaster of the tank wall with 6.35 cm (2.5") nails. Use wet nails as it makes it easier to hammer them through the plaster. Any overlapping of the chicken mesh must be at least 10 cm wide. If chicken mesh is not available, barbed wire can be used instead by doubling the reinforcement of barbed wire.



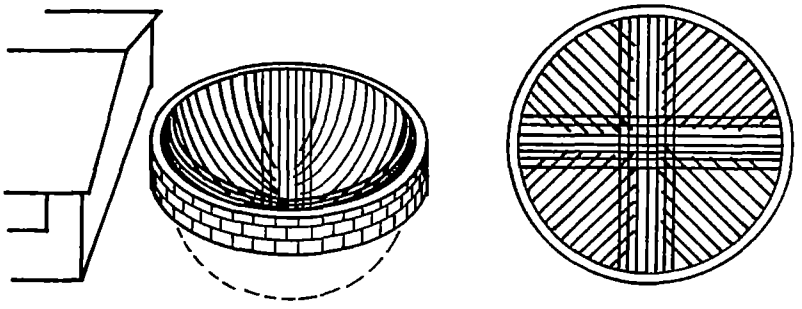
Reinforcement

b. Nail a spiral of barbed wire, gauge 16, onto the interior of the tank. Start nailing the wire at the bottom centre of the tank and continue upwards to the top edge of the tank. Spacing between the lines of wire should be 10-15 cm apart.



Barbed wire nailed onto wall in a spiral spaced 20 cm.

c. Nail seven straight lines of barbed wire, gauge 16, across the tank passing over the bottom centre. Then nail another seven straight lines of barbed wire across the tank bottom at an angle of 90 degrees to the first seven lines. Then fix lengths of barbed wire from these lines straight up the sides of the tank as shown, nailed 20 cm apart. If chicken mesh is not available, barbed wire can be used instead if the spacing is reduced to 10 cm.



Barbed wire nailed onto wall spaced 20 cm. apart

2.5 Applying the Second Coat of Plaster

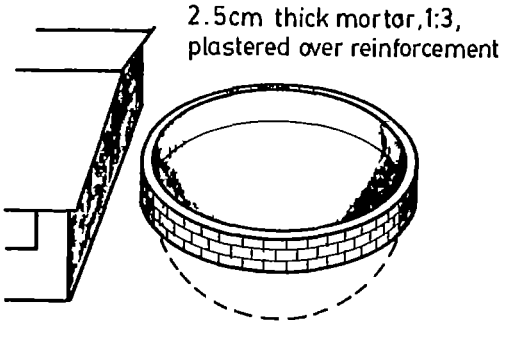
a. This second and final coat of plaster **has to be completed within one day** or the tank might crack later on. So ensure that all materials, including water, are at the site before starting to plaster.

b. Clean the interior of the tank and keep the reinforcement and the wall moist.

c. Throw mortar (1:3) onto the reinforced wall and be sure that it is embedded properly around the reinforcement. This plaster layer should be 3 cm thick so that together with the first coat of plaster the total thickness of the wall is 5.5 cm. Smooth the plaster with a wooden float until an even and uniform surface is obtained.

d. For waterproofing, apply a coat of cement slurry (cement and water Nil) with a square steel trowel. Coating with cement slurry **must** be completed within the same day as the final coat of plaster.

e. Cure the plastered ferro-cement work with polythene sheeting and water for 2 to 4 weeks. Failure to do so will result in a weak structure with many small cracks.



Final Coat of Mortar.

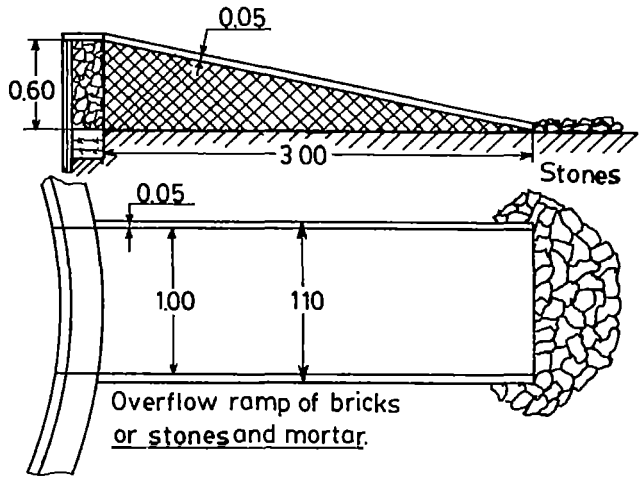
2.6 Building the Overflow

a. Build a ramp of bricks or ballast and mortar against the extension wall of the tank leading up to the 100 cm x 5 cm gap. It should be angled so that its base is 3 m long and its width should be 110 cm.

b. Plaster the surface and sides of the ramp with mortar (1:3).

c. Place two pieces of timber 10 cm x 5 cm on the ramp, 5 cm in from either edge as a form-guide. Fill this 5 cm between the edge and the timber with mortar to make the sides of the overflow chute.

d. Place an apron of stones at the lower end of the ramp and dig a ditch down to a hollow planted with fruit trees.



2.7 Fixing the Roofing Timber

a. Place a 3.75 cm (1.5") galvanized iron pipe with flat irons welded to both ends upright in the bottom centre of the tank. The upper end of the pipe must be about 20 cm lower than the top of the extension wall in order to make the tank roof slope towards the centre of the tank.

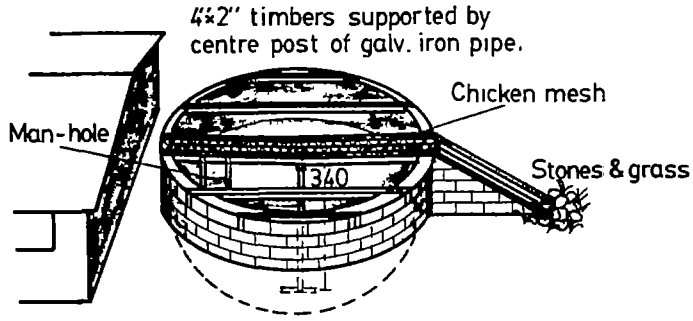
b. Place 2 lengths of 10 cm x 5 cm (4" x 2") timber from wall to wall, resting on the flat iron welded to the centre pipe. All timbers should have been treated with wood preservative prior to construction to stop it rotting in the moist environment. In coastal areas this can be done by soaking the timber in sea water for one month. These two timbers should be placed about 20 cm apart. Nail 2 layers of chicken mesh between the 2 timbers to act as a sieve.

c. Place two more 10 cm x 5 cm pieces of timber on either side of the first two timbers and space them each 150 cm from the first pieces.

d. Place another 2 lengths of 10 cm timber on each side and 150 cm from the last two timber pieces.

e. Use stones, blocks or bricks and mortar to build up the extension wall so that it reaches the top of the timber.

f. Make a square man-hole measuring 60 x 60 cm between one set of the timbers nearest the extension wall.



Roofing and Spill-over.

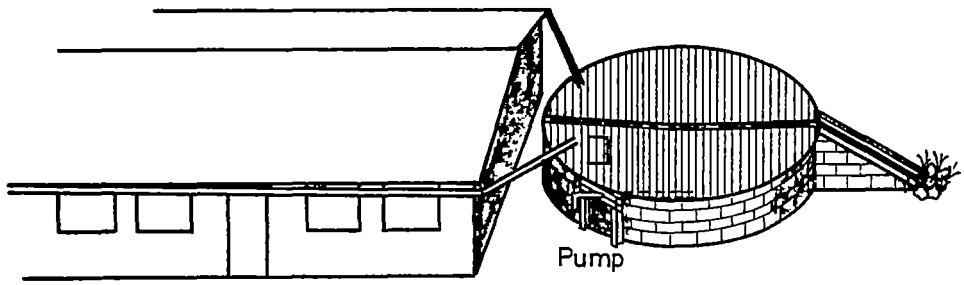
2.8 Putting on the Roof

a. Nail corrugated, galvanized roofing sheets onto the pieces of timber. Leave a space of 10 cm between the end of the sheets above the centre timbers to allow run-off water to enter the tank through that space which is covered with chicken mesh.

b. Cut a hole in the roofing sheet for the man-hole. Make a cover for the man-hole of 4" x 2" timbers and the cut piece of roofing sheet.

c. Trim the roofing sheets along the outer edge of the tank. Fill all the spaces between the sheets and the tank wall with mortar (1:4).

d. Install a hand-pump next to the man hole.



Roofing, Handpump and Gutters.

3. GENERAL QUALITY CONTROL AND MAINTENANCE GUIDELINES

There are some general guidelines that must be followed to ensure quality control and the production of leak-proof tanks.

3.1 Mortaring, Plastering and Curing

It is of great importance that all coats of plaster be completed within one day and that the plaster mix and reinforcement at all stages are the same as those listed in the building instructions. If the proportion of cement in the mix has been reduced, either through a false attempt at economy or through cheating then the wall will be crumbly and flake after wetting. If the reinforcement has been improperly made, large cracks are likely to appear in the tank. If the curing has not been carried out effectively large numbers of small cracks will appear. All these faults are due to incorrect following of the building instructions given. If the instructions are followed closely then there should be no problems.

If polythene sheeting is not left over the lining for long enough, and the mortar not kept moist, the lining will dry too quickly and cracks will occur in many places.

If cracks do appear in the tank then depending on the seriousness of the cracking several actions can be taken.

Is the lining crumbling off the tank wall?

If it is, then the mortar needs to be removed and the lining begun again from scratch.

Is the surface covered in small cracks?

If it is then this is due to too rapid drying and a new coat of plaster can be applied with a second waterproofing. Curing should be done properly this time.

