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- *(introduction...)*
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UNDP

ANTI-EROSION DITCHES are structures which are designed to protect agricultural land from erosion caused by rainfall.

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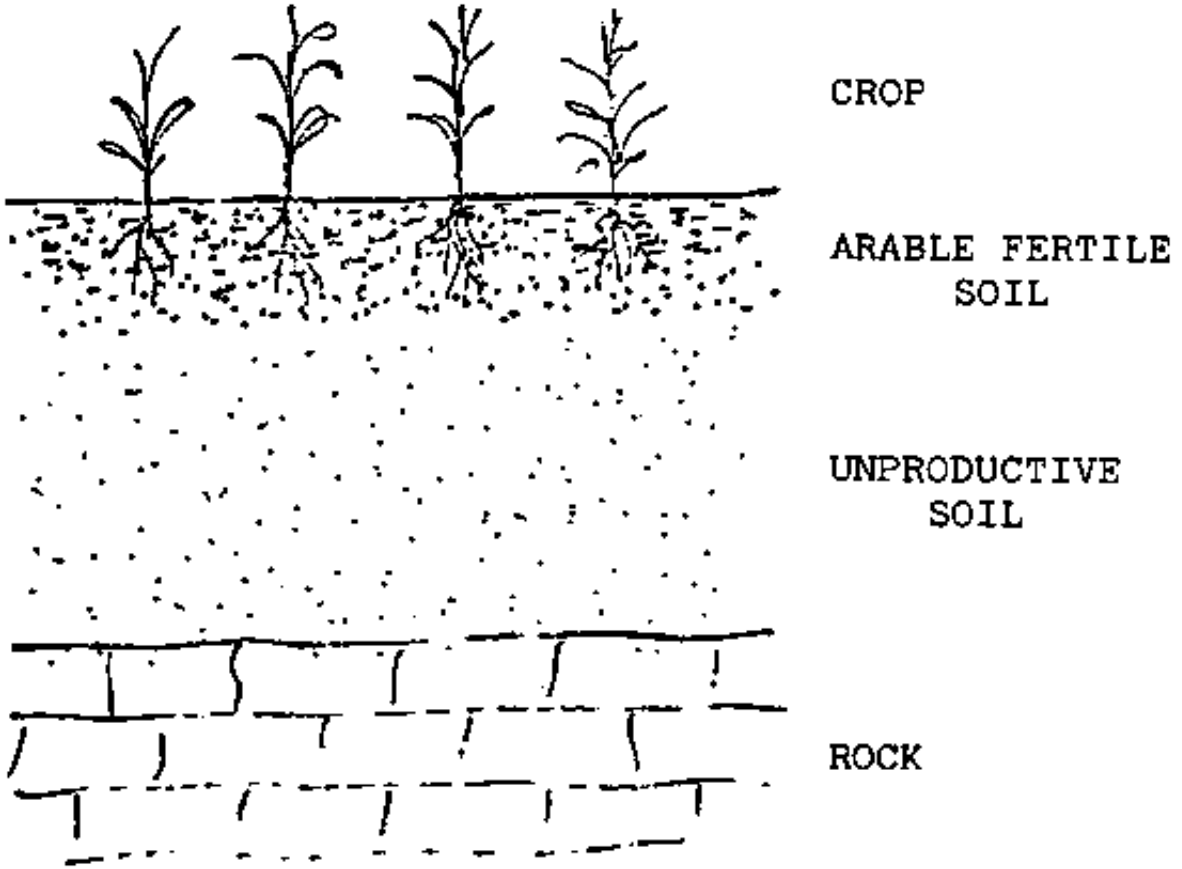
1. What is erosion?

Erosion is the loss of topsoil, the part of the soil which we till by means of the

daba or plough. It is in this layer of soil that the roots of plants establish themselves and here that they find the water and nutrients essential to their growth (minerals, trace elements). Such soil is said to be FERTILE, as it can be cultivated. Beneath this fertile layer lies a layer of unproductive or stony soil (the opposite of fertile soil).

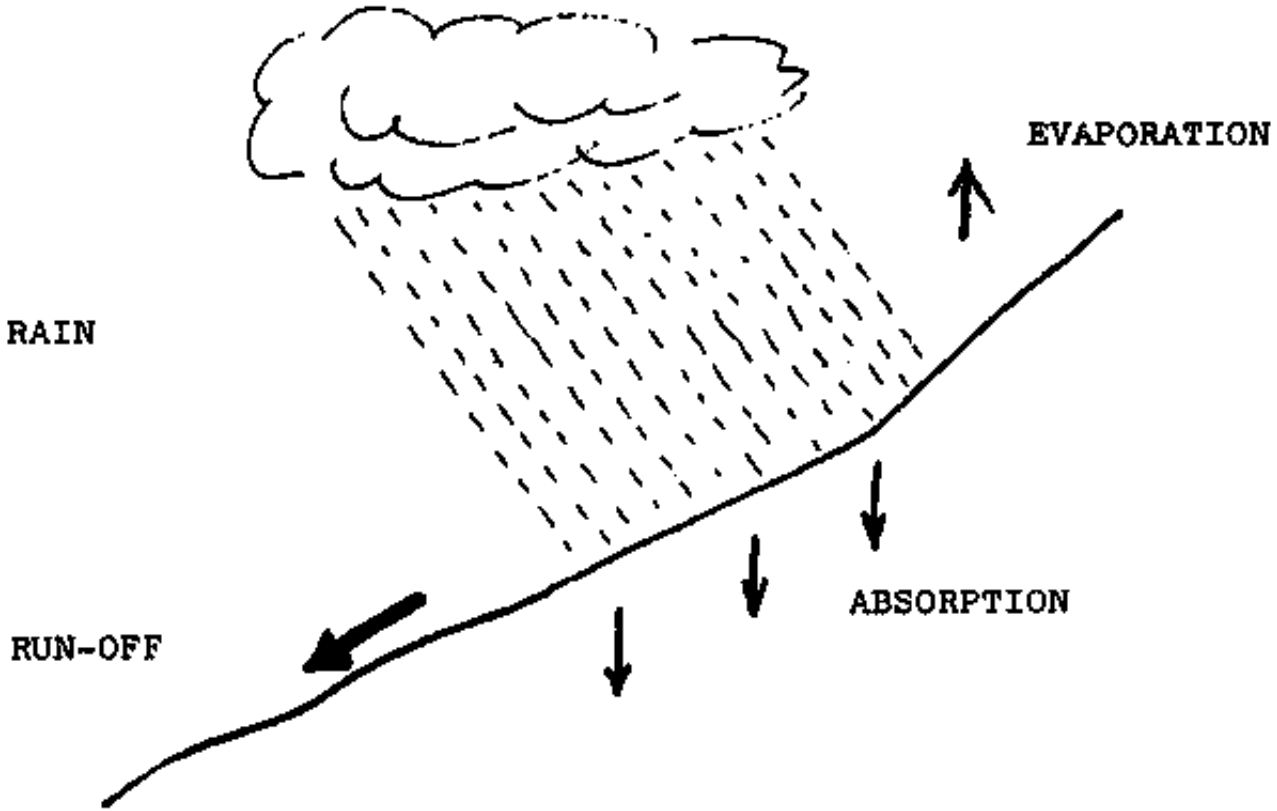


SOIL CROSS-SECTION

The type of EROSION we will deal with here is that caused by water. Other types of erosion exist, in particular WIND EROSION, which is the result of the wind

carrying away the topsoil.

Water-induced erosion is brought about by rainfall.



Figure

Rainwater falls onto the surface of the soil and follows one of three courses:

1. Part of it evaporates, the wind and warmth of the sun turning it into water vapour.

2. A certain amount of rainwater is absorbed by the soil.

3. The rest runs off over the surface of the soil.

It is this third course, the run-off of excess rainwater, which gives rise to erosion.

Drops of rain strike the soil, breaking up the particles of soil. Rivulets of rainwater running off over the soil wash these particles away.

Continuing its course, the water will carry away particles from the soil it runs over. The stronger the flow of run-off, the greater the quantity of soil washed away.

However, water does not run off everywhere in the same way or at the same rate. Therefore, in order to control erosion resulting from the run-off of rainwater over the soil, the exact causes of this erosion must be known.

An increased flow of rainfall run-off over soil may be due to:

the climate: heavy rain falling on soil which is already saturated will result in an increased flow.

the slope of the land: the rate of water run-off is greater over steep land than over gently sloping land.

the absence of vegetation: grass, trees and certain crops protect the soil from the impact of drops of water and slow down the flow of run-off; in addition, their roots help to hold the soil together.

the nature of the soil: clay soils are less permeable and lead to a greater

flow of run-off water than that occurring over sandy soil where more water is absorbed.

More often than not, Man himself, without realising it, is responsible for erosion. There are several reasons for this:

- the clearing of forests for firewood;

- the overgrazing of pastureland;

- bushfires;

- unsuitable farming techniques, such as ploughing in the same direction as the slope;

- the overworking of land through intensive cropping and reduced fallowing, i.e. the amount of time during which land is left uncultivated.

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2. How to recognise erosion

A farmer is often unaware that his land is suffering from the effects of erosion. By the time he is forced to abandon a field through poor yields, and a great deal of arable soil has disappeared, it is often too late to restore what has already been lost.

With this in mind, warning signs must be recognised early on in order for the control of erosion to be effective. These signs are:

- **poorer crop yields;**
- **channels becoming visible on the soil's surface;**
- **the formation of small gullies;**
- **the build-up of sediment in the thalwegs.**

HOW CAN EROSION BE STOPPED?

We have seen how erosion is due to the force of water flowing over the soil's surface. The rate of erosion becomes greater as the volume and speed of the water flow increase.

For erosion to be controlled, therefore, three principles must be applied:

REDUCTION OF THE SPEED AT WHICH THE WATER FLOWS
ABSORPTION OF THE WATER
DIVERSION OF EXCESS WATER

To REDUCE THE RATE OF RUN-OFF, obstacles must be created along the surface of the soil to stop the flow temporarily.

The strongest rate of run-off is to be found on steep bare land where there is no vegetation.

The speed of overland run-off is slowed down by vegetation and by appropriate structural improvements, such as contour ploughing.

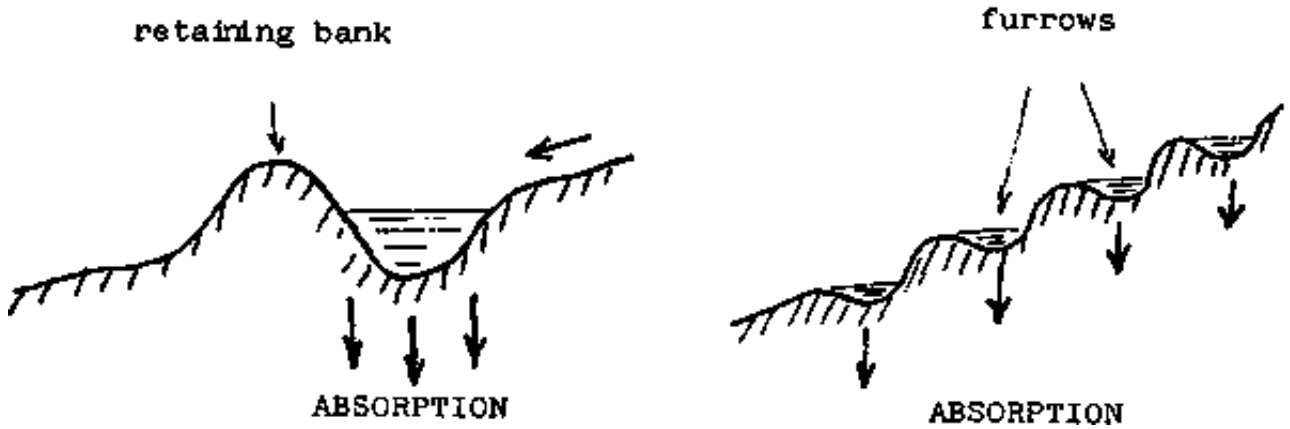
ABSORPTION OF THE WATER

Structures which reduce the speed of run-off water also encourage more water to be absorbed by the soil. With an increased volume of water infiltration, the quantity of run-off water is reduced and, consequently, also the rate of its flow.

On land which is very permeable, where water is easily absorbed, RETAINING

RIDGES are constructed to allow total infiltration of the water.

Where land is much less permeable, the same structures are used to retain the water for as long as possible but with the addition of a waterway to divert part of the surplus water.



Figure

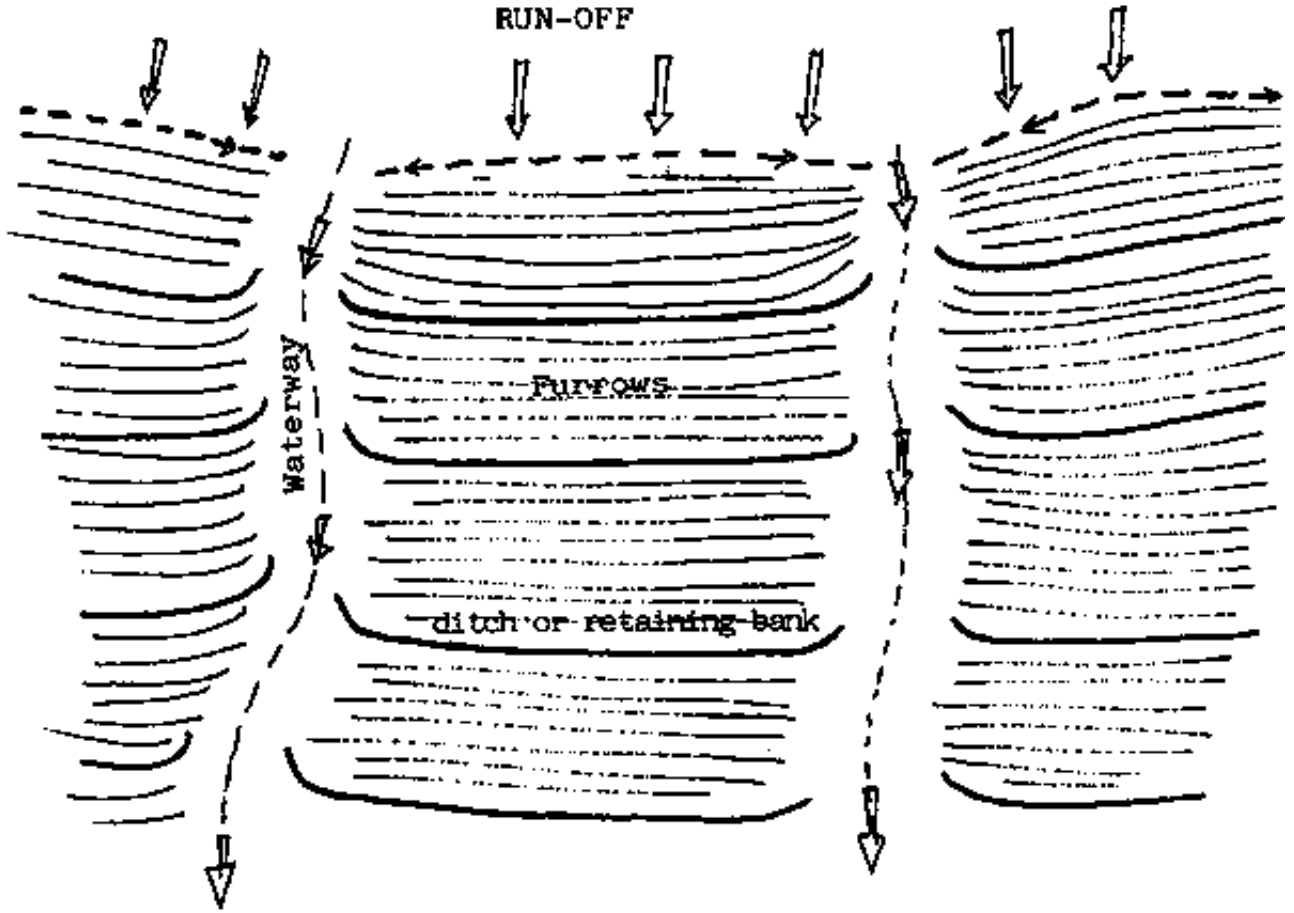
The earth at the base of the ditch must first be loosened with a pick-axe to facilitate the infiltration of the water.

DIVERSION OF EXCESS WATER

When rainfall is heavy, the continuous flow of run-off water cannot be totally absorbed, but must not be allowed to overflow the ditches as this would cause damage to the structures (holes, ravines, destruction of ridges, crop damage).

Precautionary measures must, therefore, be taken in the form of outlet channels where the surplus water can flow away. These are known as WATERWAYS. Generally, natural waterways are used - low-lying areas (thalwegs) where water

naturally flows. These waterways must first be improved, however, otherwise the increased volume of water they have to carry may give rise to erosion.

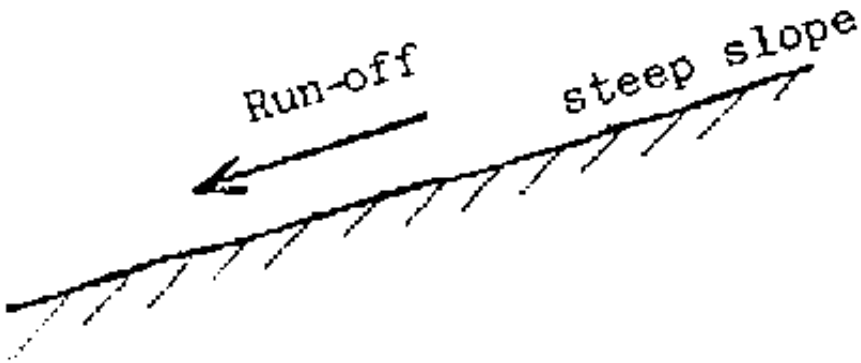


Figure

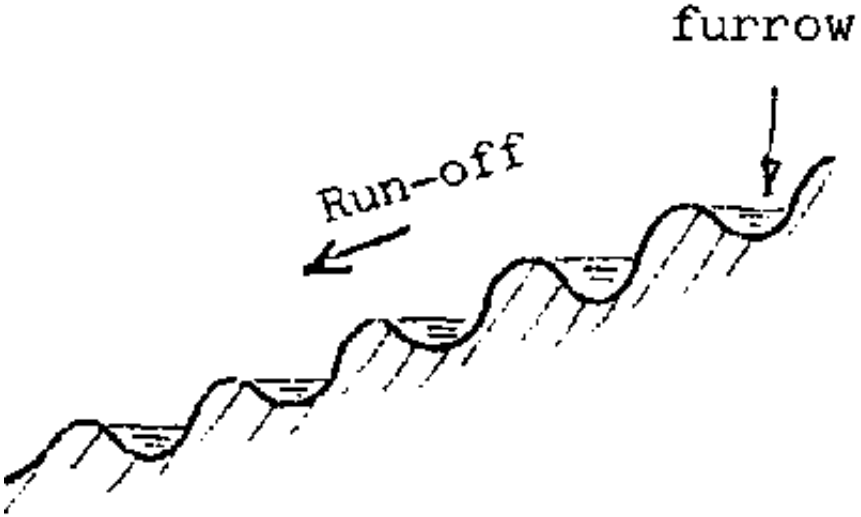
ANTI-EROSION MEASURES

Ploughing and crop-tilling following the contour line of the slope reduce the flow of water and encourage its infiltration. Ditches and ridges built along the contours stop the flow of water and allow it to be absorbed. Waterways and channels divert

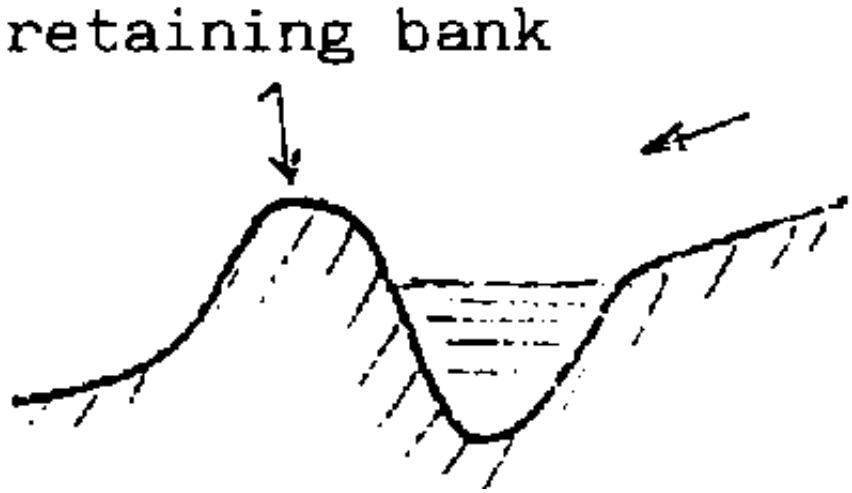
excess water.