Are there one or two large cracks through which water leaks out of the tank

If there are then these need to be chiseled out and the leakage blocked. The best method is to chisel a way 20 cm either side of the crack so that the reinforcement is exposed. Thereafter, 30 wide pieces of 5 cm x 5 cm (2" x 2") weld mesh 120 cm long are nailed across the cracks. The weld-mesh pieces must overlap at the ends by at least 15 cm. Then clean the exposed area to be replastered with water, and throw dry cement dust onto the moist surface. Let this pure cement coat dry for at least four hours before applying plaster consisting of mortar (1:3). A smooth complete coat of plaster should be applied over the crack and onto the wall of the tank around the crack. Small cracks can be painted with bitumen paste.

4. Cleaning and Management

There are several actions that can be taken to improve water quality. Firstly, the water quality is already improved over natural depressions because water is washed from a relatively clean roof into a covered tank, reducing the pollutants washed into the water and the number of insects that breed in the tank.

To maintain this water quality, the gutters and the roof should be cleaned periodically, especially just before the onset of the rainy season to prevent leaves, dust, dead animals and insects washing into the tank. there should be a chicken wire and screen-mesh filter over all the inlets and the tank overflow to keep out pollutants and stop insects entering. All or part of the first rain of the season should be diverted by moving the downpipe so that it does not flow into the tank.

If the tank is not already empty at the end of dry season it should be emptied and any silt collected in the bottom should be removed. The interior of the tank should be cleaned with a brush.

If there are any gaps between the roof and the extension wall, they should be filled with stones and mortar to keep out wind-blown material, lizards, birds and insects. This will also minimise evaporation losses.

For the extended ground tank, a clean and efficient method of drawing water from the tank can be adopted, the best being a hand-pump fixed next to the extension wall with its suction pipe fixed just above the bed of the tank. Below the hand-pump a 120 cm square platform of stones should be laid to prevent the ground from getting swampy from any spilled water. The hand-pump should be blocked with a padlock to prevent children playing with it or unauthorised use and it should be kept in good order with regular maintenance.

CONTRACTORS MANUAL ON GUTTERS

C O N T E N T S

1. Manufacturing Gutters

1.1 Ordinary Half-Circular Gutters

Ordinary half-circular gutters are generally manufactured by commercial firms in cities and sold through building suppliers. They are rather expensive. Because they flatten-out with use and get damaged, they may not be able to transport enough roof run-off leading to over-spill and water loss. This is common in very heavy showers.

This potential for water loss in heavy showers is bad for rooftop run-off harvesting. In addition, ordinary gutters must be nailed to a faciaboard. Many buildings such as schools do not have boards and even if they do, this is a difficult job.

Knowing these problems and because of the high cost of buying semi-circular gutters, two new types of gutter have been developed: the square gutter and the v-shaped gutter.

Table 1 - Comparison Between Gutters

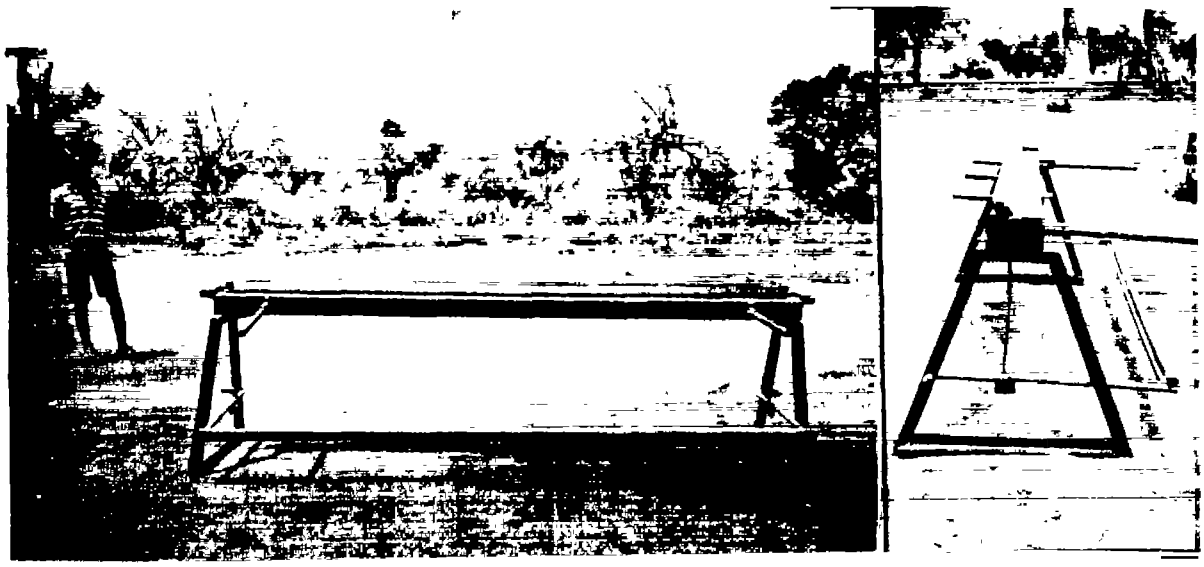
Type of Gutter	Holding Capacity	Cost per 1 metre
Ordinary half-circular gutter (with 8" faciaboard + paint)	7.5 litres	KSh. 85/-
Square gutter (with 4" faciaboard + paint)	9.5 litres	KSh. 40/-
V-shape gutter (with hangers and skirting)	10.0 litres	KSh. 39/-

1.2 The V-shape Gutter

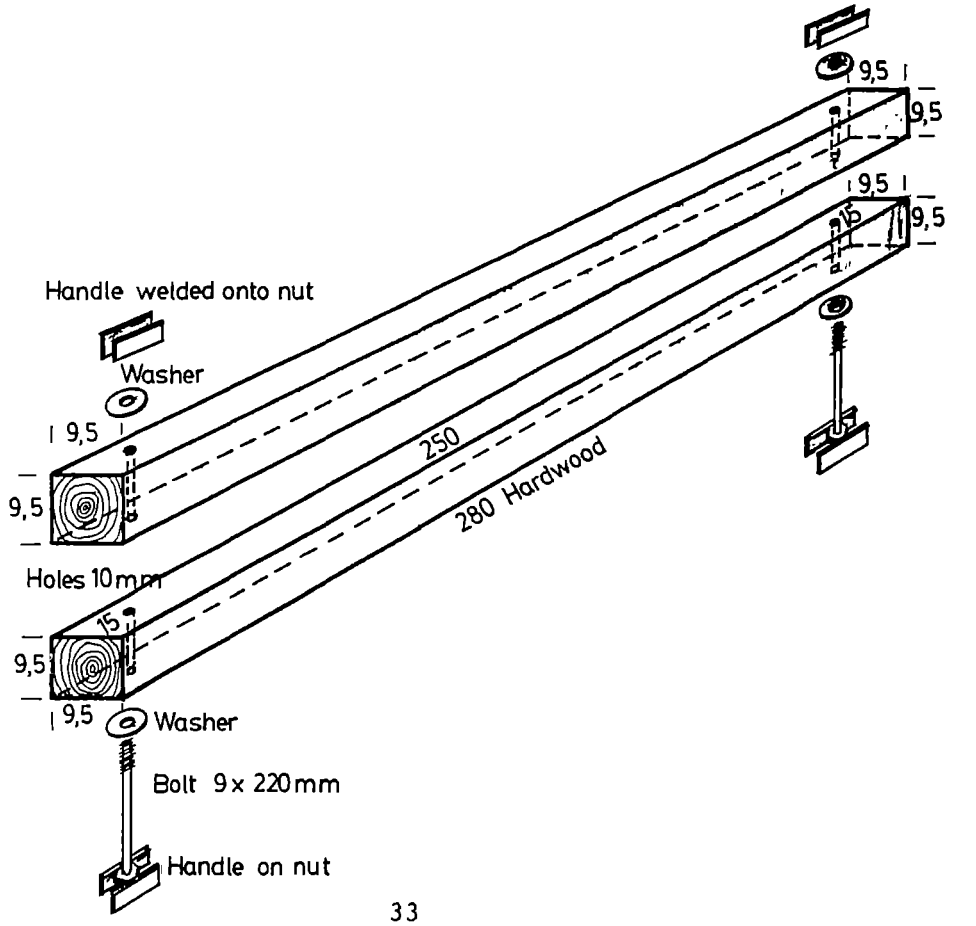
The v-shape gutter is recommended for a number of good reasons. It hangs in iron hangers from an iron sheet skirting which is nailed to the roof. The skirting is important because it directs all run-off water down into the gutter, preventing it from flowing over the edge and onto the ground. The skirting should be used for all types of gutters and not just v-shaped ones.

Because it transports all the run-off with no losses it is good to use and is in fact the cheapest of the three types of the gutters available.

The v-shaped gutter can be built with a hand-operated gutter-bending machine as shown below. It can be made by a local blacksmith who has welding equipment for about US $200.



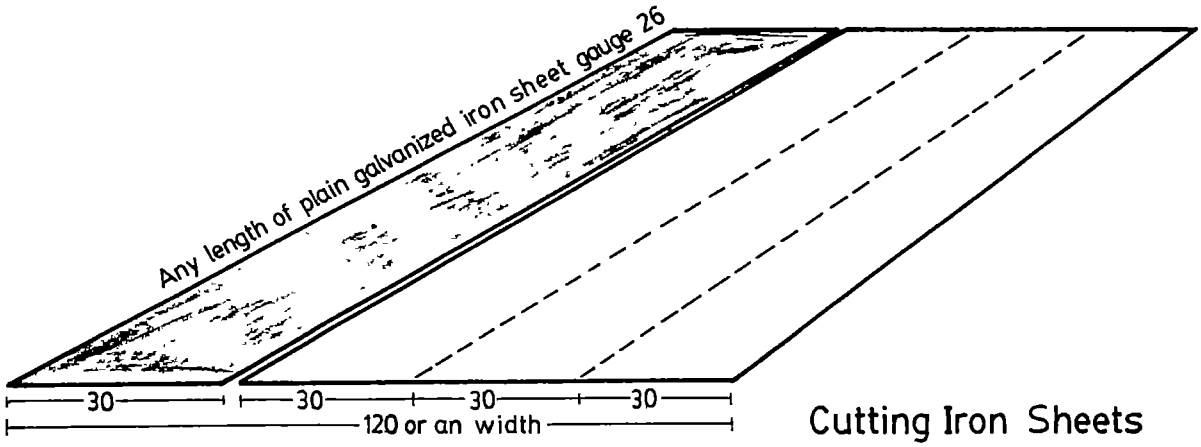
However, a cheaper gutter-bending tool can be made for about US $40 by a carpenter with basic tools. Although this tool is cheaper, it does take more time to produce gutters and if a large number of gutters are to be made it will be better to buy the hand-operated machine in the long run.