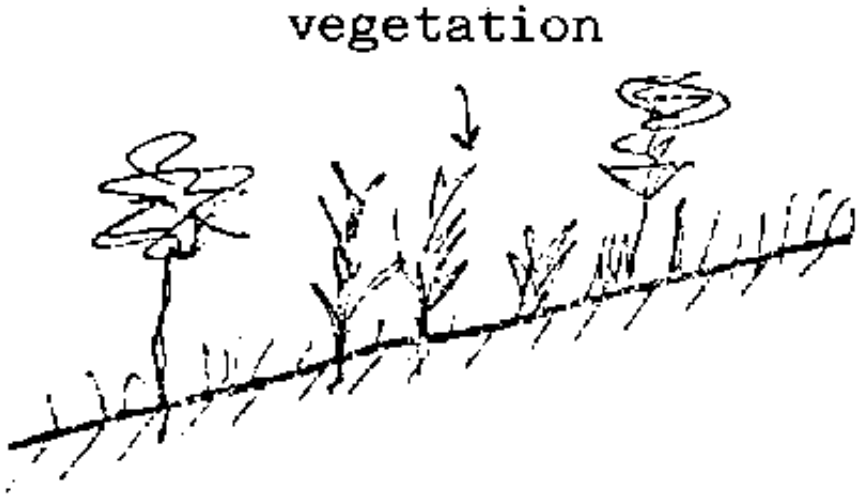
STRONG FLOW



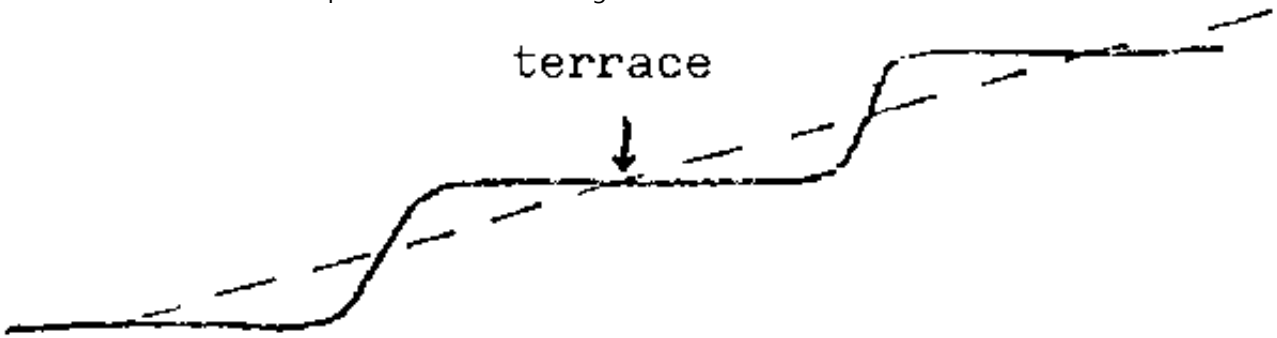
REDUCED FLOW - By contour-ploughing



REDUCED FLOW - By retaining ridges



REDUCED FLOW - By vegetation



REDUCED FLOW - By reducing the slope (terracing)

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- **3. Different types of anti-erosion ditches**
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3. Different types of anti-erosion ditches

There are many types of anti-erosion ditches and ridges. The engineer will decide which type is most suitable for the land in question. In deciding, he will take into account:

- **rainfall intensity;**
- **the nature of the soil;**
- **the slope of the land.**

The choice of ditch is not necessarily final and can be modified to take local experience and opinion into consideration.

Without going into detail on the choice of structure, a few basic considerations must be observed.

The choice of structure depends above all on:

- **the slope of the land;**
- **the permeability of the soil;**
- **the use to which the land is put (type of crop).**

Steeply sloping land (greater than 25%)

This type of land is primarily pastureland or forest. On land such as this, the purpose of anti-erosion structures is to protect the cultivated land which lies below. The appropriate structures here are ditches or terraces, in conjunction with tree plantations or silt catchment pits.

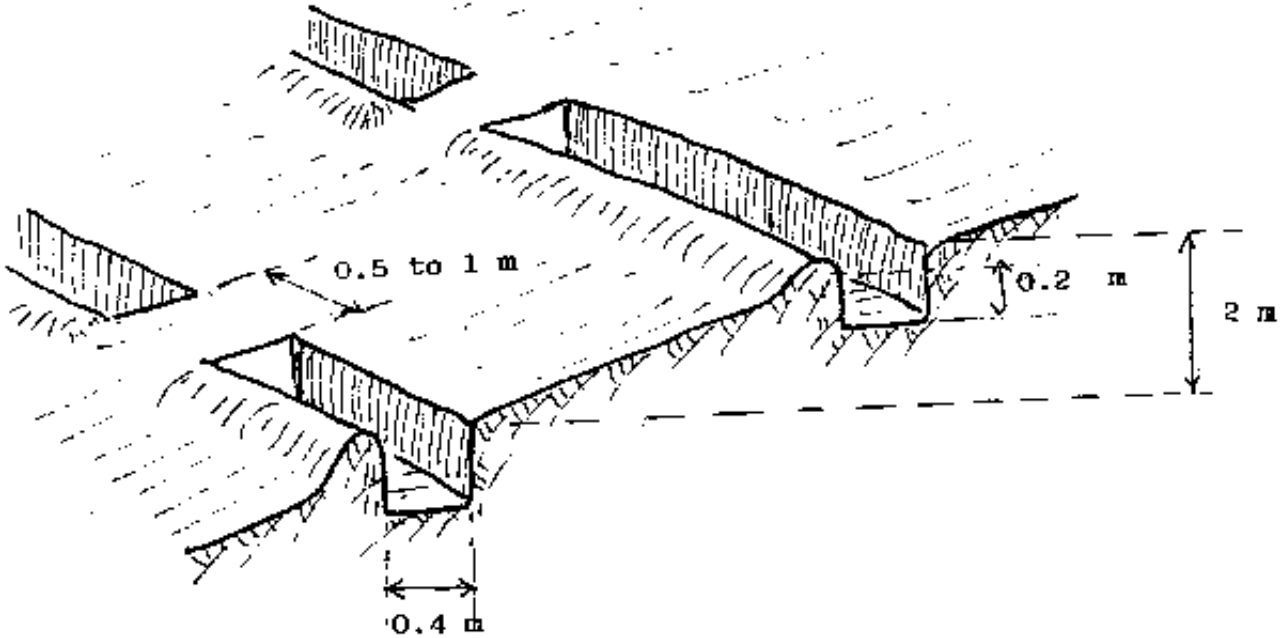
3.1 Silt catchment pits

The purpose of this type of ditch is to stop the flow of overland run-off water and allow it to be absorbed by the soil; in addition, the sediment carried by the water is collected by the pit.

These are protective structures which are located uphill from cultivated land.

They are rectangular sections, 40 cm wide, 20 cm deep and between 3 to 25 m in length and are dug along the contour line with 2 m of levelling between each ditch.

The ditches are blocked off in a zigzag pattern by a mound of earth 50-100 cm wide every 3 to 25 m to provide a path for men and animals.



SILT CATCHMENT PITS

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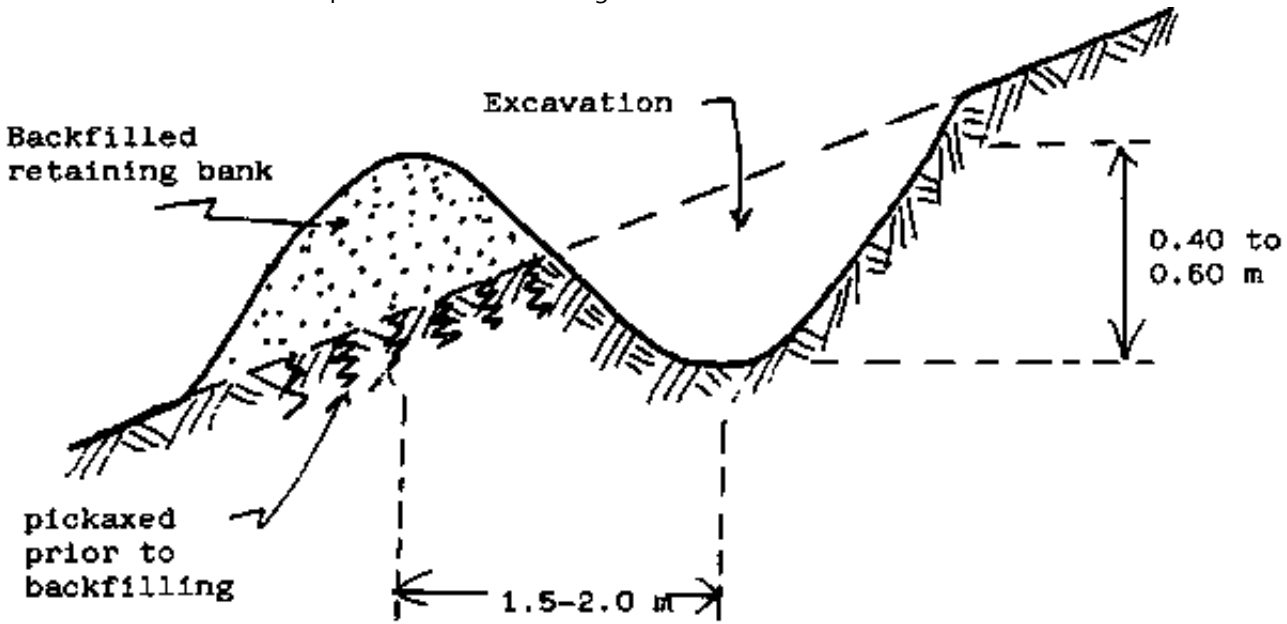
3.2 Forest tiering

This kind of tiering is used on steep ground to allow plantations to be established.

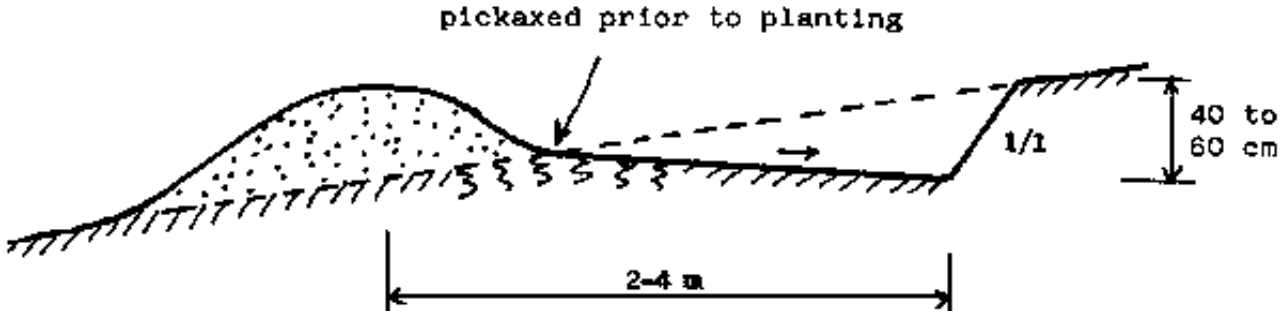


Figure

The ditch, which is dug uphill from the retaining ridge, allows the water to be absorbed by the soil.

3.3 Forest terracing

This system is used on slopes of between 15% and 20%. Fruit trees may be used for the plantation at the base of the ridge.



Figure

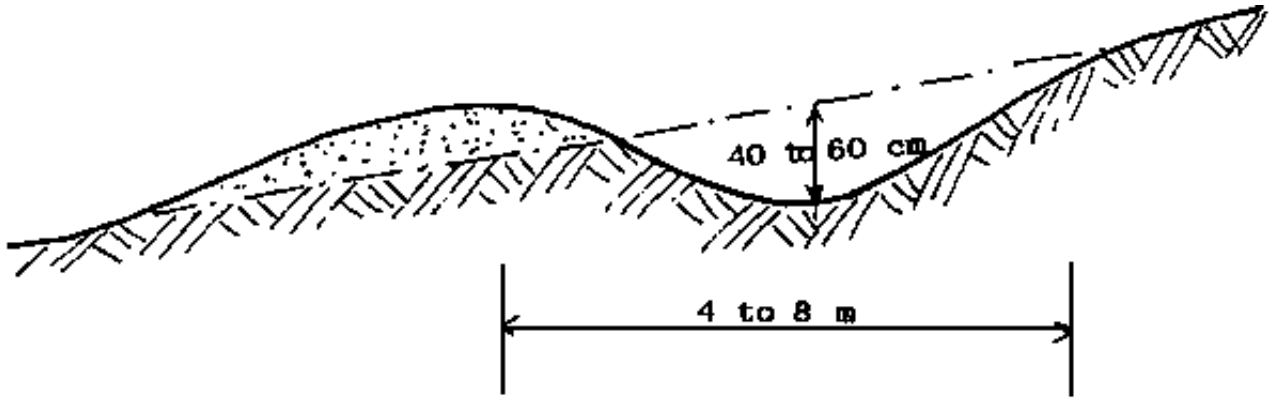
3.4 Cropping terraces

These should be built on slopes of less than 15%. The gentleness of the slope they form (flattened cross-section) means that farm machinery has easy access to the land.

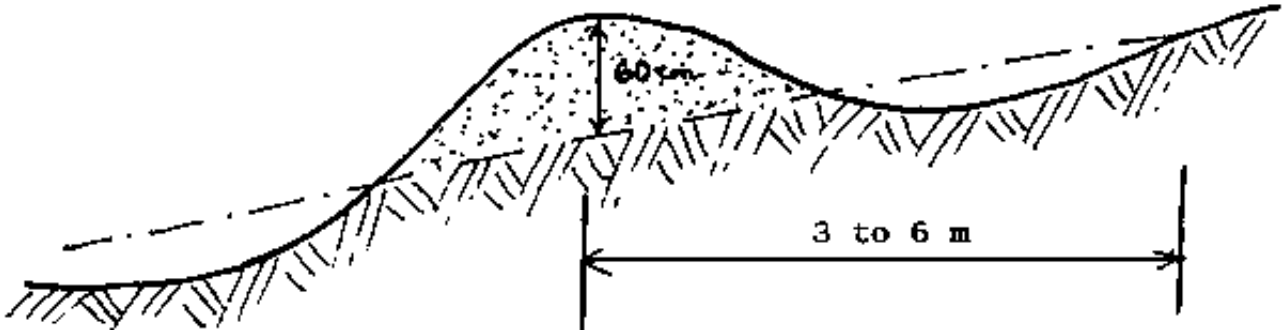
There are two main types of cropping terrace:

Channel-type terraces where the ditch is deeper that the hump is high and is used to divert the water.

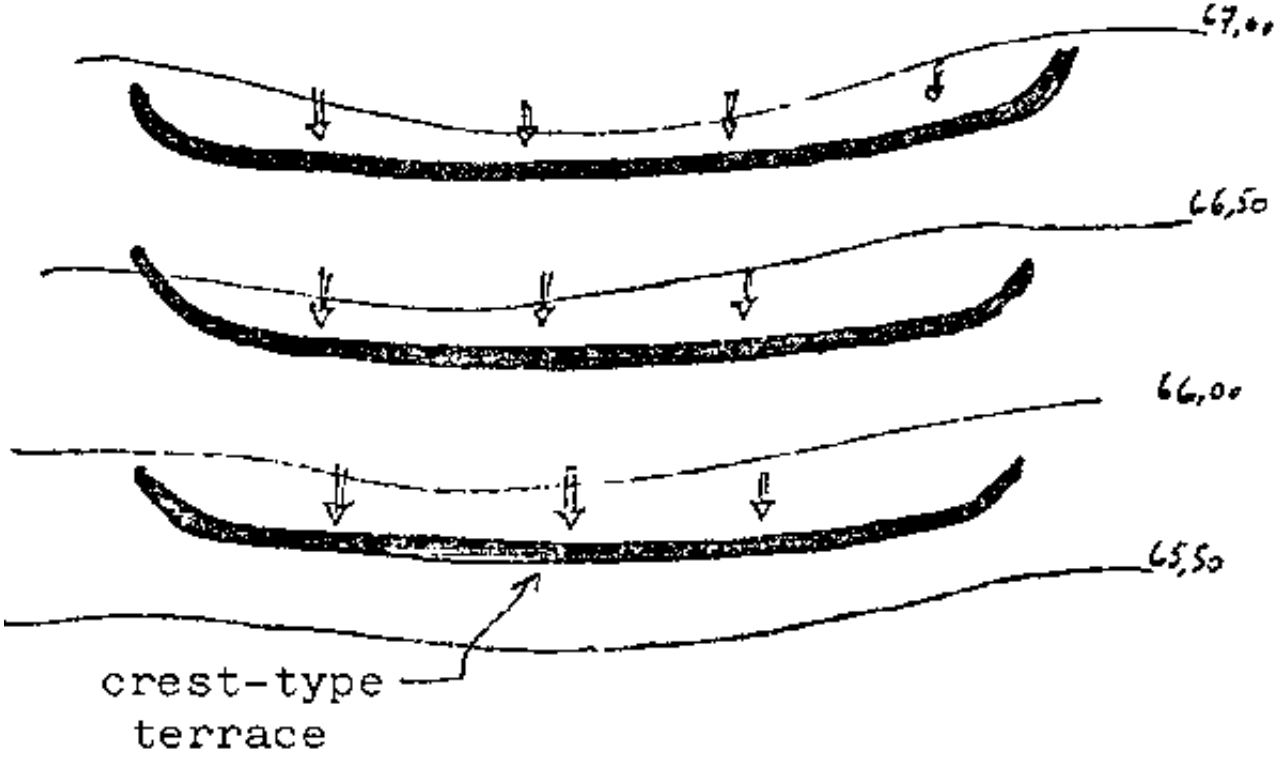
Crest-type terraces where the hump is raised and the ditch shallow so that the water is retained and absorbed.