2. Manufacturing V-shaped gutters

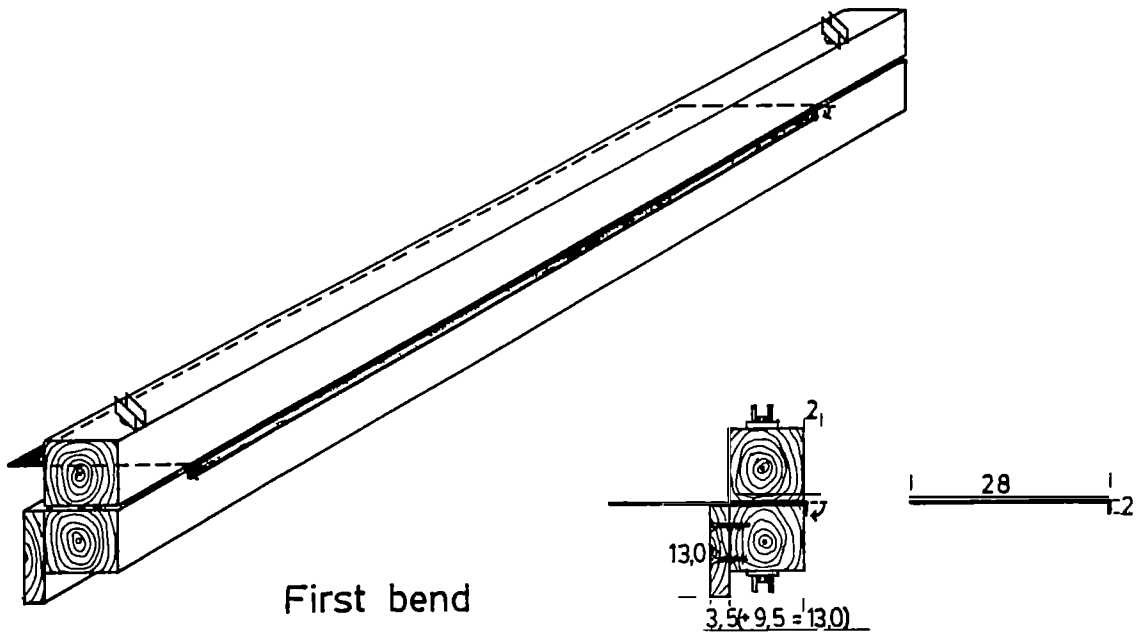
2.1 Making the gutters

a. Cut 30 cm wide strips of plain galvanized iron sheet, preferably gauge 26.



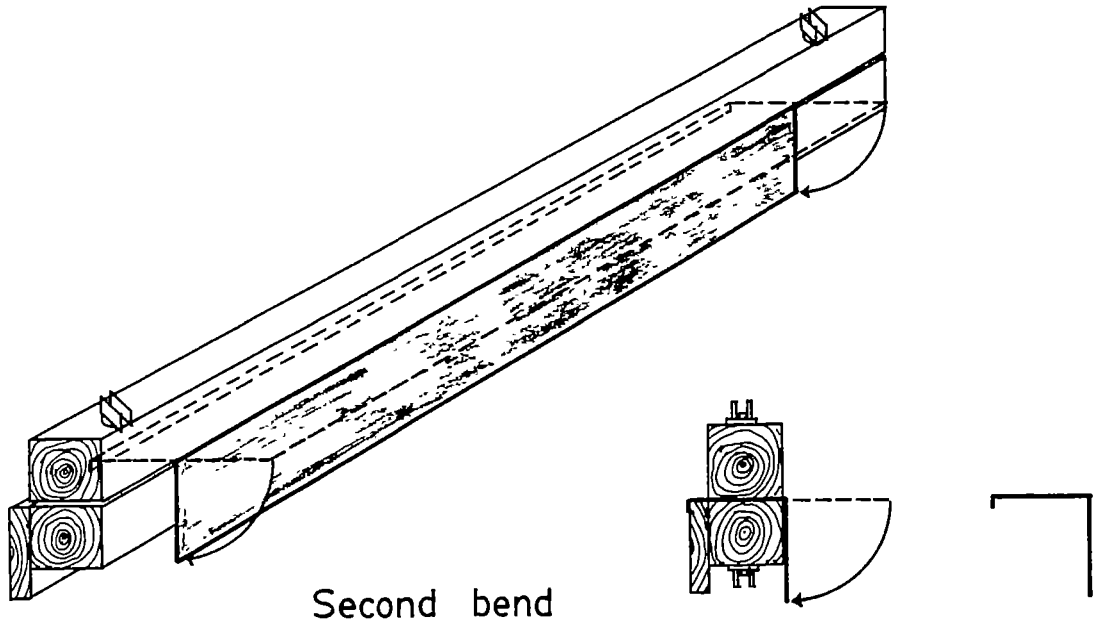
Cutting Iron Sheets

b. Screw a 280 cm by 13 cm by 3.5 cm piece of timber onto the gutter bending tool as shown below. Thereafter, place one of the 30 cm iron sheet strips between the gutter tool so that it protrudes 2 cm out of the side that does not have the extra piece of wood screwed on (as shown below). Screw the two timbers together tightly. Bend the protruding sheet downwards with a hammer and a short piece of hardwood, being careful not to damage it.



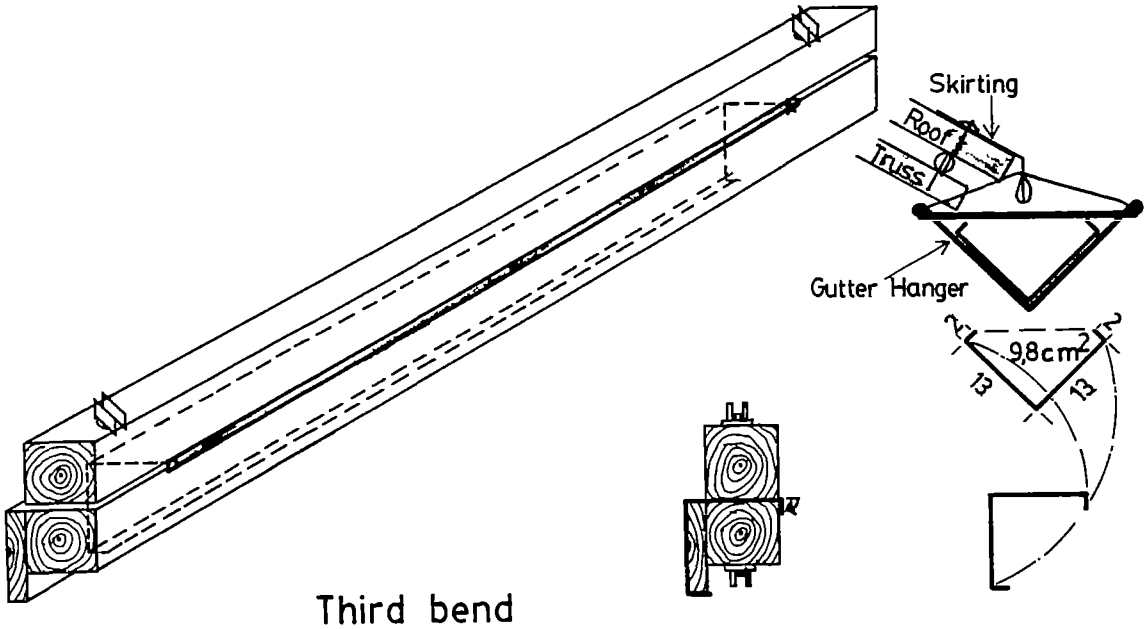
First bend

c. Unscrew the timbers, pull out the iron sheet, turn it around and insert it between the timbers with the bent edge pressed against the extra piece of wood added to the two tool timbers as shown in the next picture. Screw the bolts down again so the iron sheet is held tight and bend down the protruding sheet with the hammer and piece of hardwood.



Second bend

d. Unscrew the timbers again and place the iron sheet as shown in the next picture. Tighten the bolts and then bend the protruding 2 cm edge of the sheet downwards as before. Remove the sheet from the timbers and you can see it has now been made into a v-shaped length of gutter.