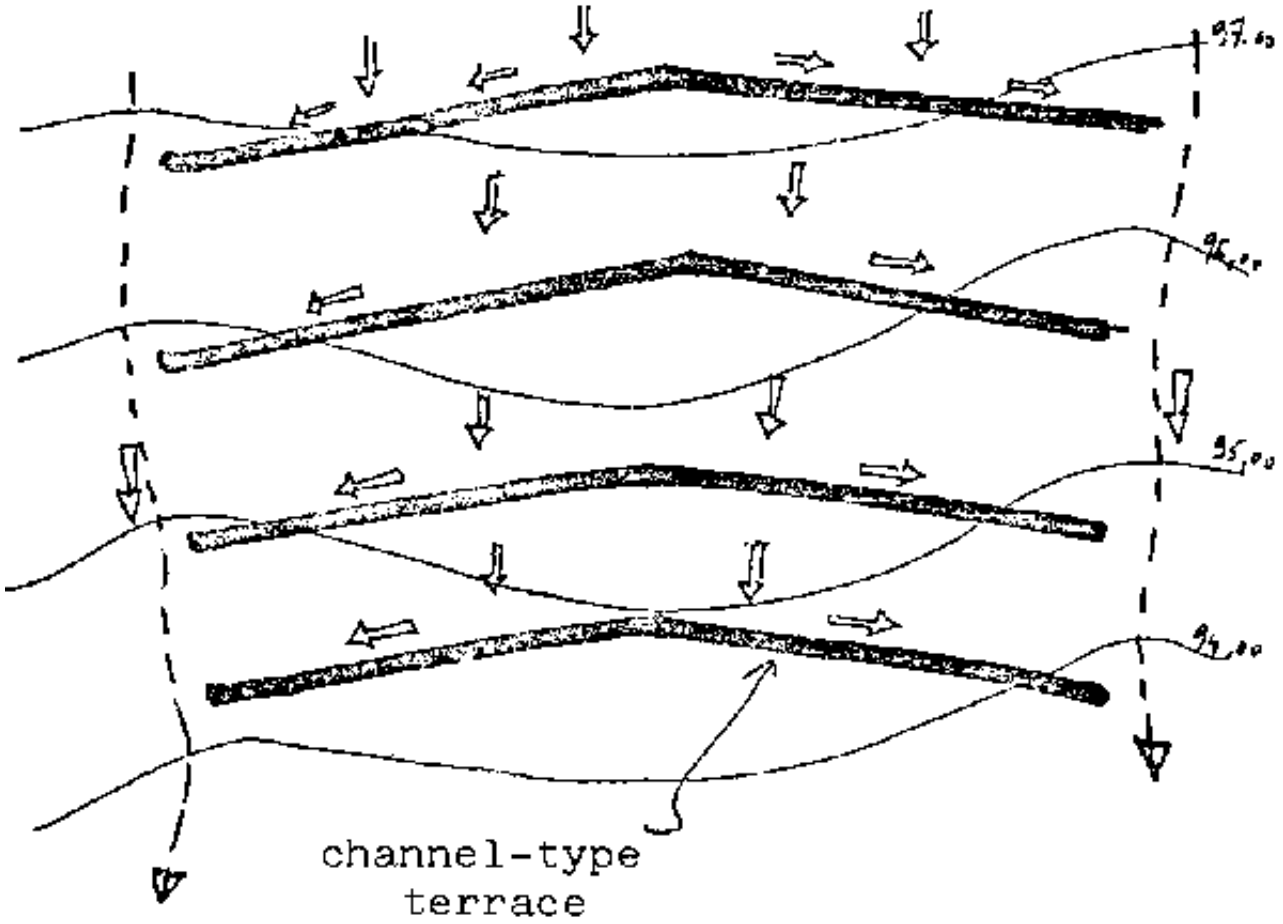
CHANNEL-TYPE TERRACE



CREST-TYPE TERRACE



ABSORPTION NETWORK



DIVERSION NETWORK

CHOICE OF STRUCTURE

NATURE OF THE SOIL	SLOPE		
	GENTLE	MEDIUM	STEEP
SAND	Crest-type terrace	Forest tiering	Silt catchment ditch
CLAY	Channel-type terrace	Normal-type terrace	Forest tiering

CLAY	Channel-type terrace	Forest tiering	Silt catchment ditch
		Normal-type terrace	Forest tiering

SOME RULES FOR THE DESIGN OF DITCHES

Length of terraces: 200-400 m
Longitudinal slope: 2/1000 maximum
Difference in level between two ditches: 0.60-2.00 m

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4. Worksite organisation
(introduction...)
4.1 Good management of the workers

4.2 Good selection of tools *(introduction...)*
4.2.1 Surveying Instruments
4.2.2 Tools used in the digging of ditches

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4. Worksite organisation

Worksite organisation implies a good management of the work force and the selection of suitable tools.

4.1 Good management of the workers

Erosion control works undertaken within the scope of SPWPs are of direct benefit to the community. The works must be carried out correctly and overseen by skilled supervisors who will be able to give the benefit of their knowledge and experience to the groups of farmers or villages concerned in the works.

An anti-erosion construction site comprises:

- a site foreman;
- gang foremen;
- unskilled workers.

(1 gang foreman is assigned to every 20 to 30 workers.)

The site foreman is responsible for the siting of the ditches. In addition, he supervises the entire worksite and makes sure the work is carried out properly and in compliance with safety regulations.

Before work is commenced, the site foreman and gang foremen clearly explain to the workers the different aspects of the task that lies ahead.

During the course of the work, the workers are free to ask questions and make suggestions with a view to improving the constructions.

On site, a choice of two forms of remuneration may be offered:

- daily rate;
- piecework rate.

The piecework rate applies when a worker is paid for a clearly-defined amount of work or "task". The worker is paid upon completion of the task, regardless of time taken. The piecework rate system is well-adapted to ditch construction.

SITE FOREMAN

SURVEYING TEAM

1 GANG FOREMAN
Workers trained in the making of posts
Workers trained in surveying

TERRACING TEAM

1 GANG FOREMAN
20 to 30 workers

BACK-UP TEAM

Transport of water
Repair of tools

PLANTATION TEAM

1 GANG FOREMAN
20 to 30 workers

4.2 Good selection of tools

Three types of tool are required in the construction of ditches:

- those which are used in the measurement of distance and slope. These tools enable us to determine the right location for the ditch and are known as SURVEYING INSTRUMENTS;

- those needed for the digging of the trench and backfilling of excavated

materials;

- those necessary to check the quality of the work.

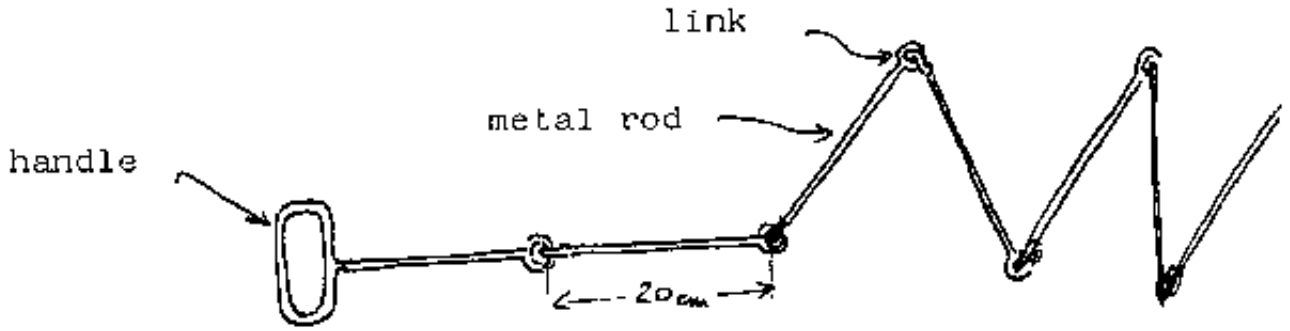
We will deal with each of these tools in turn, giving a detailed description of its use.

4.2.1 Surveying Instruments

(a) The SURVEYING CHAIN AND TAPE MEASURE

These two instruments are used to measure distance over the ground.

The SURVEYING CHAIN consists of a series of linked metal rods, each 20 cm long, giving the chain an overall length of 100 m. A handle at each end allows two workers to extend the chain over the ground to be measured.



SURVEYING CHAIN

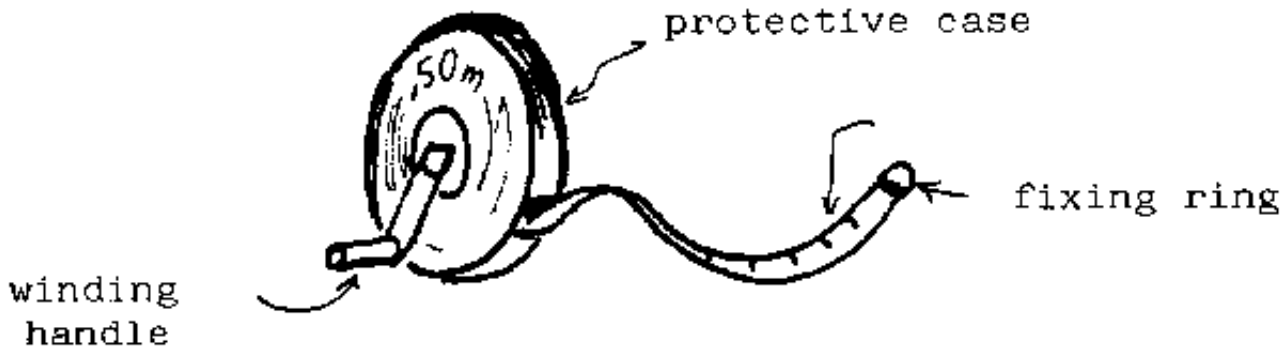
The use of the TAPE MEASURE is becoming more and more widespread and is fast taking over from the surveying chain.

It consists of a reinforced graduated tape, supple enough to be wound up inside its hard protective case.

The tape is marked off in centimetres, metres or decametres.

TAPE MEASURES are available In varying lengths

- **2 metres;**
- **10 metres, or 1 decametre;**
- **20 metres, or 2 decametres;**
- **50 metres, or 5 decametres.**



TAPE MEASURE

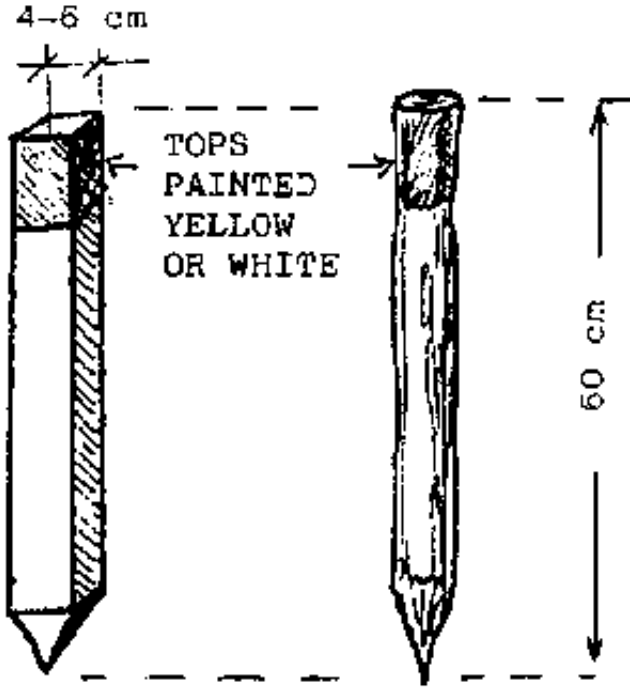
(b) BENCHMARK POSTS

Benchmarks are put in place to mark the location of the ditch and its different measuring points.

These marks assist us in determining the exact location for a structure and are represented by posts which are driven into the ground at the appropriate spot.

Two types of post are used:

- **wooden posts;**
- **iron posts.**



WOODEN POSTS

REINFORCED BAR POST

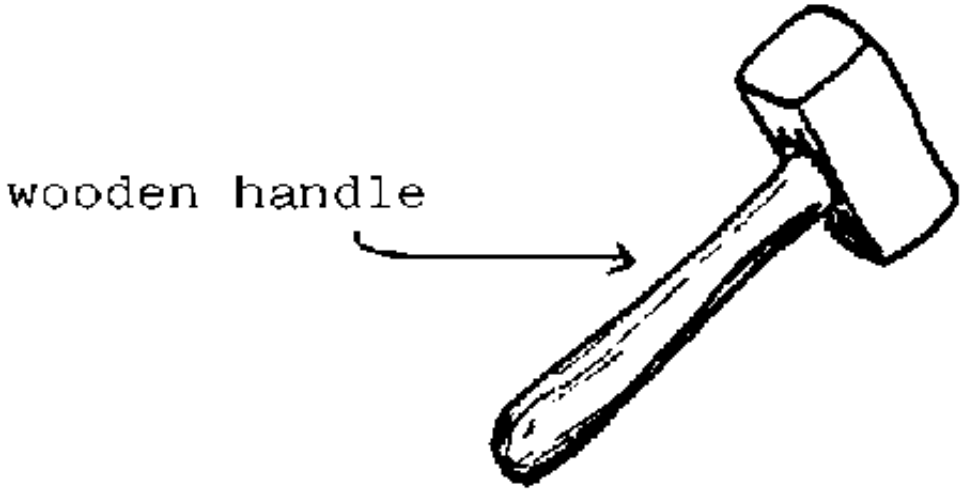
WOODEN POSTS

These are 60 cm long, either rounded or square-edged (4-6 cm sides), with a pointed or sharpened end which makes it easier to drive into the ground where required.

The top of the post is painted with brightly-coloured paint so that the mark is clearly visible.

IRON POSTS are made from reinforced iron bars.

The posts are driven into the ground using a 3 kg sledgehammer and should be driven down to a depth of about 20 cm.



SLEDGEHAMMER

(c) TRACING LINE

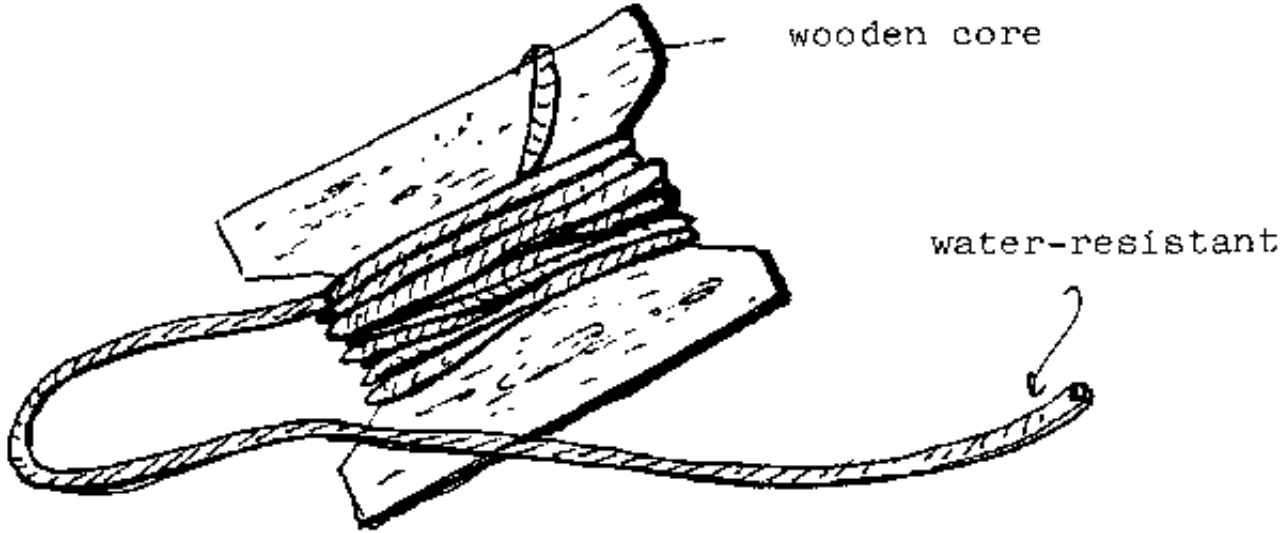
Stretched between two posts, the purpose of the tracing line is to mark out and line up a ditch.

It is made up of:

- a 20-50 m length of 6 mm cord which must be water-resistant. Synthetic cord may be used (nylon or polypropylene);

- a wooden core around which the cord is wound.

If a tracing line is unavailable, string may be used but this has the disadvantage of being both less smooth and less water-resistant and thus less manageable.



TRACING LINE

(d) SPIRIT-LEVELLING BOARD

This is a very simple apparatus but one which is very useful for siting a ditch on flat or gently sloping land.

The slope of land is its gradient. Horizontal land is land which has no slope and thus all parts of it are on the same level.

A spirit-levelling board can be made up by the local carpenter. The basic materials required are:

- **a 6 m length of plank, 20 cm wide and 35 mm thick;**
- **a spirit level;**

- 2 wooden angle pieces, 20 × 20 cm, 35 mm thick;
- steel nails;
- wood screws.

Its use in the siting of a retaining bank following the contour line

- Mark the starting point by means of a benchmark post.

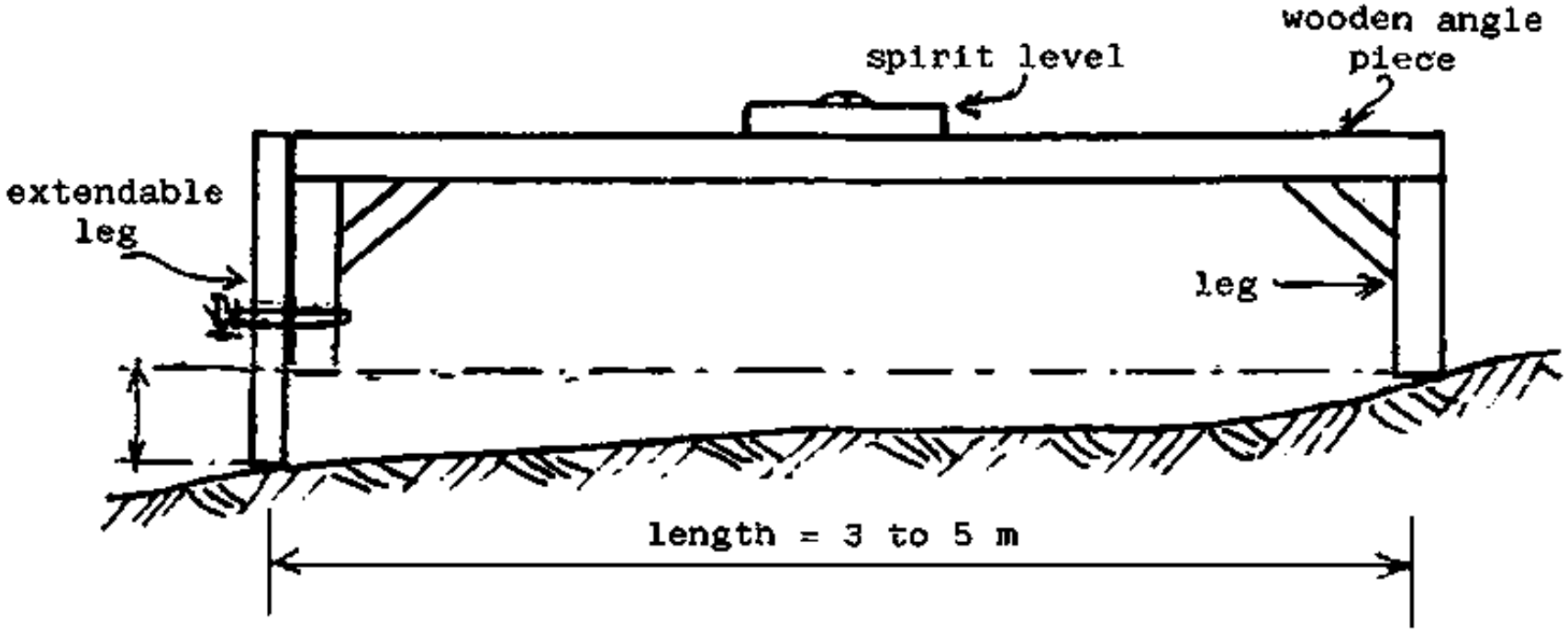
- Place one of the legs of the frame on the starting point.

- Shift the other leg of the frame along the ground until the plank is horizontal (this is checked by means of the spirit level which is fixed to the top of the plank).

- Put a post in place to mark the spot which has been found.

- Repeat the operation to find a third point, a fourth, and so on,

NOTE: Should the retaining bank need to be built with a certain gradient (G), one of the legs of the frame must be extended in height (H) accordingly, so that H/L = G (L being the length of the frame).



SPIRIT - LEVELLING BOARD

(e) FLEXIBLE TUBE WATER LEVEL

The water level enables us to measure the horizontality of a construction.

To make up a flexible tube water level, the following materials are required:

- **a length of small diameter clear plastic tubing (approx. 15m);**
- **two flat-topped wooden staves, 1 m high;**
- **string or iron wire to bind the pipe to the stave;**
- **a tape measure;**
- **a pair of wire-cutting pliers.**

Making up a flexible tube water level

- Make a mark on each of the staves 80 cm from the bottom (check the two against each other to make sure they are identical).

- Place the ends of the plastic pipe level with the top of the staves so that the pipe runs the full length of the staves.

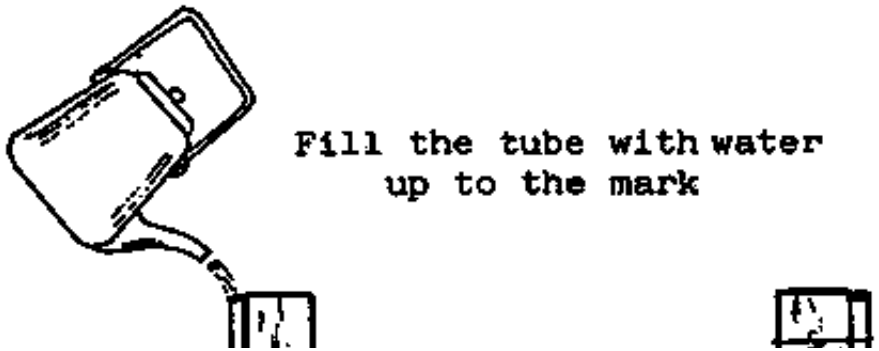
- Attach the tubing to the staves using string or iron wire. Iron wire is more convenient to use as it can be easily manipulated using a pair of pliers.