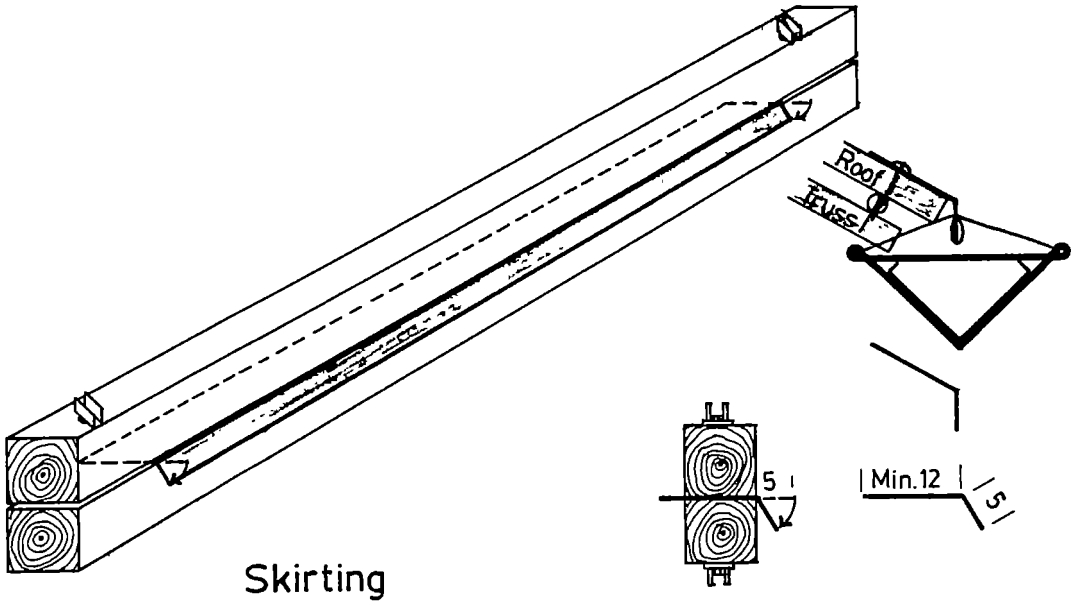
Third bend

e. The skirting is made the same way as the gutters, the only differences being that:

   (i) the width of the iron sheet strip can be anything between 17 and 30 cm,

   (ii) a skirting needs only one bend and only partly towards the timber from the horizontal as shown in the following picture.

f. The sheet should be inserted between the two timbers so that 5 cm sticks out on the opposite side, the bolts tightened, and the 5 cm edge bent downwards only part of the way towards the timber.



Skirting

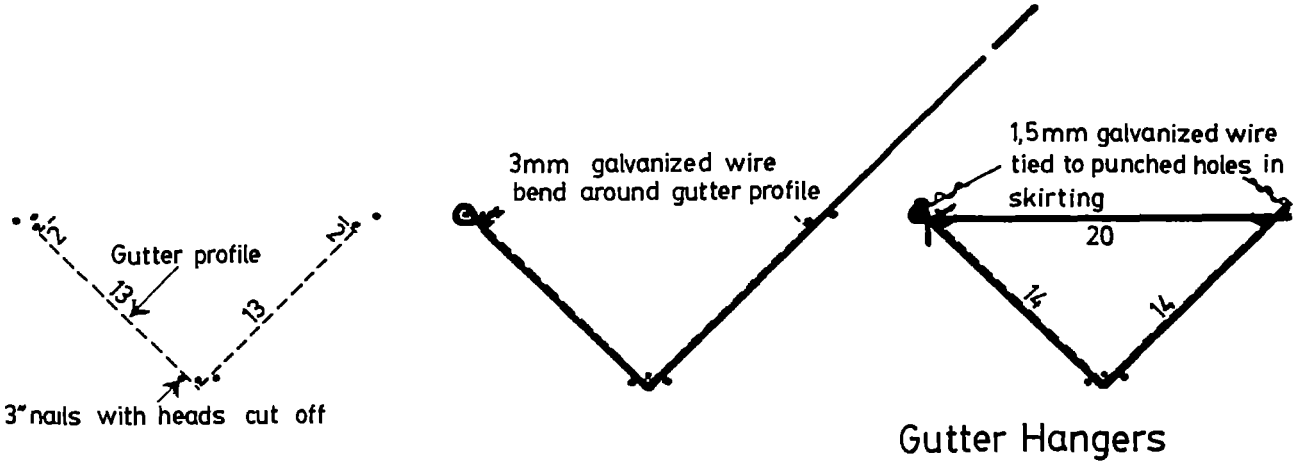
2.2 Manufacturing Gutter Hangers

Gutter hangers are produced from 3 mm galvanized wire.

a. A profile of a gutter hanger should be drawn onto a solid piece of timber such as a workbench as shown in the next pictures (it is a right-angled triangle).

b. Hammer 7.5 cm nails (3") 3 cm deep into the wood at the corners of the triangle as shown in the next pictures. Cut the heads off the nails and file the cut end so that it is not sharp and dangerous.

c. To make the hangers, bend 3 mm wire around the nails as shown in the next picture.



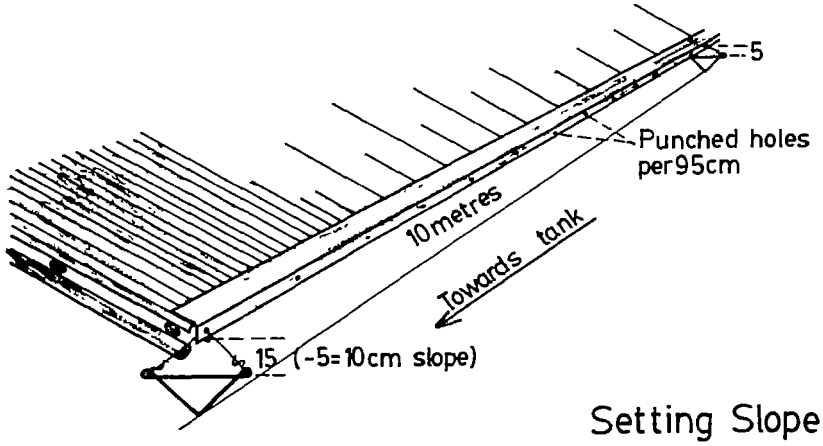
Gutter Hangers

3.3 Installing V-shaped Gutters

For triangular gutters that do not need a faciaboard follow these instructions.

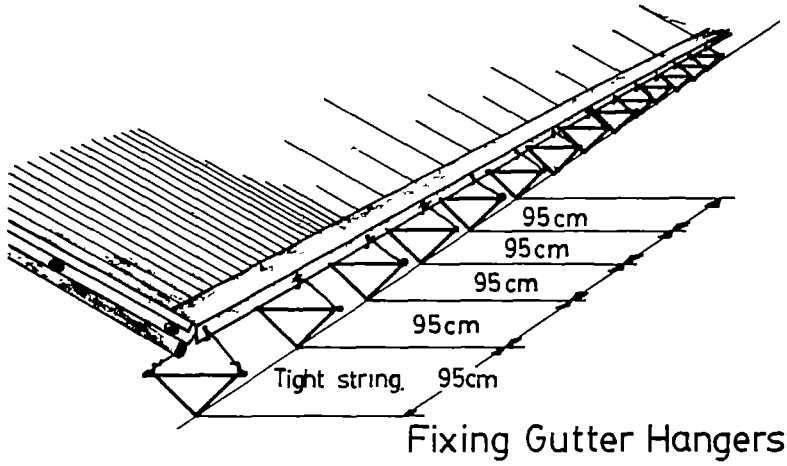
a. Gutters are fixed onto each side of the building. The slope of the gutters towards the water tank should be such that there is a drop of at least 10 cm for every 10 metres length.

b. First draw a builders line 2 cm from the edge of the roof for alignment of the skirting. Thereafter nail the skirtings onto the roof with roofing nails (without removing the nails in the roof) for every 30 cm or so. Ensure that the bend of the skirting is following the builders line. When the whole length of skirtings have been nailed onto the roof, then punch 3 mm holes in the upper part of the vertical lip of the skirting for every 95 cm starting from that end which is nearest the water tank.



Setting Slope

d. Hang up the first and last gutter hangers on either end of the house (the one near the tank should be 10 cm lower per 10 m in the horizontal) by attaching it with 3 mm galvanized wire as shown in the previous picture. Attach the inner loop of the hanger to the underside of the roof either by tying it to the nail holding down the skirting or to the purling.



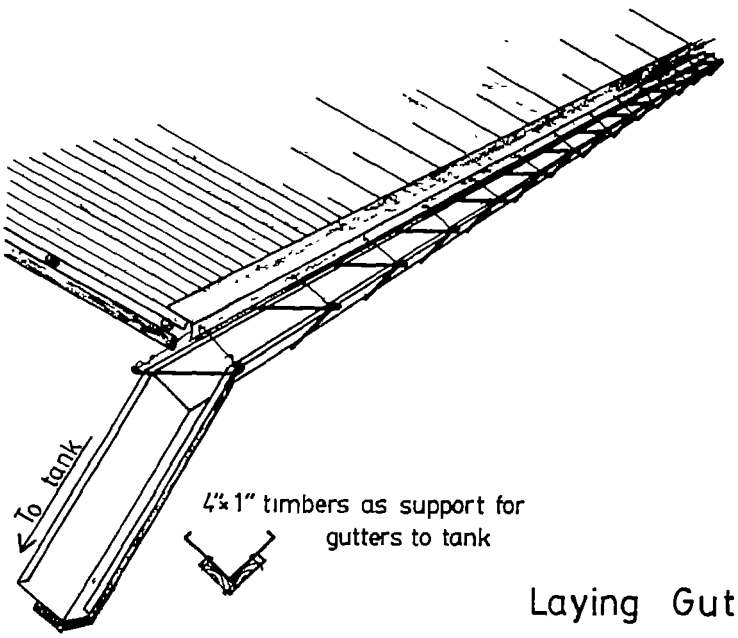
Fixing Gutter Hangers

e. To hang the other hangers, tie a builders line between the two end hangers and carefully draw it tight so that it shows the line the gutter should take. When it slopes 1 cm down in every 1 m along, the other hangers can be fixed so that their bottom angle just touches the line.