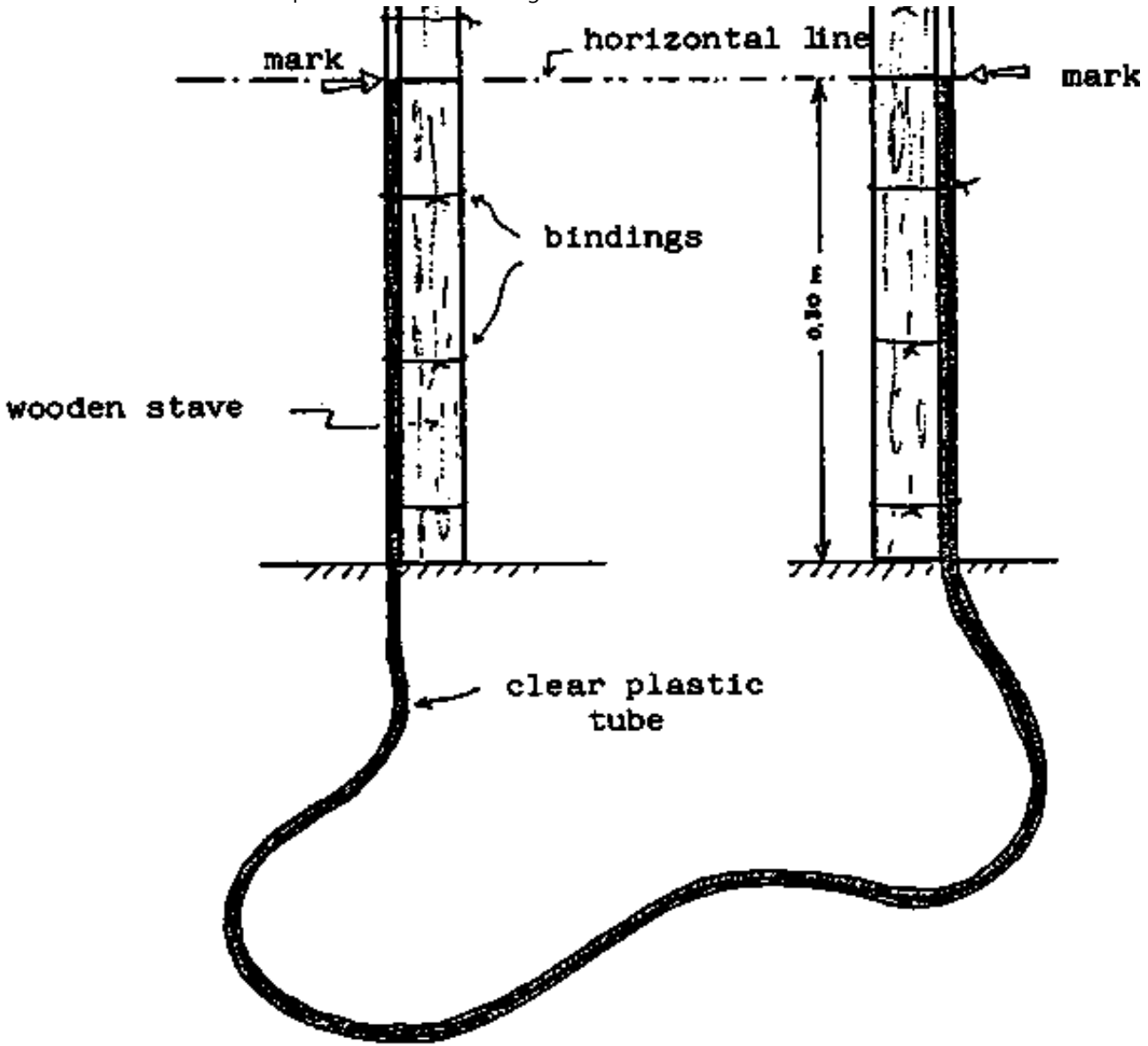
- Once the level has been put together, place the staves side by side, making sure the marks are exactly opposite each other.

- Fill the tube from one end with water until the level of water reaches the marks on the staves.

- Check that there are no air bubbles in the tube.

- The apparatus is now ready for use.





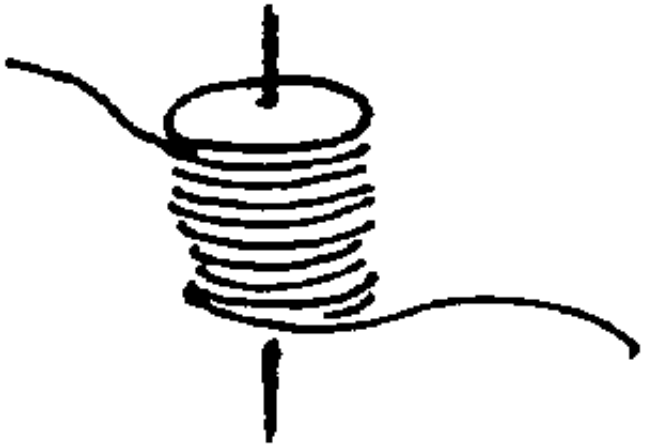
FLEXIBLE TUBE WATER LEVEL

When transporting the level to the worksite, it is easier to empty the pipe of water and refill it on the spot where it is to be used. For this, a supply of water must be provided.

To avoid water being spilt from the tube when the level is being moved about during the course of the work, put a finger over the ends of the pipe. Alternatively, a cork or stopper may be used as long as one remembers to remove them before re-using the level.

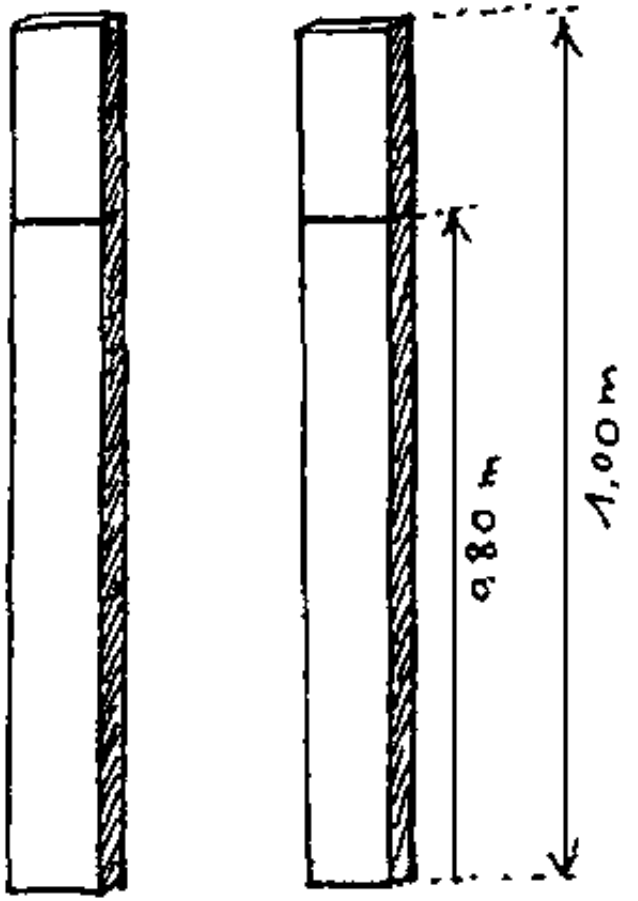
Each time the level is to be used, it is essential to first make sure the water level meets the marks on the staves when the latter are placed at the same height. Add more water if it is required.

Materials needed for assembling a flexible tube water level

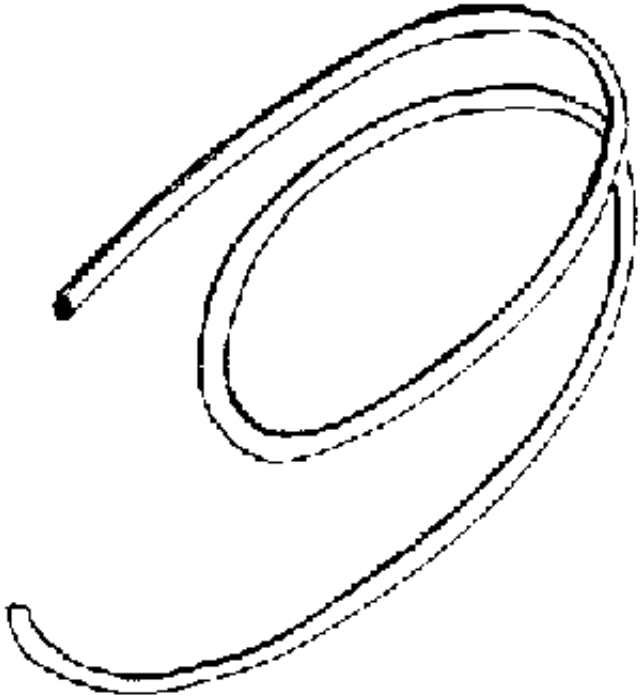


IRON WIRE

PLIERS



WOODEN STAVES



CLEAR PLASTIC TUBING

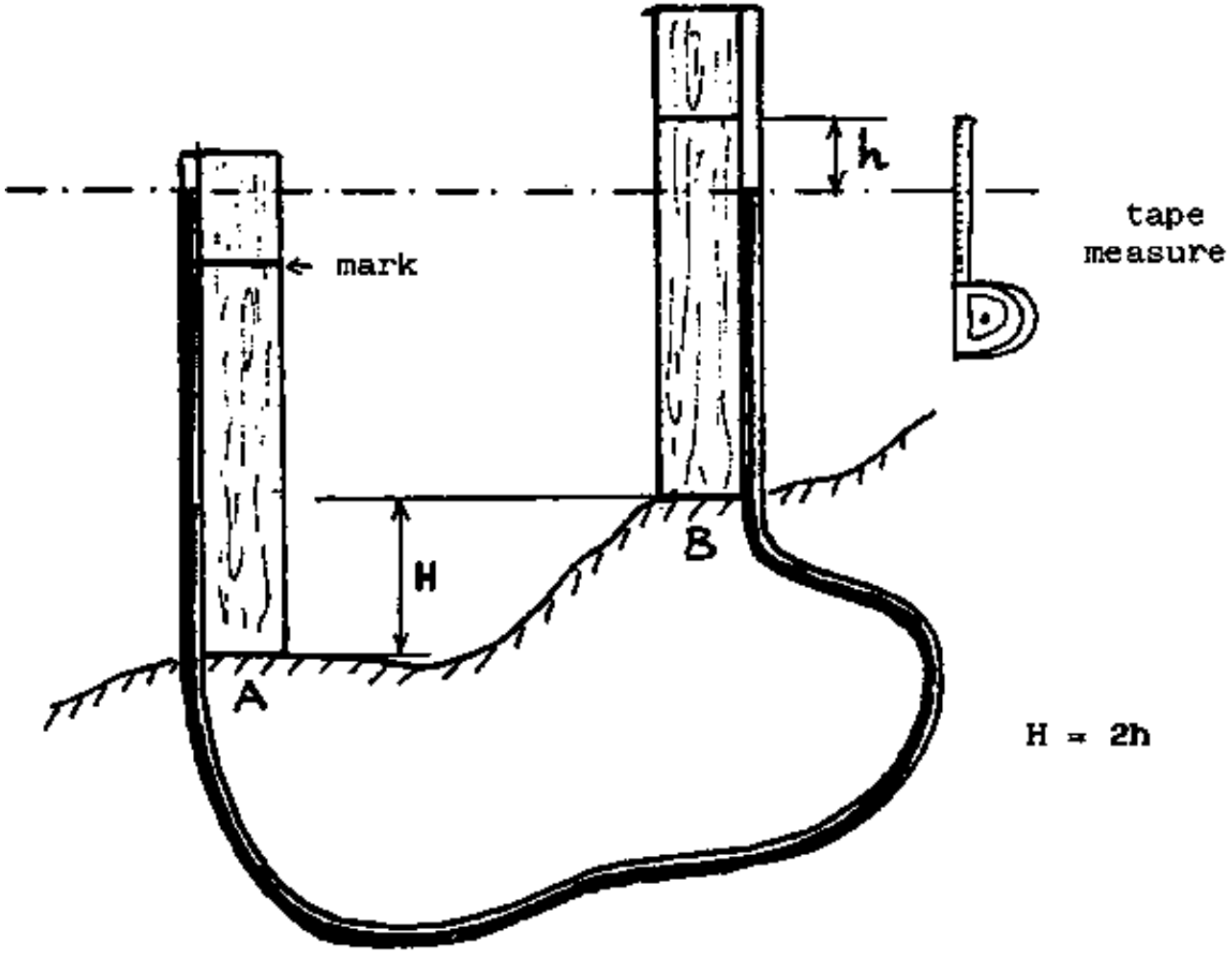
TAPE MEASURE

Use of the water level

A water level is used to:

- measure the difference in level or height between two given points;

- trace out the contour lines of a slope.



MEASURING THE DIFFERENCE IN LEVEL

Measuring the difference in level

To find the difference in level or height between points A and B:

- Place the two staves side by side with the marks exactly opposite each other, making sure the level of the water inside the tube also corresponds to the marks on the staves. If the water level is too high, tip some water out. If the level is too low, add some water.

- Place one of the staves on point A and the other on point B. At the lowest point A, the level of water in the pipe will rise above the mark. At the highest point B, the water level will fall below the mark.

- Using a tape measure, calculate the difference between the water level and the mark on one of the staves.

- The difference in level between points A and B will be equal to twice this difference.

Tracing out the contour lines of a slope

- Put the staves side by side, with the marks on them and the level of the water in the tube at the same level.

- Drive a post into the ground in place of the first stave (A).

- Move the second stave (B), leaving stave A where it is, and place it somewhere else on the slope.

- The water level on stave B is no longer opposite its stave mark.

- If stave B is raised, the water level will fall in relation to the stave mark.

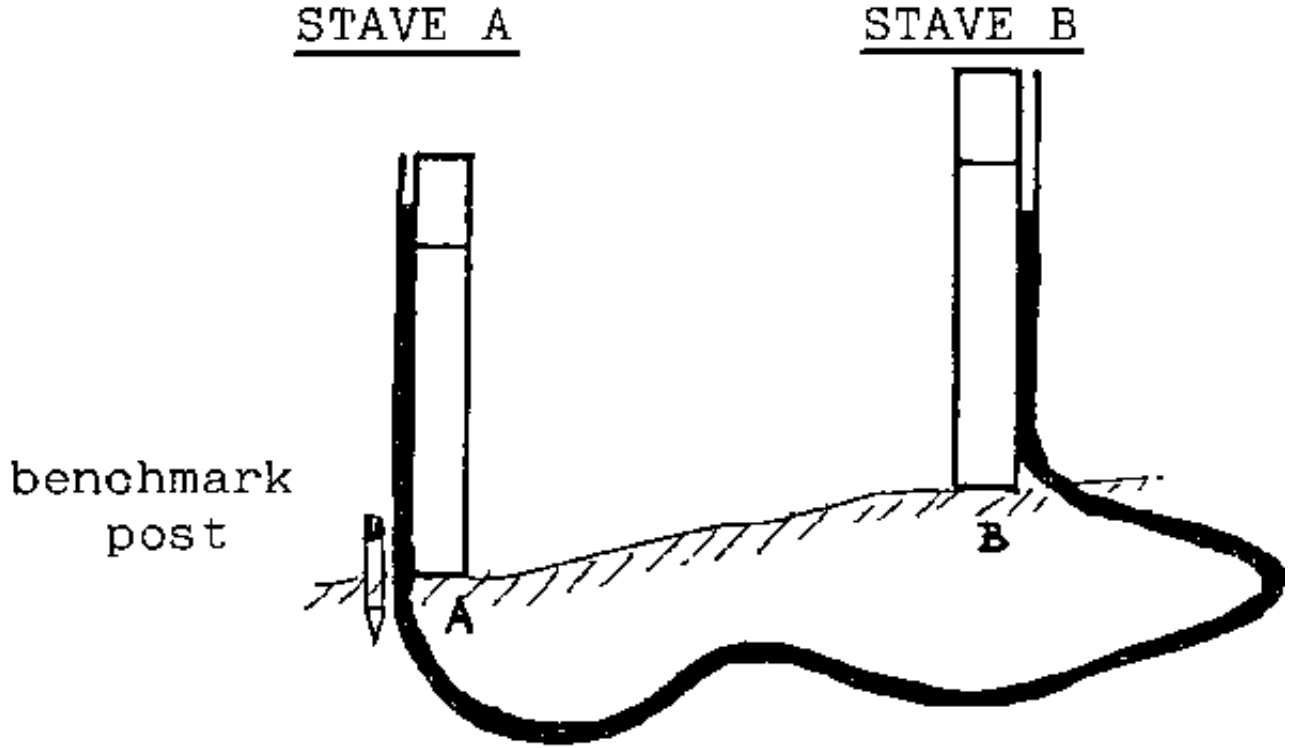
- If stave B is lowered, the water level will rise above the stave mark.

By moving stave B to different locations along the ground, we will discover the place where the two marks meet.

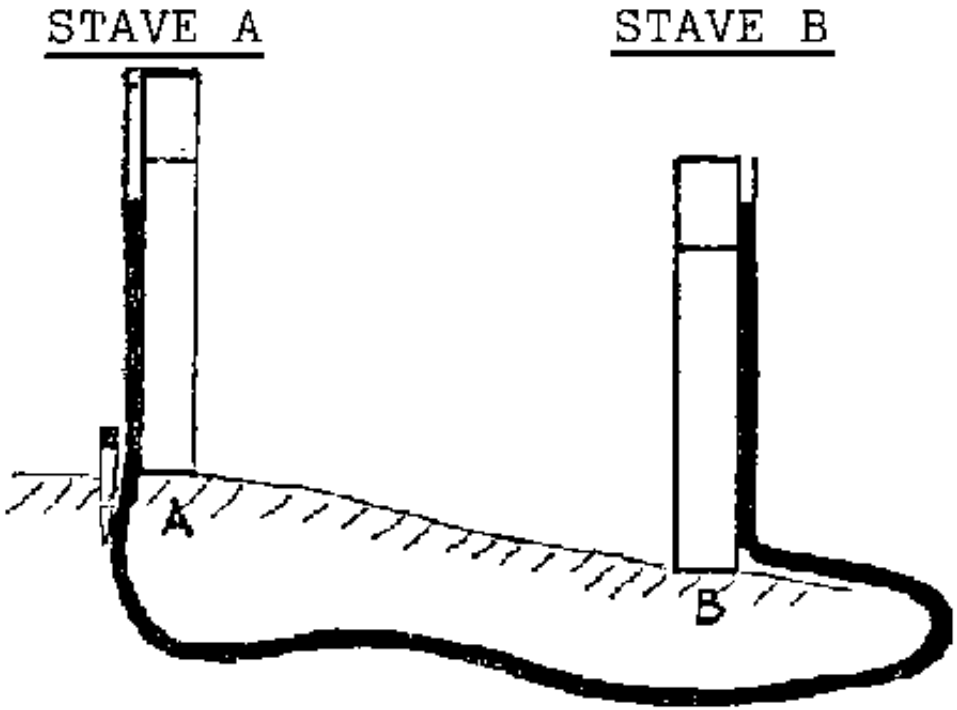
When the water is level with the stave mark, a post is put in place of the stave and this post will thus be on the same level as the first post which marks the place of stave A.

Stave A is then moved to replace stave B and the operation is repeated to locate a third point, C.

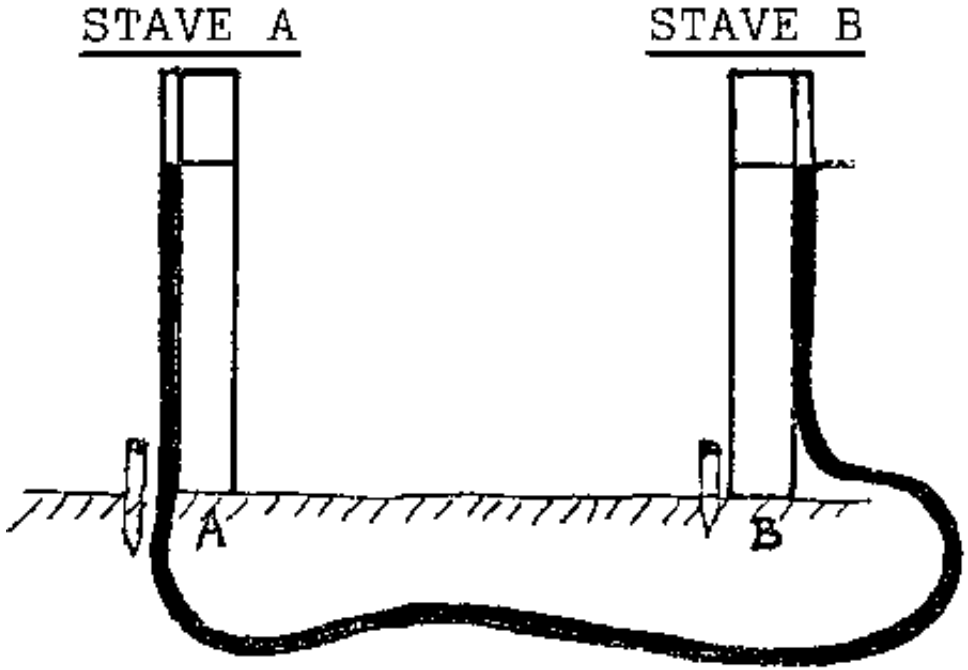
This simple piece of equipment enables us to measure differences in level and to trace out contour lines to an accuracy of 2 cm over 100 m.