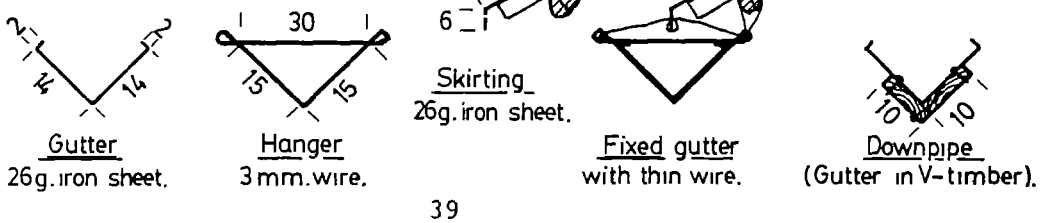
f. With gutters lengths being 200 cm, the hangers are spaced 95 cm apart, so that every second hanger will support an overlap of 20 cm in the joints of the gutters.

g. When all the gutter hangers are in position, fit the lengths of gutters into the hangers. Start with the gutter nearest the tank and continue away from the tank. Each next gutter should be fitted so that its lower (tank) end sits on top of the previous gutter length. They must overlap by 20 cm. The joint should sit exactly in the gutter hanger with 10 cm of the gutter overlap either side. A thin coat of bitumen is smeared onto the end of each gutter length before the overlapping gutter is laid onto it. This will create a water-tight seal.

h. The guttering is extended to the water tank by gutters nailed onto two 10 cm x 2.5 cm (4" x 1") timbers forming a V. The far end of the gutter should be closed by bending the sides of the gutter together and sealing with bitumen.



Laying Gutters



Gutter 26g. iron sheet.

Hanger 3 mm. wire.

Skirting 26g. iron sheet.

Fixed gutter with thin wire.

Downpipe (Gutter in V-timber).

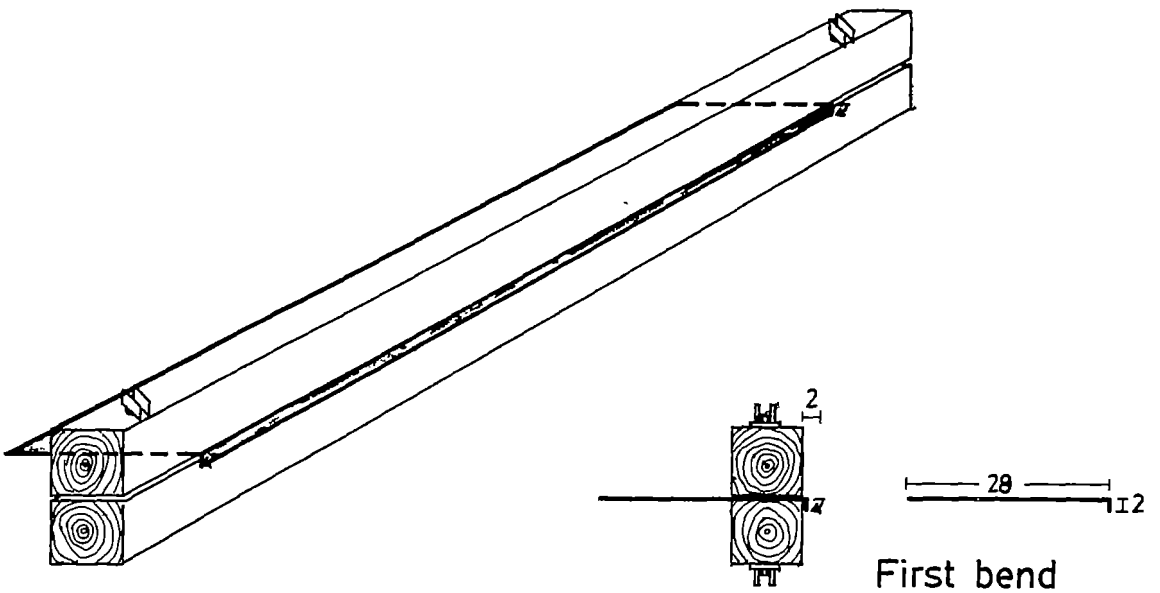
4. Manufacturing Square Gutters

4.1 Making the Gutters

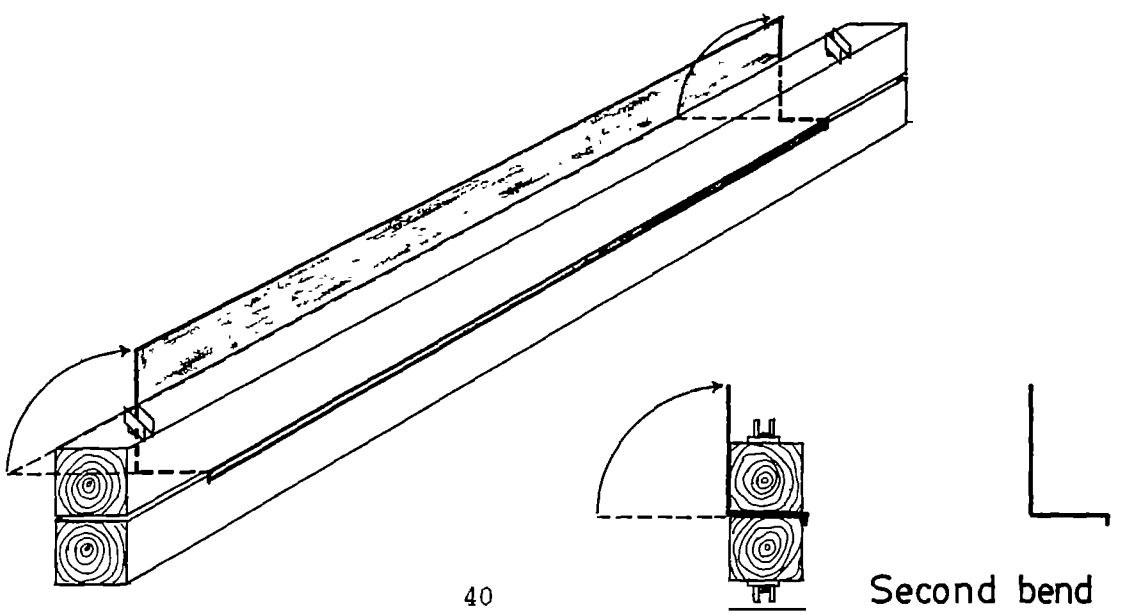
The benefits of square gutters are:

- that some people think they look nicer than the v-shaped gutters,
- if the house already has fixed faciaboards then it is easier to fit square gutters than to hang V-shaped gutters.

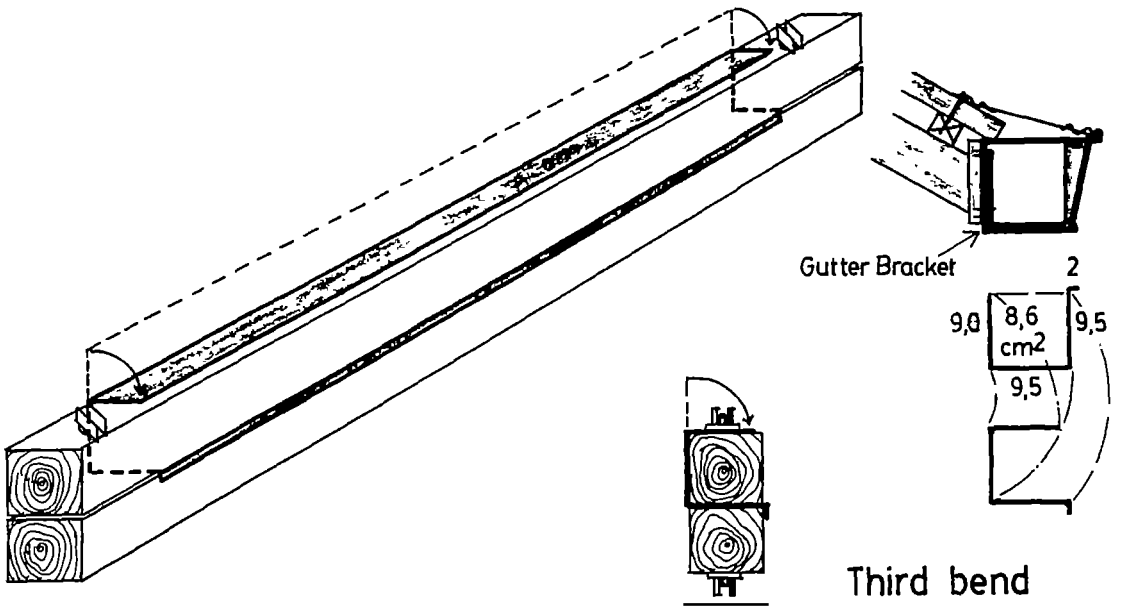
a. As with the V-shaped gutters, put a 30 cm wide strip of iron sheet (gauge 26) between the two timbers of the sheet-bending tool so that 2 cm sticks out the other side. Bend this down against the timber using a hammer and a piece of hardwood.



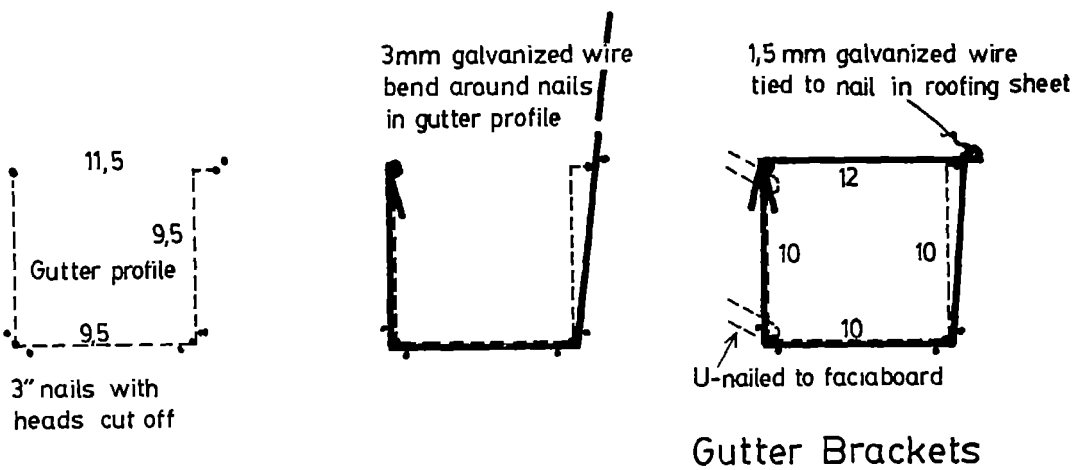
b. Afterwards, bend the other protruding part of the iron-sheet upwards as shown in the picture below.



c. Lastly, bend the edge that sticks up past the timber downwards in the direction of the timber as shown in the following picture.



d. Gutter brackets should be made with 3 mm galvanized wire bent around a profile of the bracket drawn onto a solid piece of timber such as a workbench. The wire is bent around 7.5 cm nails which have been knocked in 3 cm deep and had their heads cut-off and filed smooth as shown below.



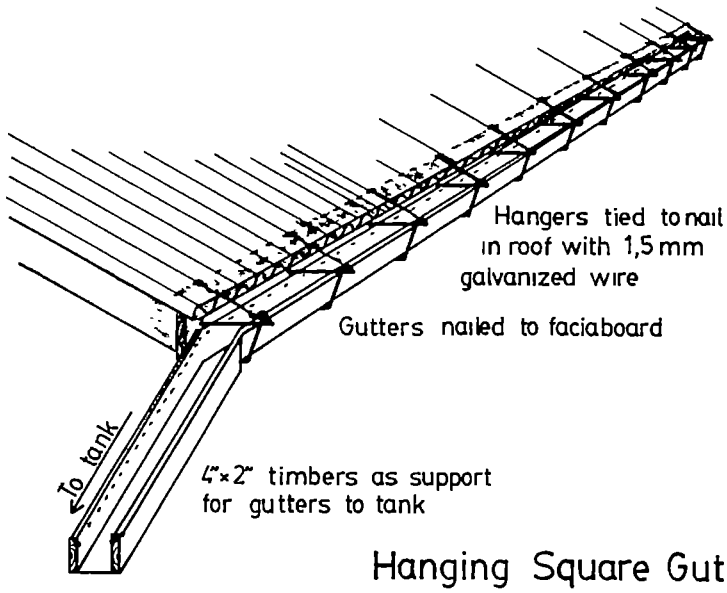
5. Installing Square Gutters to the Roof

a. Using U-nails, fix the first gutter bracket to the faciaboard 10 cm in from the end nearest to the water tank. It must be nailed to the lowest position possible on the faciaboard to allow maximum slope of the gutter towards the tank.

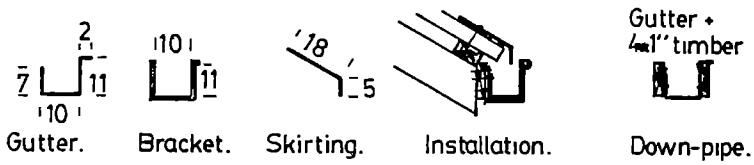
b. Tie the bent circle in the gutter bracket to a roofing nail hammered into the roof using 1.5 mm galvanized wire. Afterwards, nail another bracket at the furthest end of the faciaboard, again 10 cm in from the end, but this time as high up on the faciaboard as possible. With a good slope towards the tank, the gutter will deliver all the run-off water.

c. Check the slope between the two gutter brackets by drawing a builders line tightly between the bottom of the two brackets. It should have at least 1 cm drop every 1 m along which you can check using a hosepipe level.

d. Fix the rest of the brackets using the builders line as your guide. The bottom of the bracket should just touch the builders line. There should be 20 cm overlap of the gutters and so if the gutters lengths are 200 cm long the hangers should be spaced 95 cm apart.



Hanging Square Gutters



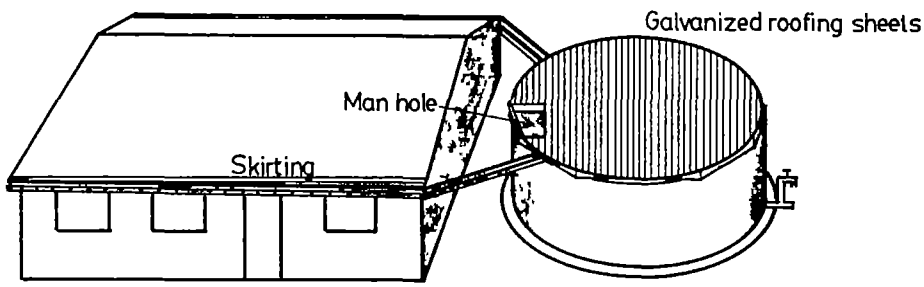
Gutter. Bracket. Skirting. Installation. Down-pipe.

e. Starting from the end nearest the tank, gutters are laid into the brackets so that the next gutter sits inside the previous gutter with a 20 cm overlap. Before placing the next gutter down, the previous gutter should be painted with bitumen so that they make a water tight seal. The overlap should centre exactly in the bracket, with each gutter sticking out 10 cm either side.

f. The guttering is connected to the tank with a few lengths of guttering supported by 10 cm x 5 cm (4" x 2") timbers. The downpipe gutters, which are similar to the gutters themselves, are nailed onto the two lengths of timber fixed between the ends of the faciaboards and the tank. Ensure that these downpipe gutters extend some 20 cm into the tank and that joints to the gutters are watertight. There should be 2 gutter lengths on each downpipe section.

g. The far end of the gutter should be closed by bending the sides and bottom together and bending the 2 cm tongue over the top. This should be done before the last length is put in the hanger and it should be sealed with bitumen.

h. To avoid spill-over of run-off water from the roof of the house during heavy storms, nail a skirting of iron sheets onto the roof. The skirting will direct all run-off into the gutter.



6. Quality Control and Maintenance

6.1 Guttering and Roofing

If the gutters have not been hung properly, water may not flow down efficiently towards the tank inlet. Instead it may just build-up in the gutter and overflow onto the ground alongside the house.

Does water collect in the gutters and fail to flow freely towards the tank?

If this is the case, the hangers need to be suspended at an increasingly lower level towards the tank end of the roof.

If the gutters leak, then the joints between each section of guttering need a more even coat of bitumen paste to seal them together.

Does water drain away from the opening into the tank once it flows onto the roof?

If the tank roofing does not drain towards the centre of the tank it needs to be removed and repositioned so that it does. This should not happen if the correct height of wall and correct length of galvanized support pipe has been used.

3.2 Take-Out Pipes

With the 21 cubic metre raised tank, the stand-pipe should be well sealed in plaster but care should be taken not to block it with mortar or waterproofing. The following check must be made;

Does water flow out of the stand-pipe when you open the tap?

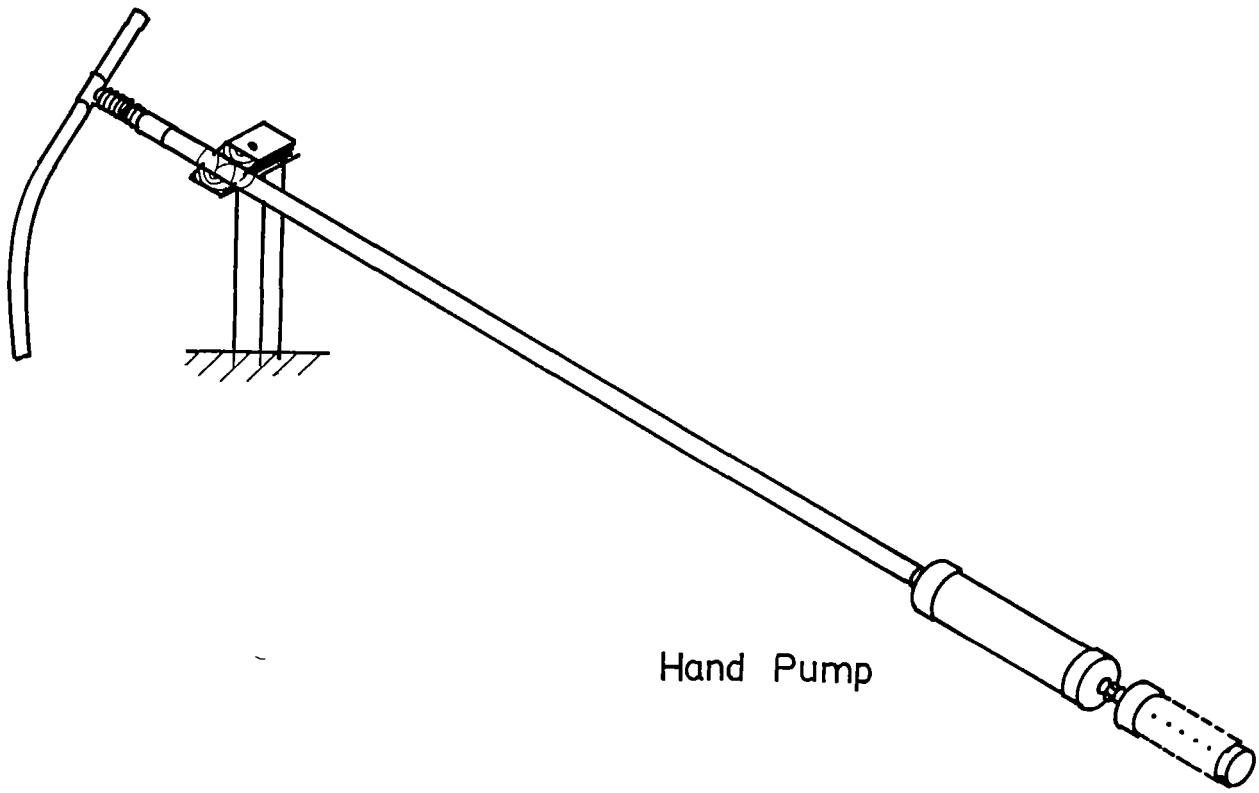
If water does not flow out of the pipe when the tank is full this means the pipe is blocked. The tap can be unscrewed and a flexible wire pushed through the pipe to clear the blockage.