POINT B HIGHER THAN POINT A



POINT B LOWER THAN POINT A



POINT B LEVEL WITH POINT A

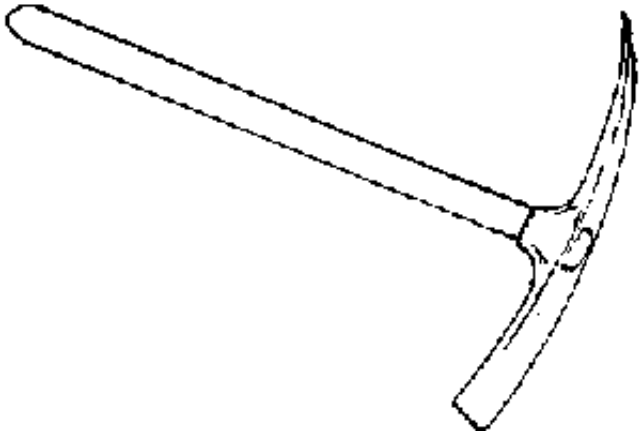
4.2.2 Tools used in the digging of ditches

(a) The PICKAXE

This tool consists of a long wooden handle and a metal head. The metal head is double-ended: one end is pointed and the other is in the form of a wide cutting edge.

The pointed end is used to pierce through the hard surface of the soil and to break up stony ground.

The cutting edge is useful for slicing through roots and for shifting clods of earth.

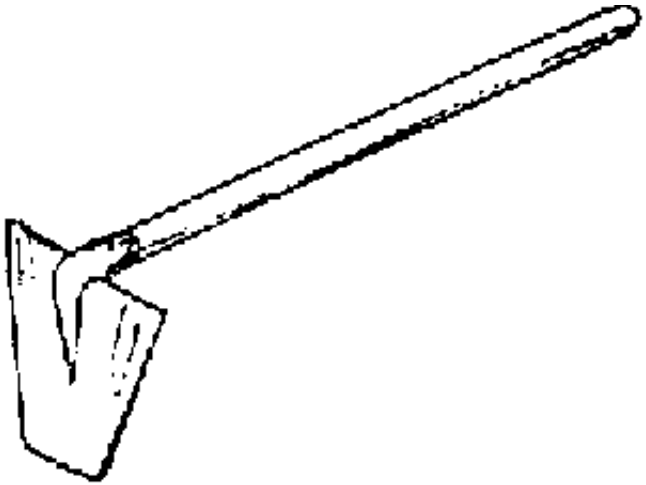


PICKAXE

(b) The DABA (traditional African hoe)

The daba can be used in place of a pick on soft ground.

It is also used to scrape the surface of the ground clear of vegetation.

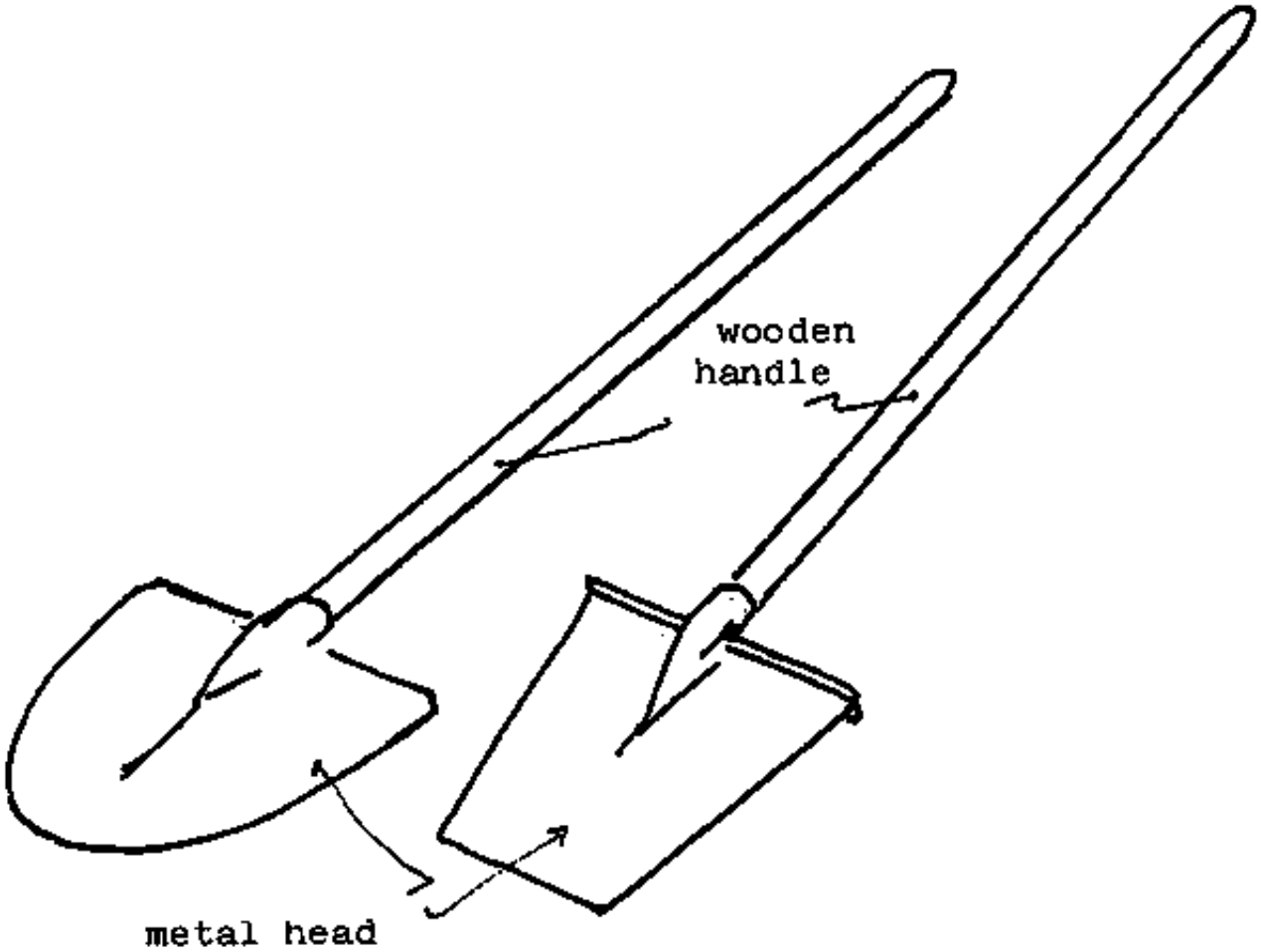


DABA (traditional African hoe)

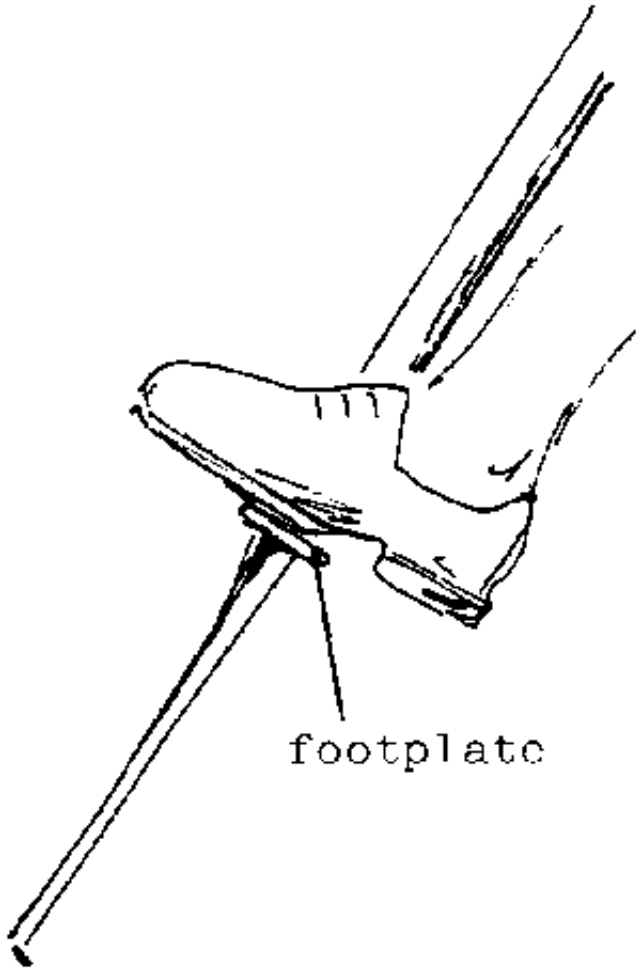
(c) The SHOVEL and SPADE

There are several variations of the basic shovel and spade. The most commonly used for earthworks are the round-mouthed shovel and square-mouthed spade.

This type of shovel is ideal for digging but is ineffective when it comes to scraping flat surfaces. On soft or sandy ground, a square-mouthed spade is equally useful. This latter type has a wide straight cutting edge. A tread is fitted to the top of the metal head to enable the worker to force the spade into the ground with his foot.



ROUND-MOUTHED SHOVEL



SPADE

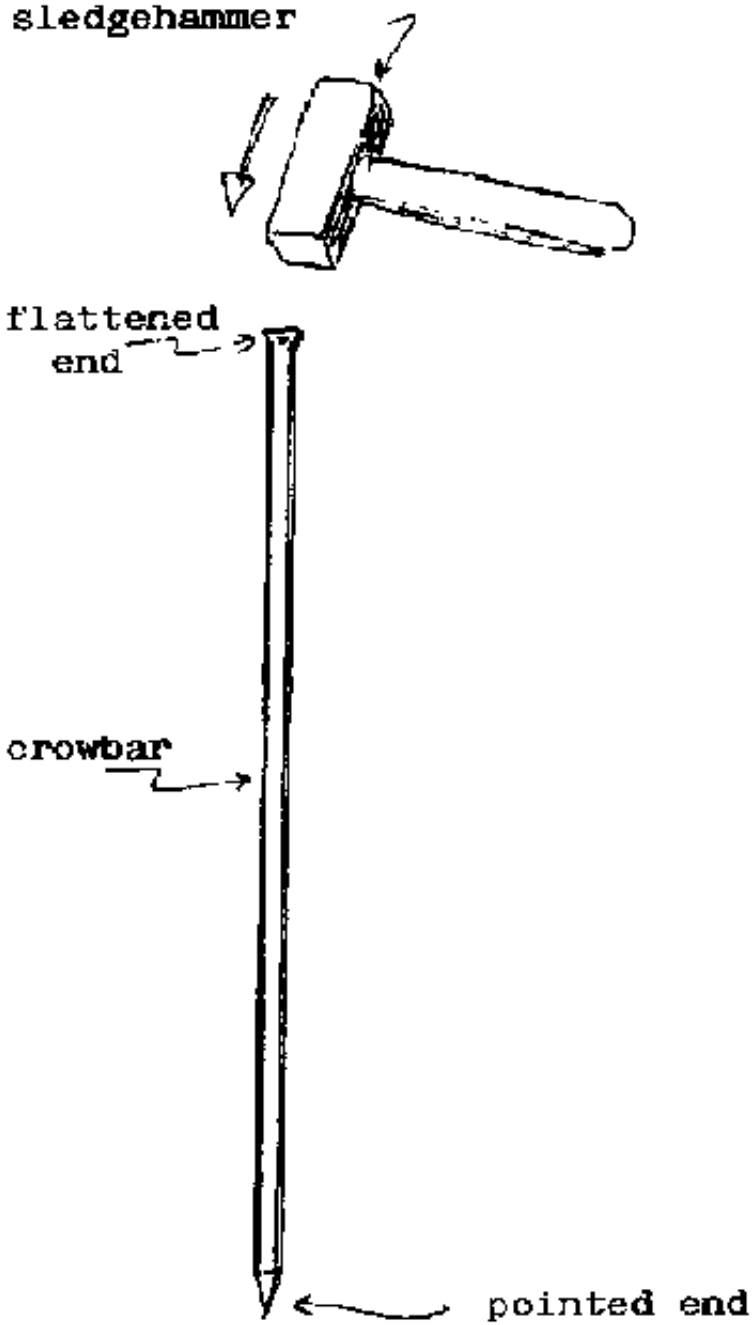
(d) The CROWBAR

This tool is essentially a solid metal bar which is used to penetrate and break up rocky ground.

An improvised crowbar can be forged from a length of 16 mm reinforced iron. One end is pointed to break through rock and the other flattened so that the bar can be

struck with a sledgehammer.

We use the crowbar when the going becomes too difficult for the shovel or spade.



CROWBAR

To break through rock, the following procedure is used:

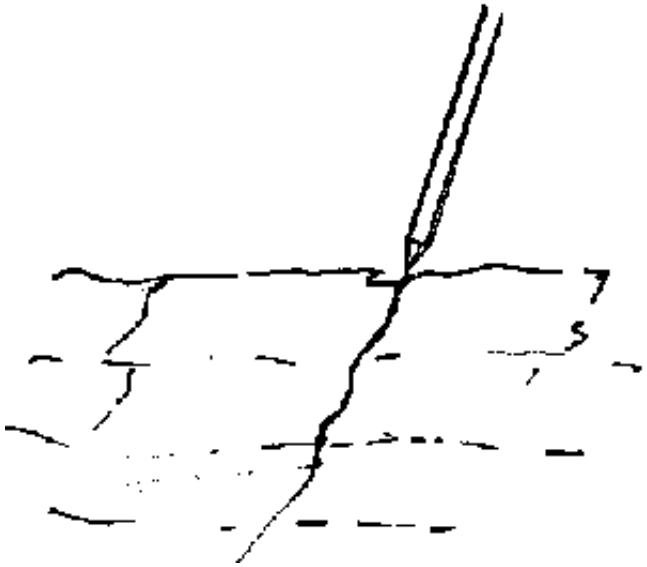
- Select the weaker areas of the rock where cracks are to be found.

- Place the pointed end of the crowbar inside one of the cracks

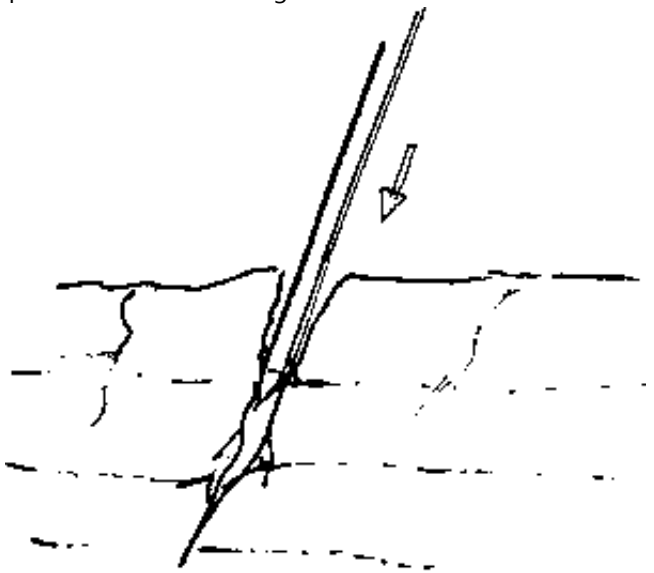
- Force the crowbar into the crack by hitting its other end with a sledgehammer.

- Holding the-top of the crowbar, move it backwards, forwards and from side to side to separate the pieces of rock.

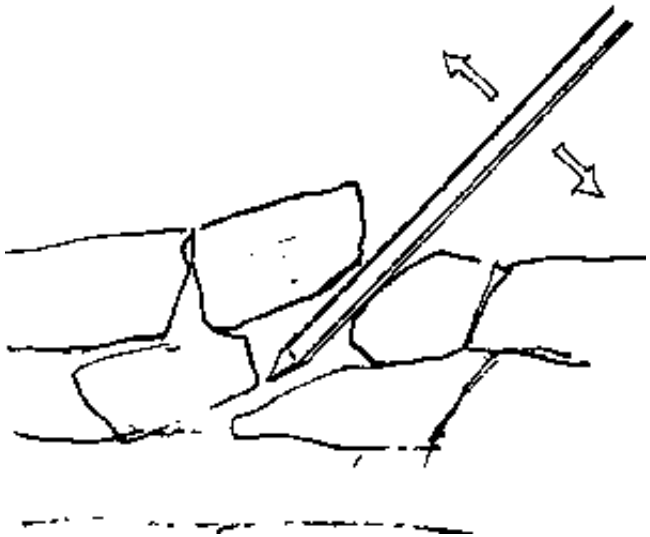
- Remove the loosened pieces of rock.



USING A CROWBAR - 1



USING A CROWBAR - 2



USING A CROWBAR - 3

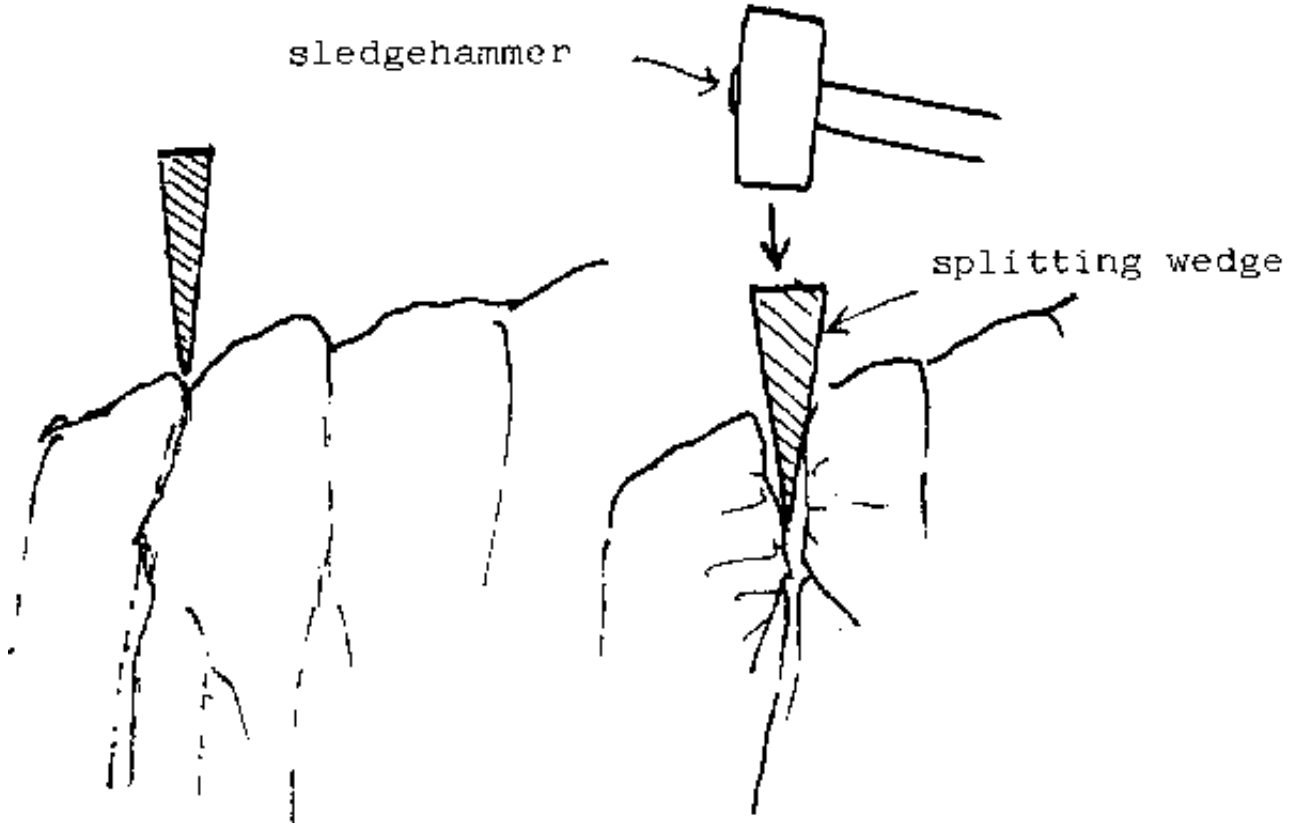
(e) The SPLITTING WEDGE

This is simply a forged piece of metal which is used to break up already cracked rock. It has a pointed side which is wedged into a crack and a flat side which is struck with a sledgehammer.