CONTRACTORS MANUAL ON HAND-PUMP

C O N T E N T S

1. The Hand-pump

In this section it is explained how to manufacture a hand-pump for use to draw water out of an extended ground tank. It can also be adapted to use on a shallow lined well. Using a hand-pump is much more hygienic than taking water directly by hand or by rope and bucket because it prevents pollutants being introduced into the water source through immersion of vessels, and allows for the water to be sealed off from the outside by a complete roof or cover.



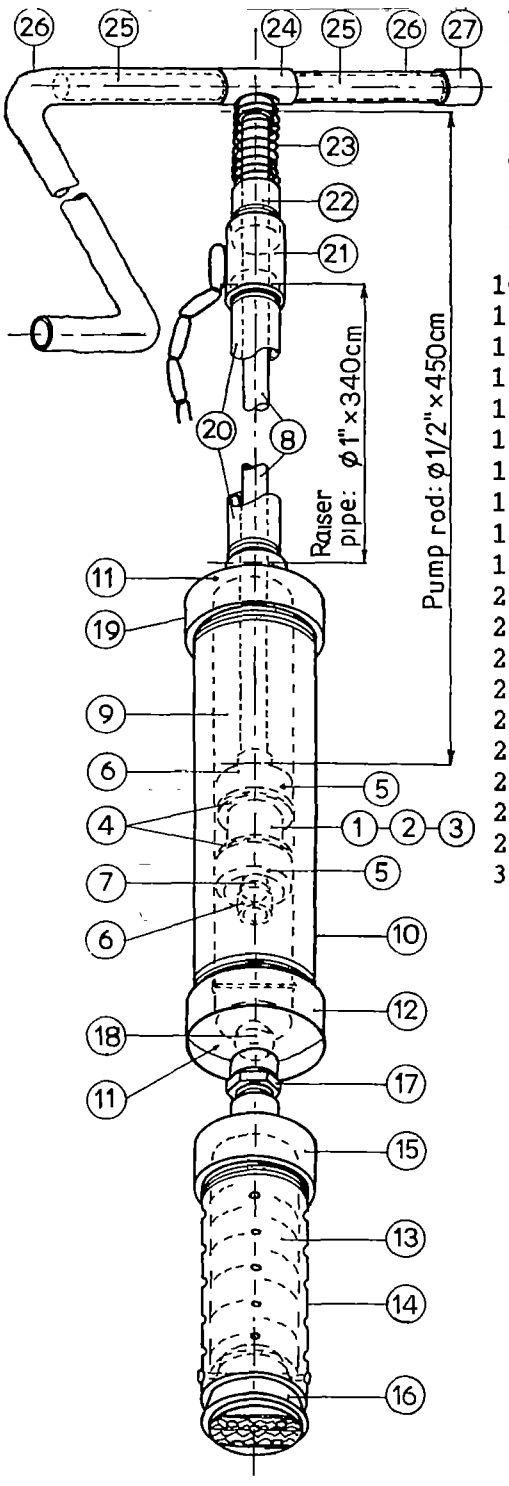
The tools required to make the hand-pump include;

1 die stock 1/2" - 2"
1 die stock 2.5" - 4"
1 pipe vice
1 engineering vice
1 hacksaw
1 hammer
1 centre punch
1 bench drilling machine (hand or power driven)
1 4 mm drill bit for metal
1 5 mm drill bit for metal
1 16 mm drill bit for wood
1 half-round 6" file
1 2 metre tape measure
2 adjustable spanners

The total cost of the hand-pump is roughly US $ 90.0

2. Materials for the Hand-pump Manufacture

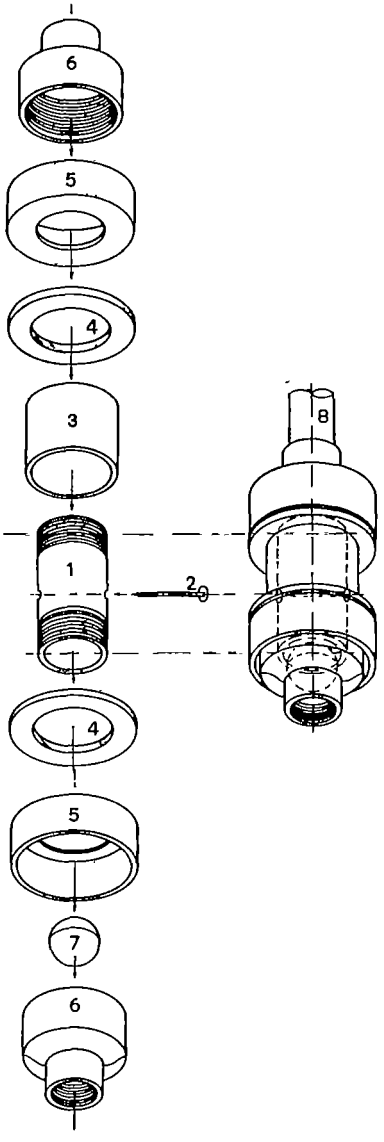
This diagram describe the parts of the hand-pump. The part numbers refer to the order they are discussed in the following instructions. They are listed below along with their dimensions and the quantity of each required;



Number	Part Name	Dimensions	Quantity
1	G.I. nipple	1"	1
2	Round nail	4"	2
3	G.I. pipe	1.25" x 4 cm	2
4	Metal washer	53 mm x 33 mm	2
5	Leather washer	100 mm x 30 mm	2
6	Reducing socket	1" x 1/2"	2
7	Rubber ball	22 m	1
8	G.I pipe class B	1/2" x 450 cm	1
9	PVC pipe class C	2" x 80 cm	1
10	G.I pipe class A	2.5" x 70 cm	1
11	Rubber discs	78 mm x 28 mm	2
12	Reducing socket	2.5" x 3/4"	1
13	PVC pipe	1.5" x 15 cm	1
14	G.I pipe	2" x 20 cm	1
15	Reducing socket	2" x 3/4"	1
16	Wooden plug	2" x 4"	1
17	Hexagonal nipple	3/4"	1
18	Rubber ball	34 mm	1
19	Reducing socket	2.5" x 1"	1
20	G.I. pipe	1" x 340 cm	1
21	G.I. socket	1"	1
22	G.I. pipe	1" x 5 cm	1
23	Spring	1" x 5 cm	1
24	G.I. pipe	1/2" x 15 cm	2
26	Plastic hosepipe	3/4" x 135 cm	1
27	G.I cap	1/2"	1
28	Termite proof posts	110 cm	2
29	Timber	4" x 2 "	3
30	Nuts and bolts	1/2"	2

3. Manufacturing Instructions

The Piston



a. Drill a 4 mm hole in the middle of a 1" nipple (1). Fix a round 4" nail (2) into the hole. Cut the protruding ends of the nail off a few millimetres from the sides of the nipple and rivet the ends with a hammer.

b. Cut a 4 cm long length of 1.25" G.I. pipe (3) and push it over the nipple (1). It will function as a spacer between the two leather seals.

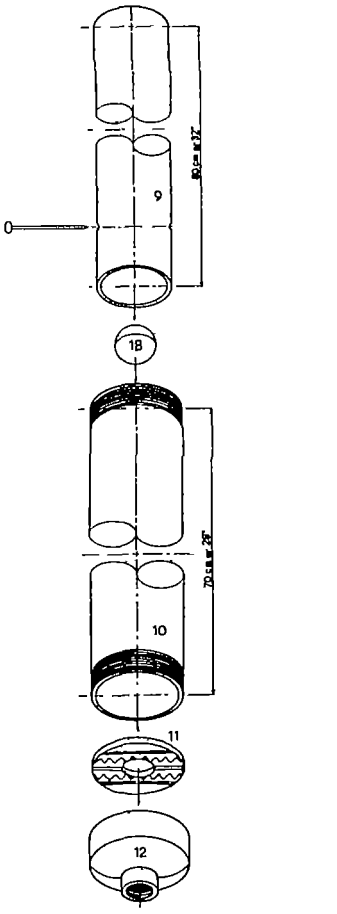
c. Push two metal washers (4), with outer and inner diametres of 53 mm and 33 mm, over the ends of the nipple (1).

d. Cut 2 leather washers (5) with inner and outer diametres of 100 mm and 30 mm out of 3 to 4 mm thick leather. Soak the washers overnight in water and then put them into boiling oil for a few minutes. Reduce the outer diametre to 50 mm by pushing the leather washers through a 50 mm (2") steel pipe and leaving them inside it overnight. Fix the two cupped seals over the nipple (1) and against the metal washers (5) with the more open end of the cupped seals facing away from the nipple.

e. Wrap sealing tape around both ends of the nipple (1) and screw a reducing socket 1" to 1/2 (6) on one end of the nipple.

f. Put a rubber ball with a diametre of 22 mm (7) into the open end of the nipple (1) to act as a valve and screw another reducing socket 1" to 1/2" onto the open end of the nipple.

g. Screw a 450 cm length of pipe (8) onto this piston to act as a pump rod.

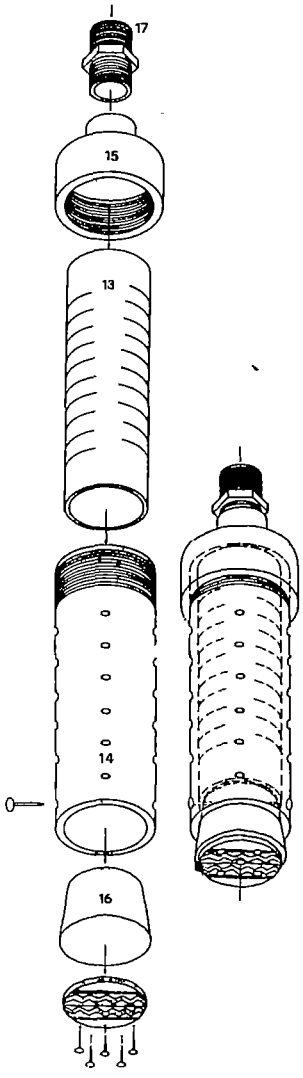


The Cylinder

a. Cut an 80 cm length of 2" PVC pipe class C (9) for a pump cylinder. Drill a 4 mm hole 60 mm from one end of the pipe. Fix a round 4" nail (2) into this hole and rivet its ends with a hammer as before.

b. Cut a 70 cm length of 2.5" G.I. pipe (10) for housing and make threads at both ends of it.

c. Cut out a rubber washer 5 mm thick and with an outer and inner diametre of 78 mm and 28 mm (11) from an old tyre. Place this washer in a reducing socket 2.5" to 3/4" (12) and screw this socket onto one end of the 2.5 G.I. pipe (10).



The Filter

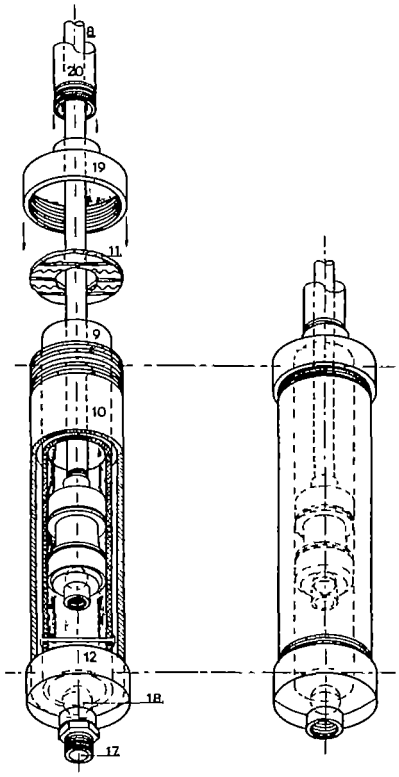
a. Cut a 15 cm length of 1.5" PVC pipe and cut many slots in the side of the pipe (13) as a fine filter.

b. Cut a 20 cm length of 2" G.I. pipe (14) and thread it at one end. Drill 32 holes of 5 mm diametre into the side of the 2" G.I. pipe as a coarse filter.

c. Screw a reducing socket 2" to 3/4" (15) onto the threaded end of the 2" G.I. pipe (14).

d. Insert the slotted PVC pipe (13) into the 2" G.I. pipe (14) and close its open end with a wooden plug (16). Nail the wooden plug into its position through the drilled holes in the G.I. pipe. Nail a disc of an old tyre onto the plug end.

Assembly of the Pumphouse and Filter



a. Drop a rubber ball with a diametre of 34 mm (18) into the pump house so that it rests in the centre at the bottom.

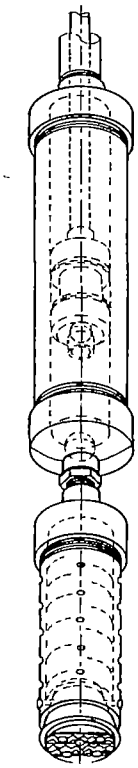
b. Push the PVC cylinder (9) into the pumphouse with the nail near the rubber ball to act as a stopper.

c. Push the piston and pump rod (8) into the PVC cylinder (9).

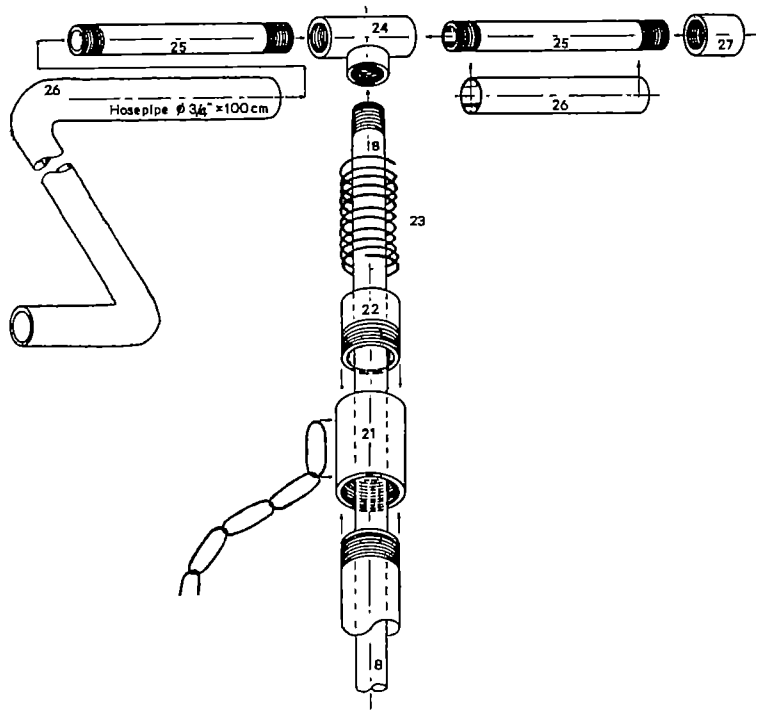
d. Close the cylinder with a reducing socket 2.5" to 1" (19) with a rubber disc placed inside it. The rubber discs keep the PVC cylinder in place.

e. Cut a 340 cm length of 1" G.I. pipe and thread it at both ends (20). Thereafter, push it over the pump rod (8) and screw it into the reduction socket (19).

f. Connect the filter to the pumphouse with a 3/4" hexagonal nipple (17).



The Handle and Raiser Pipe



a. Screw a 1" socket with a 20 cm long steel lockable chain welded to it onto the raiser pipe (21).

b. Cut a 5 cm length of 1" G.I. pipe with one threaded end and screw it into the 1" socket (22).

c. Place a spring 50 mm x 12 mm (23) from a lorry engine valve onto the pump rod (8) so that it rests on the end of the raiser pipe.

d. Screw a 1/2" G.I. tee (24) onto the pumping rod (8). Screw two 15 cm lengths of G.I. pipe (25) into the two open ends of the tee (24).

e. Push a 12 cm length of 3/4" plastic pipe (26) over one of the handles (25) and close its end with a cap of 1/2" G.I. (27). Push a 120 cm length of 3/4" plastic pipe (28) over the other handle to act as the delivery pipe.

Testing

The fully assembled pump should be secured to a pump stand made from termite proof posts and 4" x 2" timber so that its lower end is in the ground-tank and tested to see if it works properly. (Where the pump is fitted to a well, the lower end should be far enough down to reach the bottom of the well and hence pump the water).

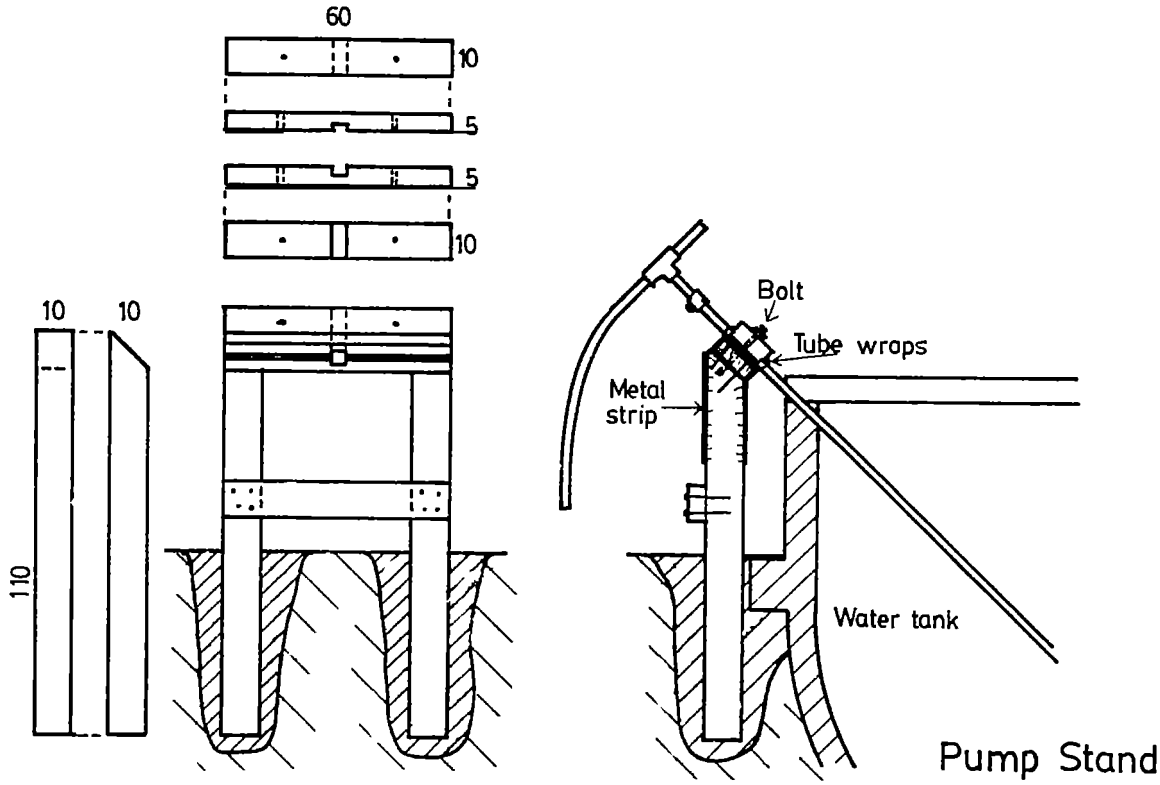
4. Installation of Pump at Extended Ground tank

a. Place the pump stand in an excavation 60 cm x 60 cm x 60 cm next to the edge of a ground tank at a convenient place for drawing water.

Erect the pump stand vertically and horizontally with the slot pointing towards the centre of the water tank. Fill up the excavation with concrete 1:4 and stones.

b. Wrap a strip of an old tube approximately 2 metres long, tightly around the upper end of the raiser pipe (18).

c. Put the lower end of the pump into the bottom centre of the ground tank and place the rubber-wrapped end of the pump in the slot between the two timbers with bolts. Tighten the slot until the raiser pipe of the pump is held firmly in place.



Pump Stand