- Wedge the pointed side into a crack in the rock.

- Strike the flattened side with a sledgehammer in order to widen the crack.

- Clear the rocks away by hand or with a pickaxe.

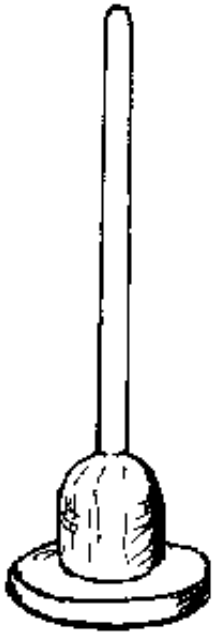


SPITTING WEDGE

(f) The EARTH RAMMER

This tool is made up of a circular plate of metal or wood attached to a 1.30 m long wooden handle.

Its purpose is to pack down the earth: in the context of ditch-digging, it is used more particularly to pack down the retaining banks.



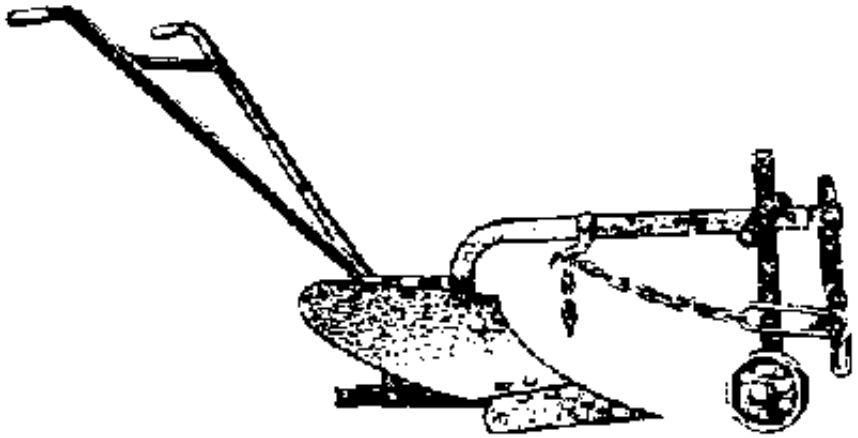
EARTH RAMMER

(g) The PLOUGH

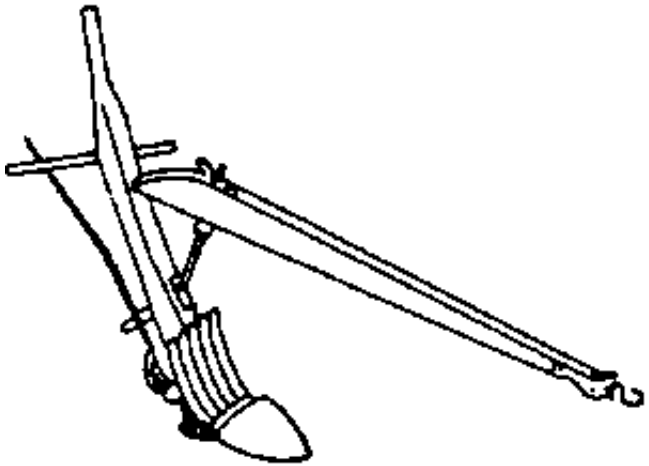
This implement is used to break up and turn over the uppermost layer of soil. A farmer ploughs a field as the initial step towards cultivating the land. The plough can also be employed in the construction of anti-erosion ditches. In the latter context, its role is to break up the soil and render it easier to dig. Ploughs are

drawn either by animals (oxen, buffalo, horses, camels) or by tractor. They may vary in form but the basic implement must include:

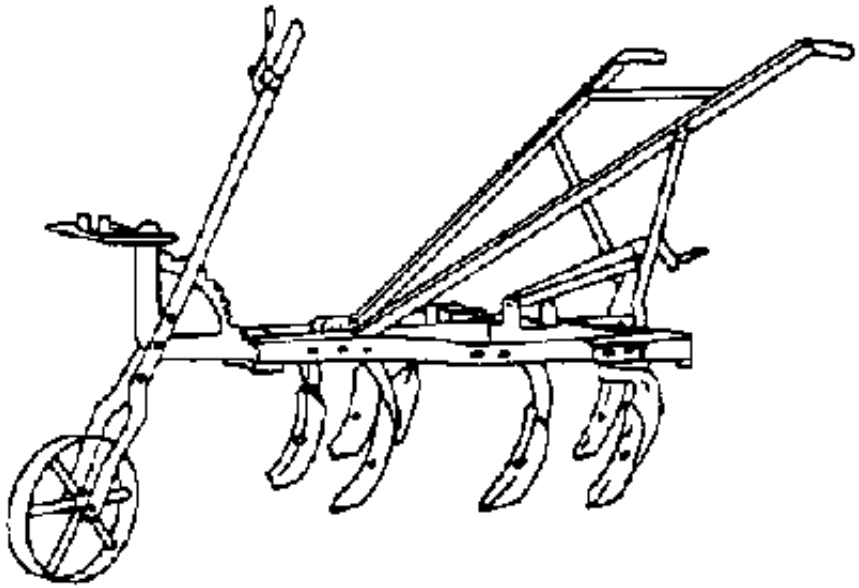
- **a ploughshare which acts as a blade, cutting the turf and turning it over;**
- **two handles with which the operator can steer the implement;**
- **some type of harness or hitch.**



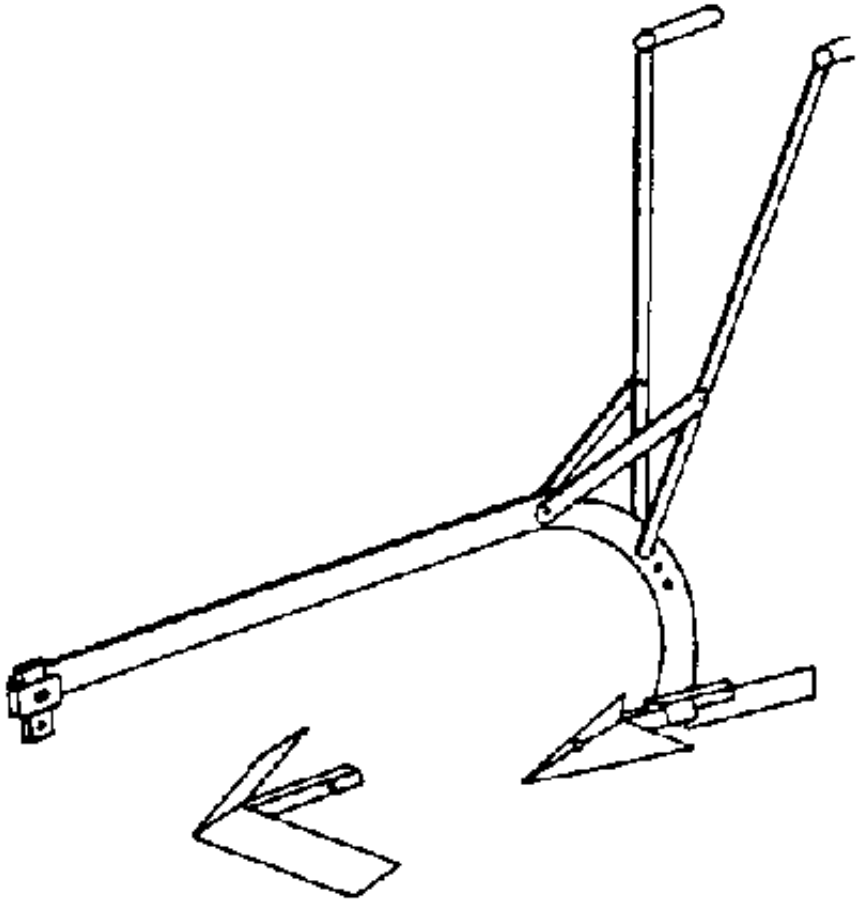
SINGLE FURROW PLOUGH



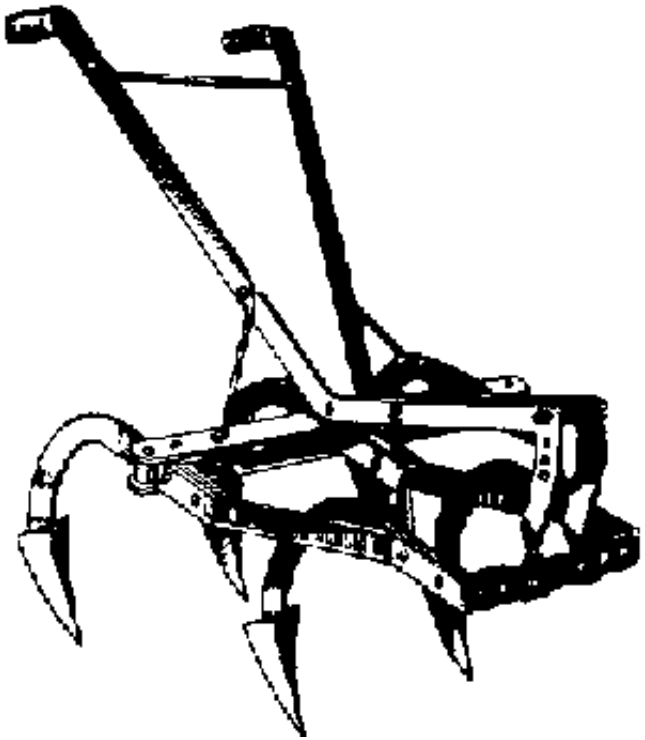
TRADITIONAL ASIAN PLOUGH



CHISEL PLOUGH



SUBSOILER



FIXED-TINE CULTIVATOR

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Special Public Works Programmes - SPWP - Anti-Erosion Ditches - Training Element and Technical Guide for SPWP Workers, Booklet No. 1 (ILO - UNDP, 84 p.)

- 5. Procedure
  - 5.1 Site selection
  - 5.2 Siting of the ditches
  - 5.3 Plotting the dimensions of the ditch
  - 5.4 Preparing the surface soil of the ditch site
  - 5.5 Excavating the ditch
  - 5.6 Checking the dimensions of the ditch
  - 5.7 Constructing the retaining banks
  - 5.8 Checking that the retaining banks are horizontal
  - 5.9 Improving the waterways
  - 5.10 Protecting the slopes

Special Public Works Programmes - SPWP - Anti-Erosion Ditches - Training Element and Technical Guide for SPWP Workers, Booklet No. 1 (ILO - UNDP, 84 p.)

5. Procedure

5.1 Site selection

The choice of site should be determined by the community of farmers, as a whole, with everyone working together to ensure the success of the project.

Work should begin with the protection of the highest-lying fields. Areas will be chosen which, although already suffering from the effects of erosion, can still be cultivated. It is pointless constructing ditches on land where all the topsoil has already been lost through erosion.

It is up to the engineer in charge of the works to advise the farmers on the selection of appropriate sites.

5.2 Siting of the ditches

MATERIALS AND MANPOWER REQUIREMENTS

This important task needs to be carried out by specialised personnel.

Generally speaking, a surveying team consists of:

- **one gang foreman, with a knowledge of topography (this may, in fact, be the site foreman in many cases);**

- **two semi-skilled workers to transport the surveying equipment, It is a good idea to make the same two people responsible for this task throughout operations;**

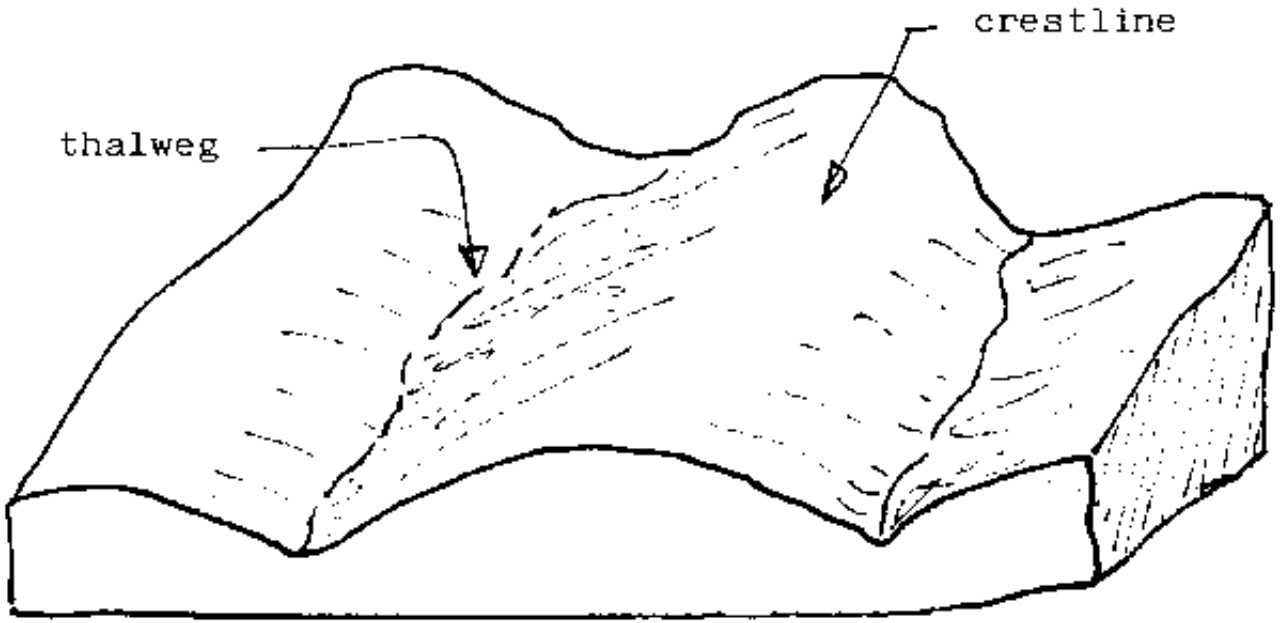
- **a number of workers to carry the benchmark posts.**

The equipment needed for this preparatory phase of operations has been described earlier.

SURVEYING THE LAND

Once it has been decided where the works will be sited, the first task of the siting team is to take note of the principal topographical features of the area.

- **the high-lying areas, or crestlines;**
- **the flowpaths of run-off water, or thalwegs.**



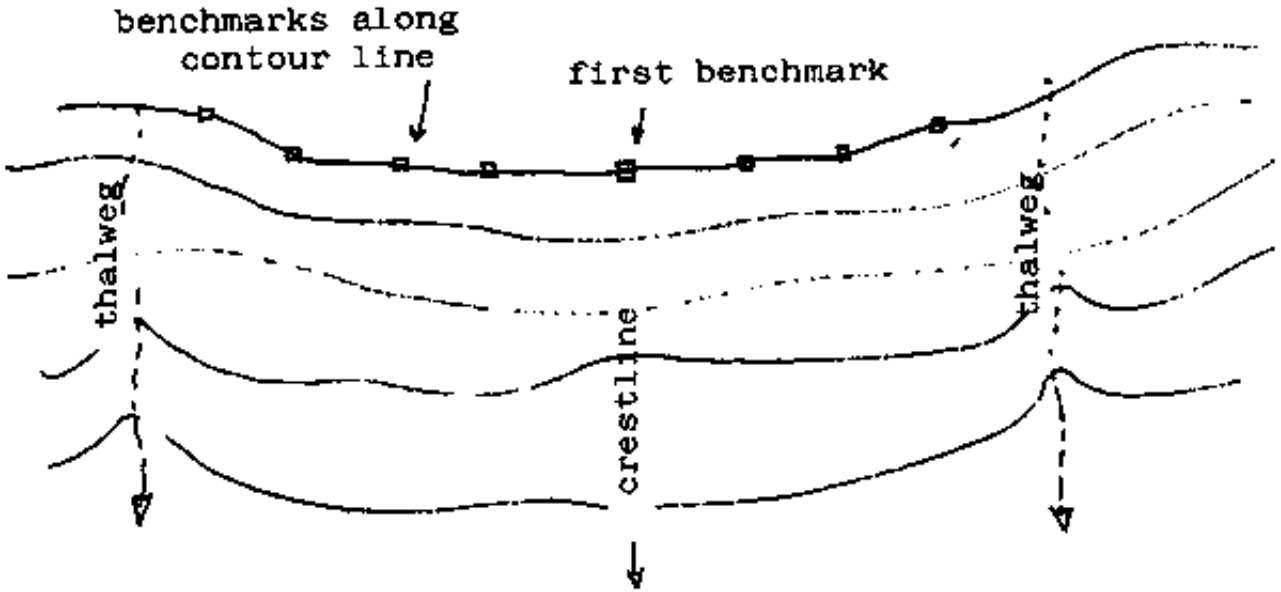
Figure

In this, the siting team will be greatly assisted by the farmers who, knowing well their own land, will be able to point out the various courses water takes (thalwegs) and each will be subsequently marked out using wooden posts. In the same way, the main crestlines will be plotted out. To avoid confusion, one could use yellow posts to mark the crestlines and red for the thalwegs.

SITING THE FIRST CONTOUR LINE

Siting starts from a crestline which has already been marked out.

Beginning from the first benchmark, the contour line is found by means of a spirit-levelling board or water level, plotting out a series of points which are on the same level - a procedure which has been explained previously.



Figure

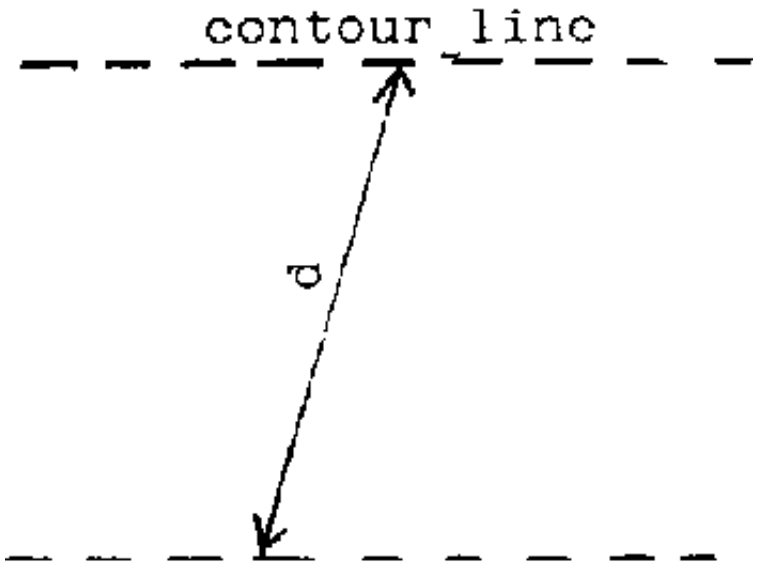
These points are marked using wooden posts. Once the siting of the first contour line of posts has been completed, we go on to mark the second and so on, using different coloured posts for each line, to avoid confusion.

SITING THE SECOND CONTOUR LINE

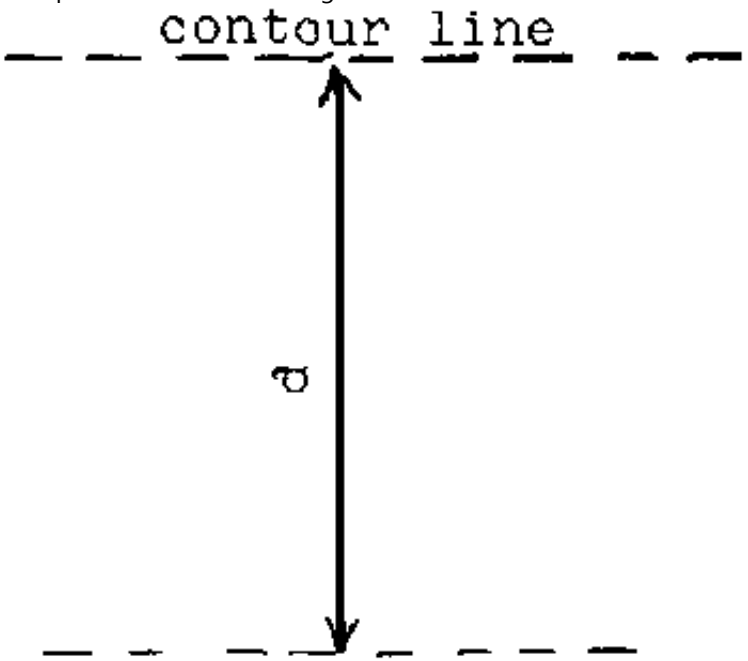
Starting from the middle post, and using either a measuring chain or decametre,

we measure the required distance down the steepest section of the slope. To achieve this, one of the workers holds the end of the measure against the middle post whilst a fellow worker unwinds the measure to find the desired distance. A wooden post is driven into the ground at the point which has thus been found.

Care must be taken to ensure that, while measuring, the decametre or chain is at a right angle to the first line of contour benchmarks.



WRONG



RIGHT

Using this post as a starting point, a new contour line is plotted out with the help of the spirit-levelling board or water level, in the same way as the first.

We continue plotting the retaining banks one after another, following this same procedure.

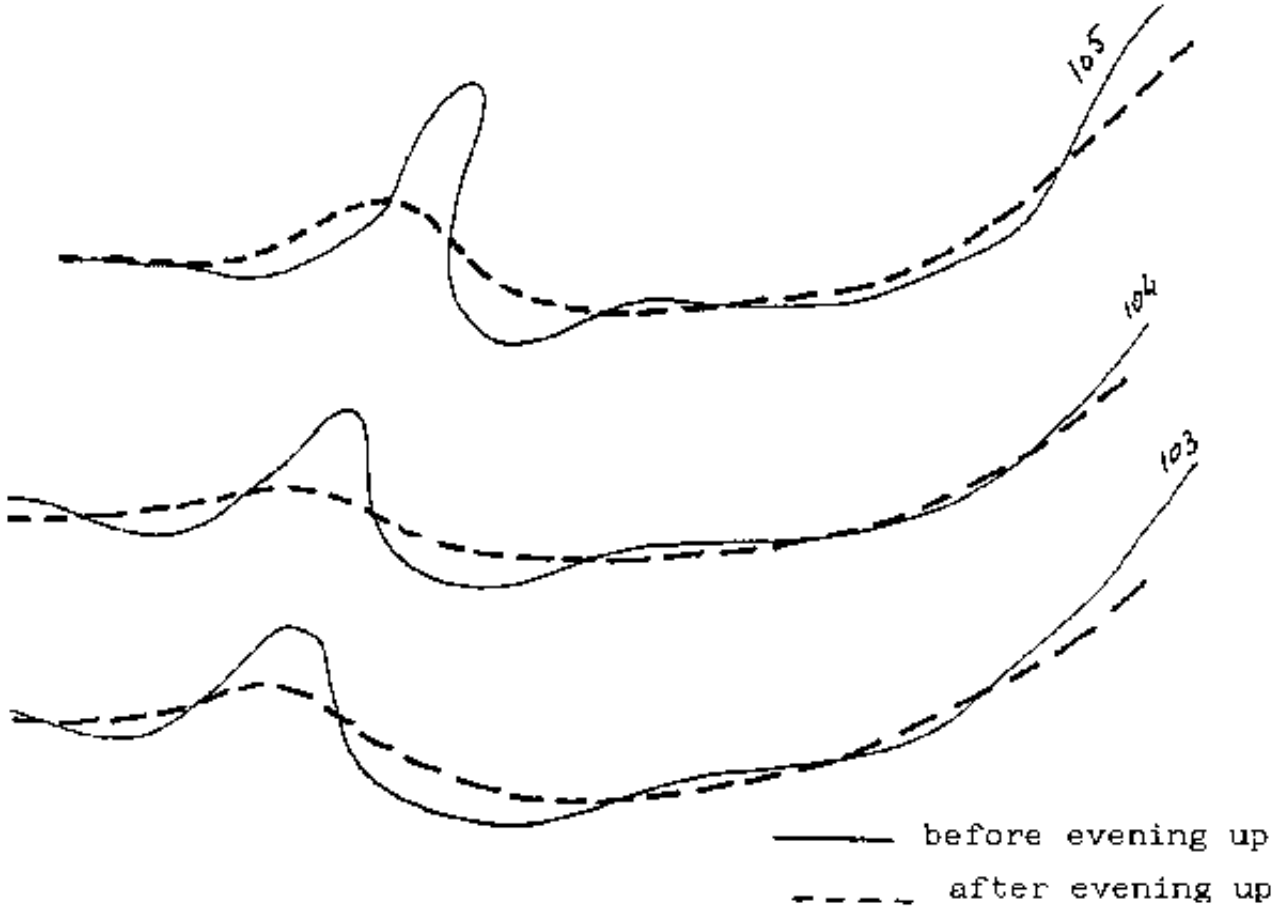
EVENING-UP THE CONTOUR LINES

Once all the retaining banks have been plotted, certain irregularities in their appearance may be noticed. Sometimes the posts are not in an even line. If this is the case, the contour line should be evened up by smoothing out any irregularities which occur along its length.

This evening-up is achieved by slightly modifying the position of those posts which are not in line with the form of the contour as a whole.

The post marking a point which seems to have been placed too low should be moved up slightly, and vice versa.

The difference between the real contour which was originally plotted out and the newly evened-up contour line should not, however, exceed 10 cm.



EVENING UP THE PLOTTED CONTOUR LINE

5.3 Plotting the dimensions of the ditch

This entails marking the position in which the ditch should be dug and the boundaries it should keep within.

Tools needed for this task are a tracing line and either a pickaxe or a plough.

<u>The procedure to follow if a pickaxe is used</u> is the following:

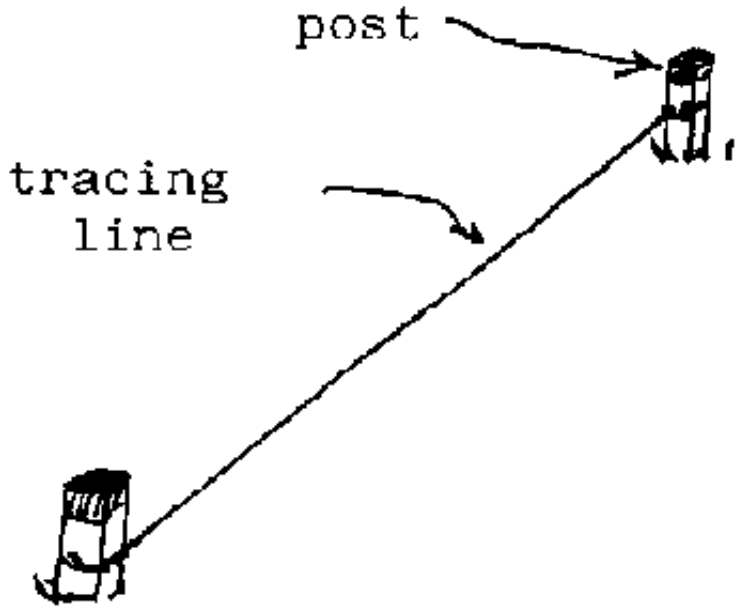
- The tracing line is stretched between the posts which should be approximately 30 cm apart.

- With the pointed end of the pick, trace out the furrow, using the tracing line as a guide.

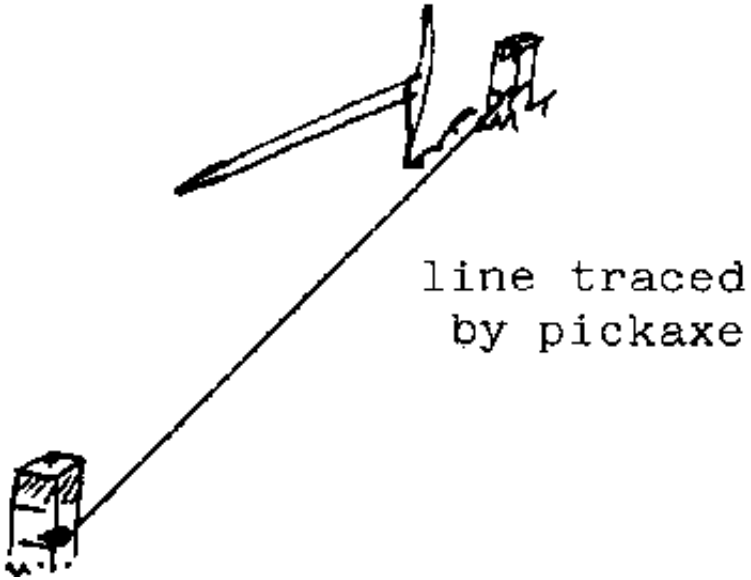
- A second groove, parallel to the first, is now traced along the ground, again using the pickaxe.

- The two grooves correspond to the dimensions the ditch will have.

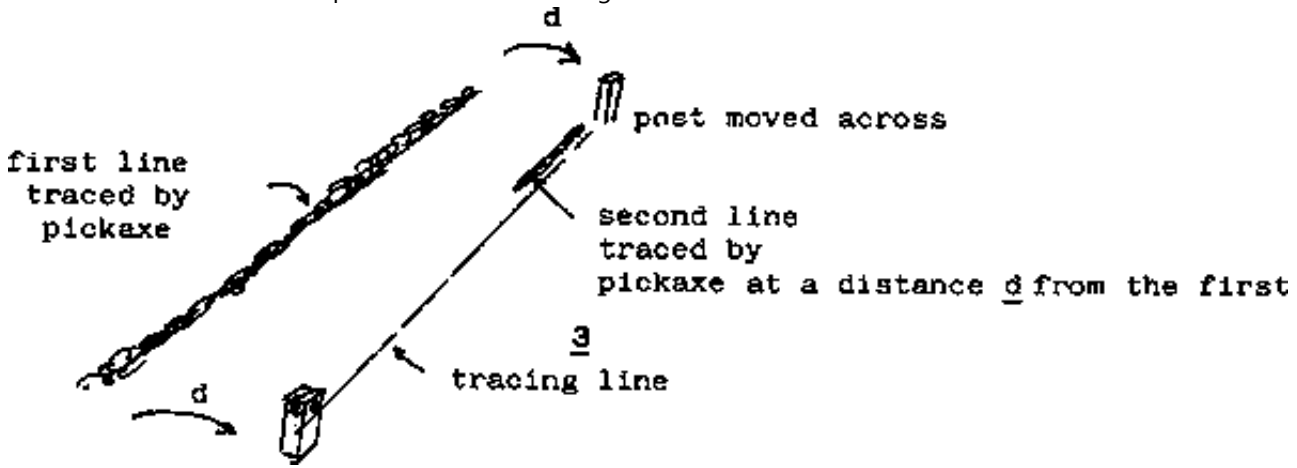
- Next, the posts are moved in such a way as to mark the total extent of the retaining ridge.



PLOTTING THE DIMENSIONS OF THE DITCH - 1



PLOTTING THE DIMENSIONS OF THE DITCH - 2



PLOTTING THE DIMENSIONS OF THE DITCH - 3

If an animal-drawn plough is used, the method is as follows:

- The plough traces out a furrow along the ground following the layout of the ditches. The operator must be sure to steer the plough exactly along the line of posts of the same colour.

- When the first furrow has been completed, the posts are moved across, keeping an equal distance between them, to mark the bounds of the ditch. A second furrow is made, using the posts as a guide. These two furrows mark the boundaries of the ditch. The ground between may then be ploughed to ease the task of digging.

If a tractor is used, the choice of implement depends on the nature of the soil:

- a disc plough is needed on soft ground;
- a subsoiler should be employed on hard ground.

The worker drives the tractor along the line of posts and then continues to plough back and forth within the bounds of the site so that the ground is prepared thoroughly for the next task which consists of excavating the ditch.

5.4 Preparing the surface soil of the ditch site

Once the site of the ditch has been traced out, the next task is to prepare the ground by scraping the surface, clearing it of vegetation and then breaking up the surface soil (unless a disc plough has been used, in which case this task will have already been done).

The tools required for this operation are the pickaxe and shovel.

The pointed end of the pickaxe is used to break up the surface layer of soil which is often hard and compact.

The cutting edge of the pick is useful for slicing through roots and for removing clods of earth.

Preparing the site to be backfilled

The site of the retaining bank is also worked over with the pickaxe in order to break up the soil. This is particularly useful if trees are to be planted on the bank as water is then more easily absorbed and it also encourages the roots to establish themselves.

5.5 Excavating the ditch

The tools used for this stage of the works are the shovel and pickaxe.

If the task is arranged as piecework, each worker has a set amount of ditch to dig. His section is marked out with posts. He should be equipped with both a shovel and a pickaxe.

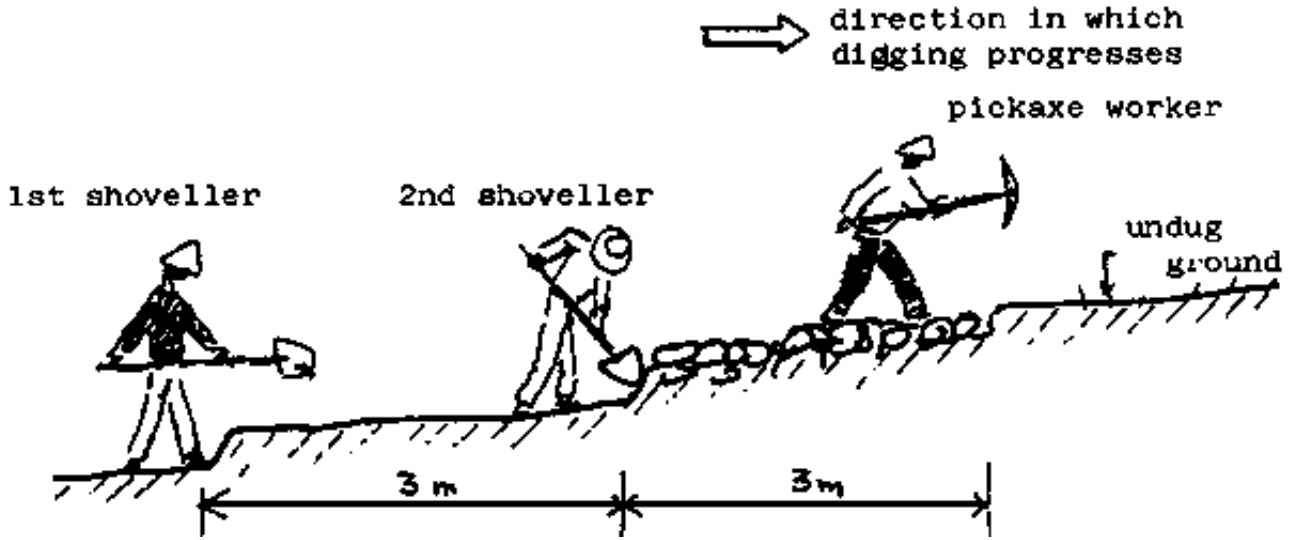
If the digging is to be carried out by a line of workers, each worker is given either a shovel or pickaxe. The diggers form a line with the one using the pickaxe at the front, followed by the shoveller(s).

According to the type of soil, the following is a guide to the composition of the team:

- on hard ground: 1 pickaxe to one shovel;
- on normal ground: 1 pickaxe to every two shovels;
- on soft ground: 1 pickaxe to every three shovels.

The excavation of the trench is commenced at the middle of its plotted siting.

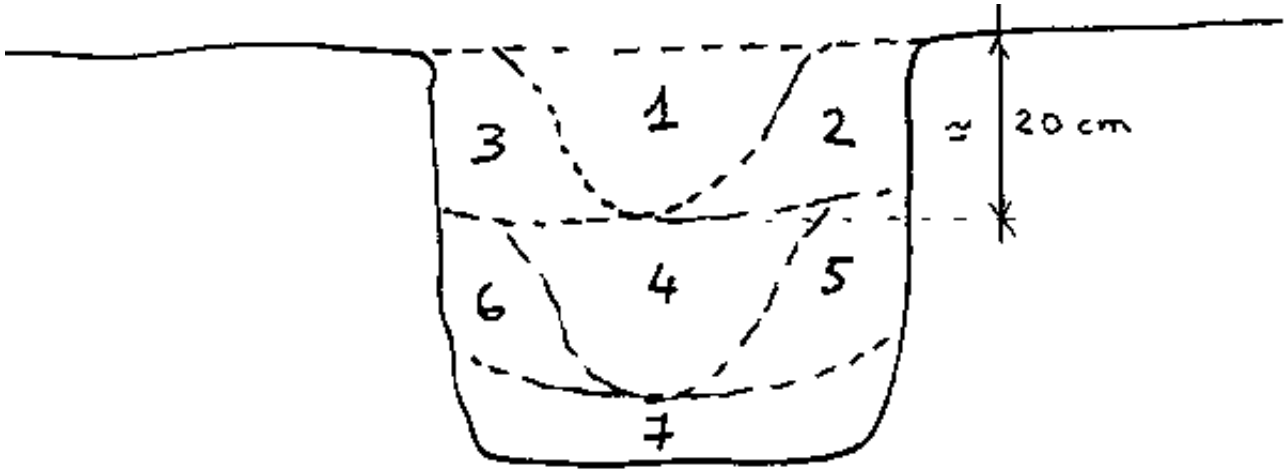
1. The soil is broken up, using the pickaxe, to a depth of about 20 cm and the earth removed by shovel. In a single movement, the earth is thrown by the shoveller to the place where the embankment is to be constructed. A worker is capable of shovelling earth a distance of 3 m in a single throw, on average.



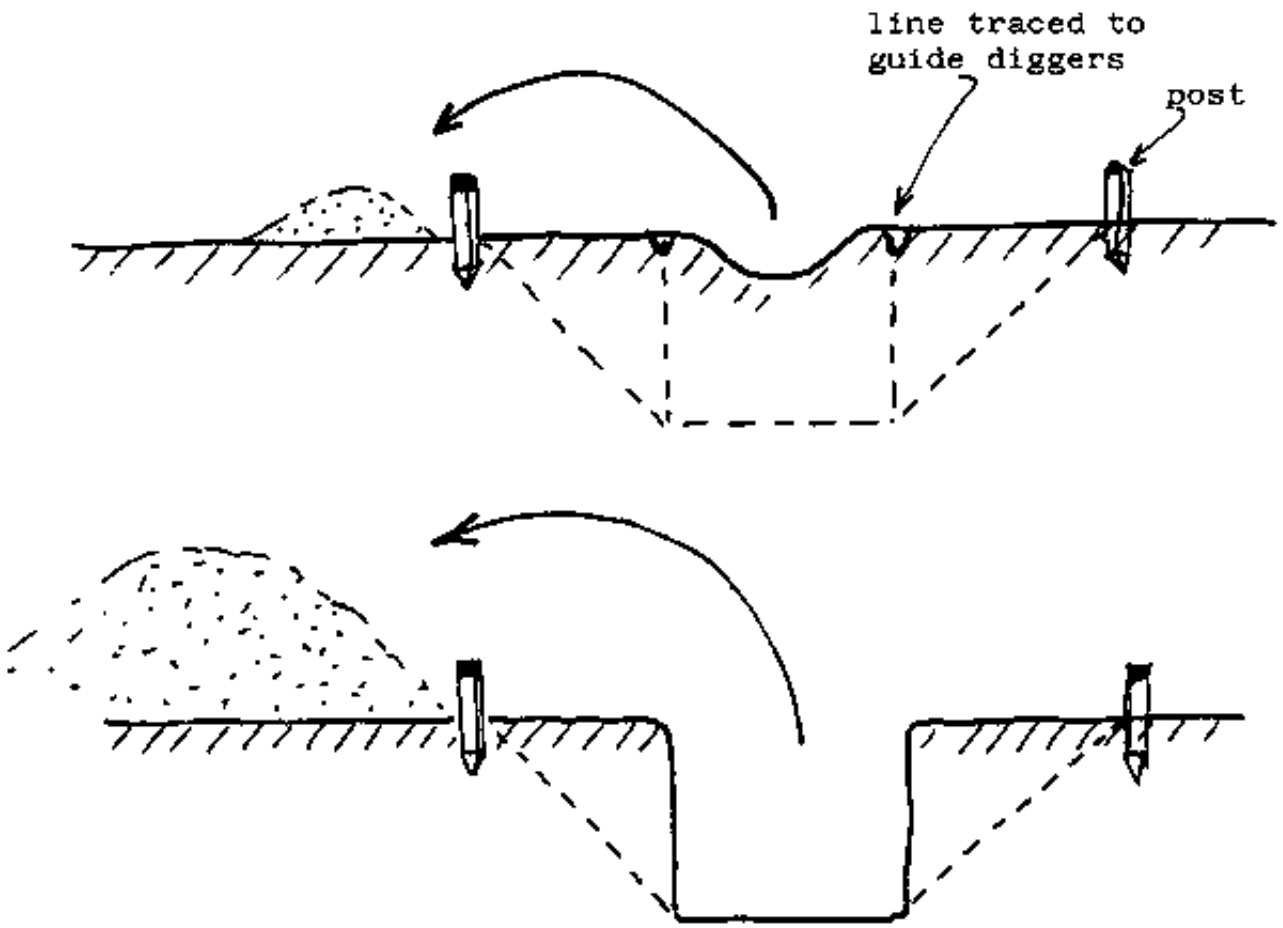
Figure

<u>Note</u>: When constructing contour line ditches, the embankment should always be situated downhill from the ditch.

2. The middle of the ditch is dug out in the same way as before, in 20 cm sections until the required depth, as specified by the gang foreman, is reached.



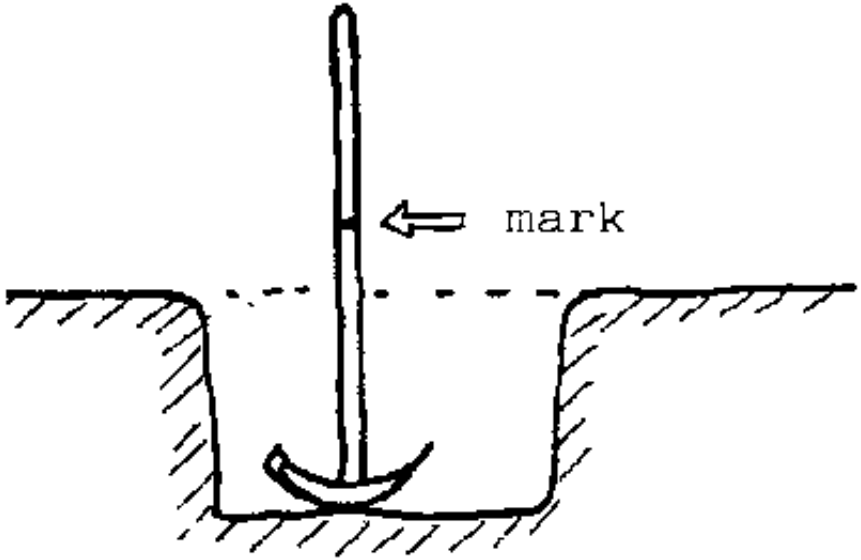
Figure



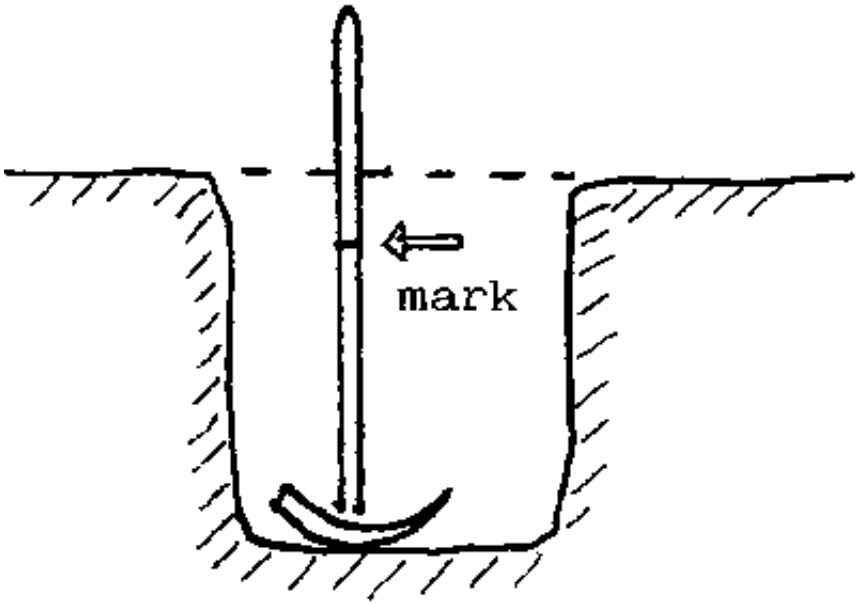
EXCAVATION OF THE DITCH

CHECKING THE DEPTH OF THE DITCH

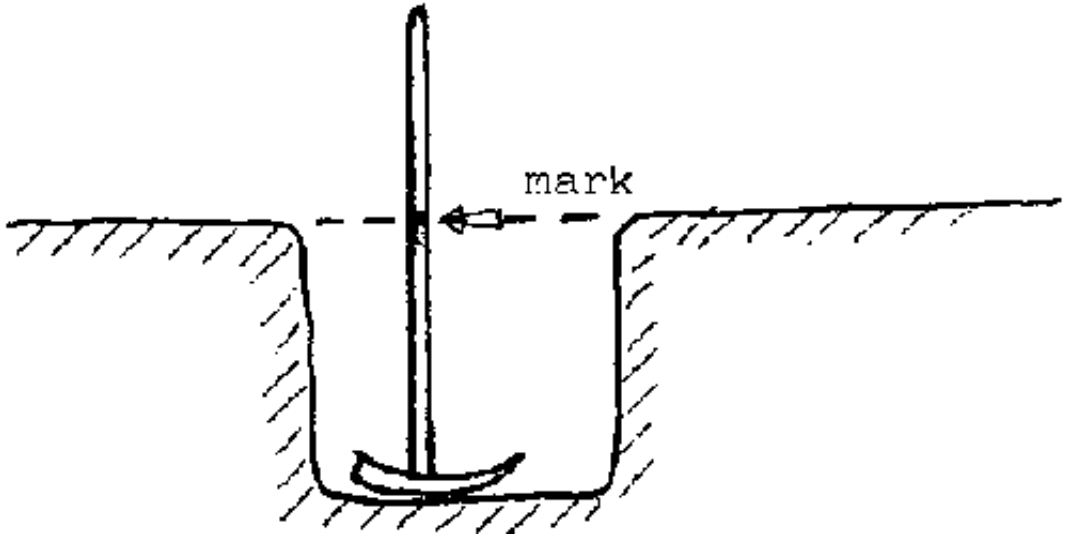
To make sure the ditch has been dug to the correct depth, the worker makes a mark on the handle of his shovel or pickaxe, representing the required depth and uses it to guide him during the course of the digging.



TOO SHALLOW



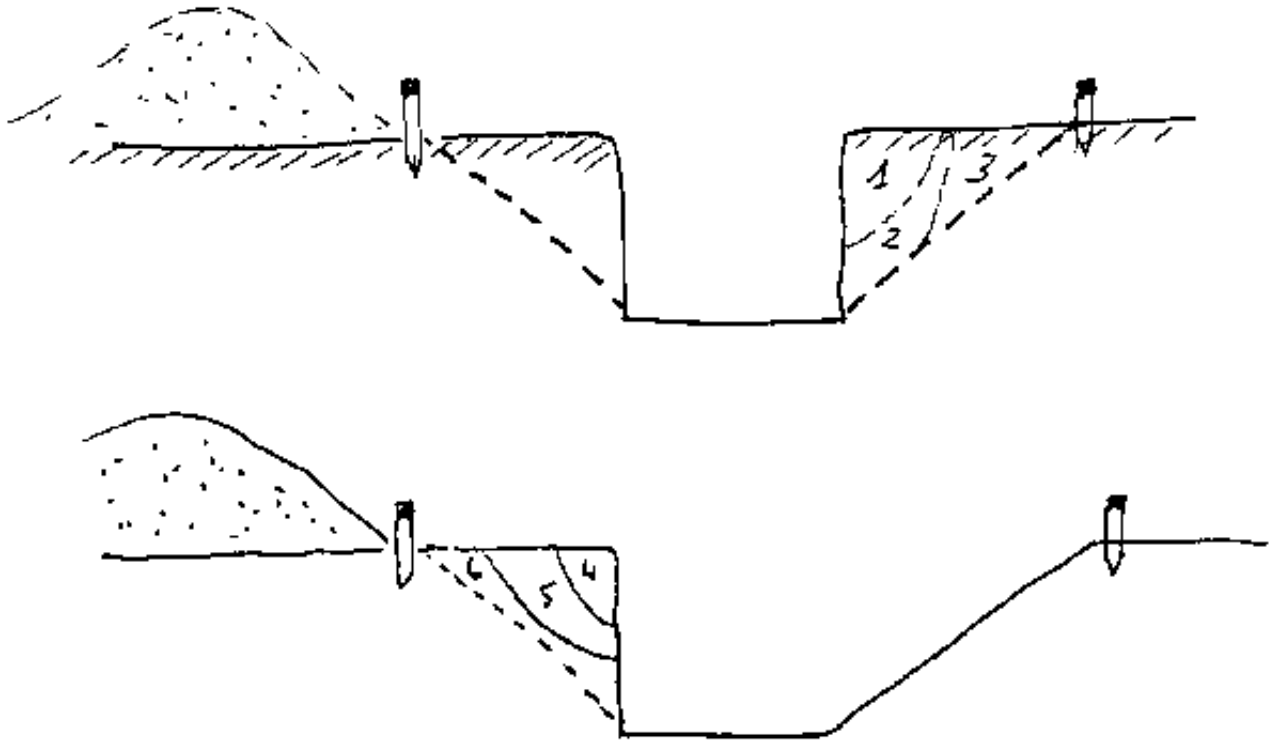
TOO DEEP



RIGHT DEPTH

With the middle of the ditch dug to the required depth, the sides will be more or less vertical so, in order to prevent them from caving in, they should be sloped off.

To do this, the bounds of the bank should be marked out. The gang foreman will work out what the distance between the vertical side of the trench and the edge of the bank should be.



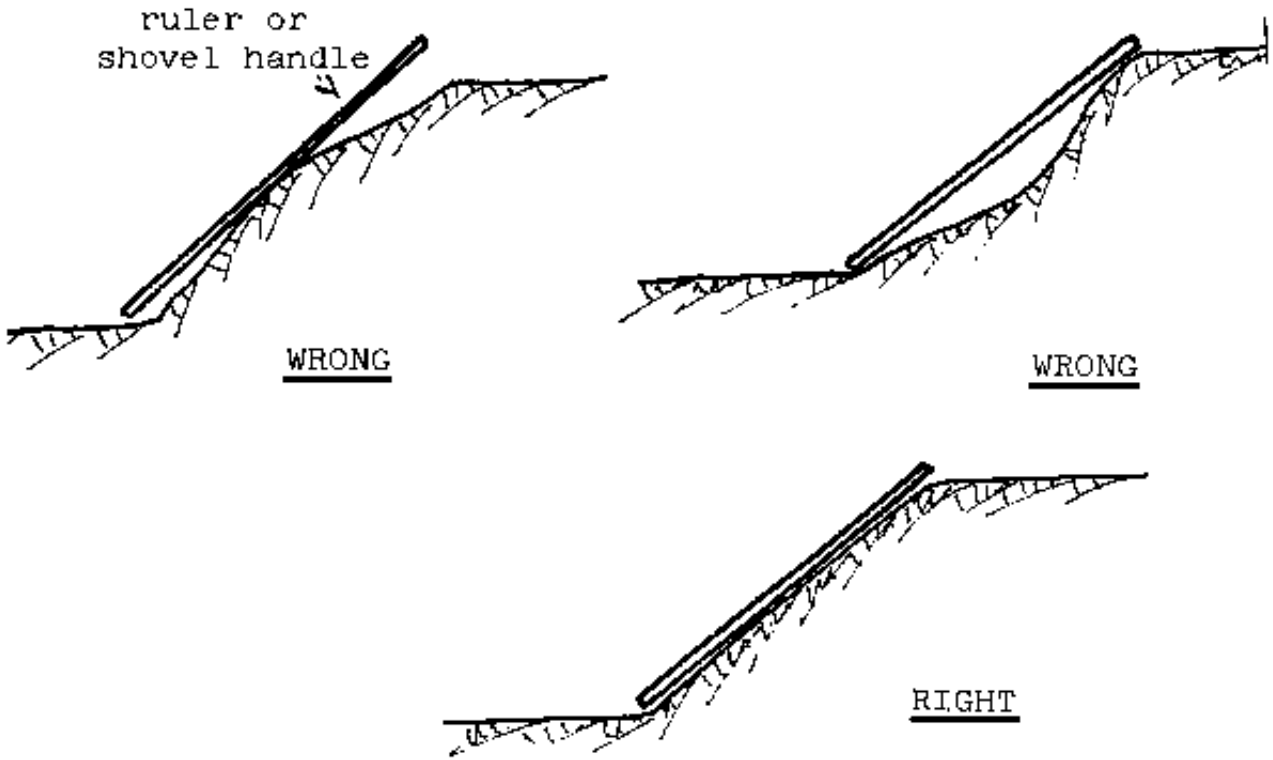
Figure

The uphill bank (the side the water runs down) is levelled off first in the following way:

- The worker stands in the ditch, facing the bank which he then proceeds to level off using the cutting edge of the pickaxe. The earth is removed from the ditch by shovel.

- When this operation has been completed, the slope of the bank from the bottom of the ditch to the natural level of earth above should be level, with no hollows or bumps. Its level-ness can be checked with the handle of the shovel which should rest flat against the bank from top to bottom.

- The downhill bank is then levelled off in the same way.



CHECKING THE SLOPING OF THE BANK

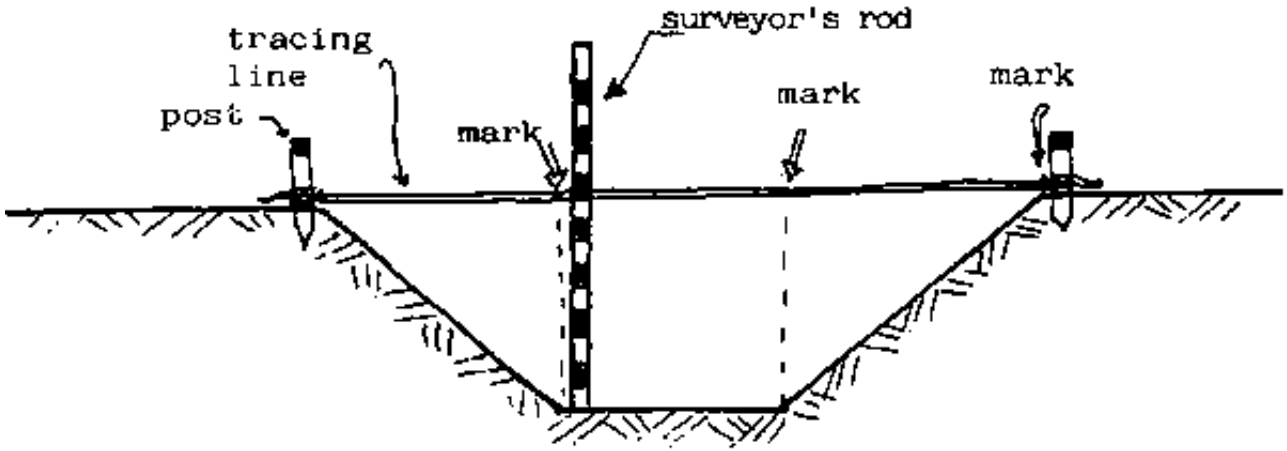
5.6 Checking the dimensions of the ditch

Upon completion of the ditch-digging, the gang foreman should inspect the work and check that the actual dimensions of the ditch correspond to those which were foreseen.

In order to do this, a tracing line is stretched across the top of the ditch, with four coloured marks along it. The two outer marks indicate the overall width of the ditch and the two inner ones the width of the base of the ditch.

Using a graduated rule, or surveyor's rod, the gang foreman checks the depth of the ditch straight down from the two central marks.

If the ditch is too shallow, it must dug out to the required depth. Should it have been dug too deep, the ditch should be left as it is.



CHECKING THE DIMENSION

5.7 Constructing the retaining banks

The earth which has been excavated in the digging of the ditch should be backfilled downhill.

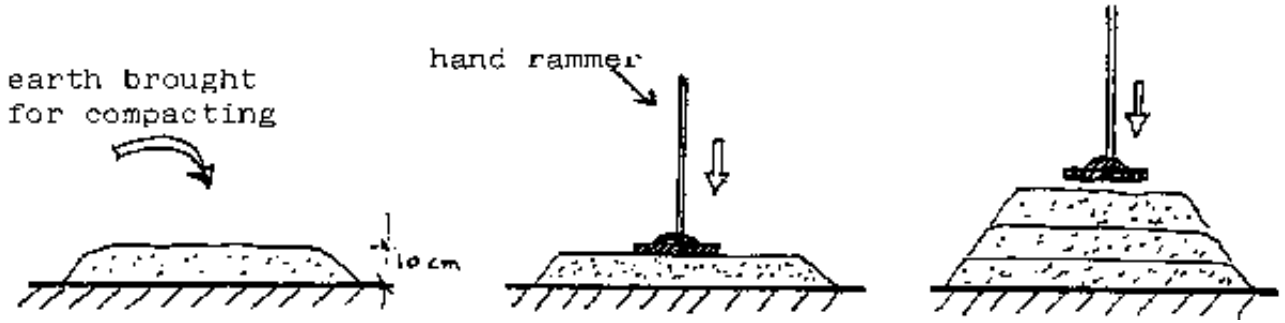
The purpose of a retaining bank, like that of a ditch, is to stop the flow of run-off water. It must, therefore, be strong enough to withstand the thrust of the run-off water. This is ensured by compacting the backfilling material.

Compaction consists of packing the earth down so as to give it more cohesion. This can be achieved using simple methods such as stamping by foot or working

with a hand rammer.

Stamping the soil down involves men and animals passing on top of the embankment and to be most effective is best done when the soil is damp.

Compaction by hand rammer is achieved in the following way: a 10 cm layer of earth is placed on the bank and carefully packed down by pounding the area with the rammer. Another layer of earth is brought and packed down and so on, until the required height of the bank is reached.



Figure

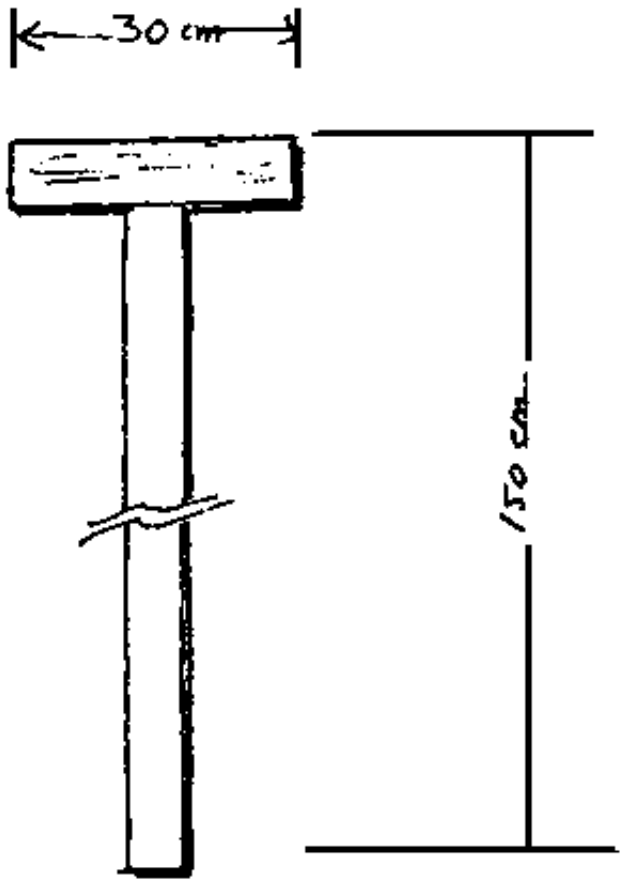
To be most effective, compaction is best carried out on damp earth, although this is seldom possible since work is usually undertaken during the dry season.

Therefore, to make sure the retaining embankment is really solid, it should again be compacted after the first rains of the season.

5.8 Checking that the retaining banks are horizontal

The banks must either be horizontal (absorption network) or have a slight slope (diversion network). LEVELLING RODS are used to check this.

These rods are T-shaped, 150 cm high, with a 30 cm bar.



LEVELLING ROD

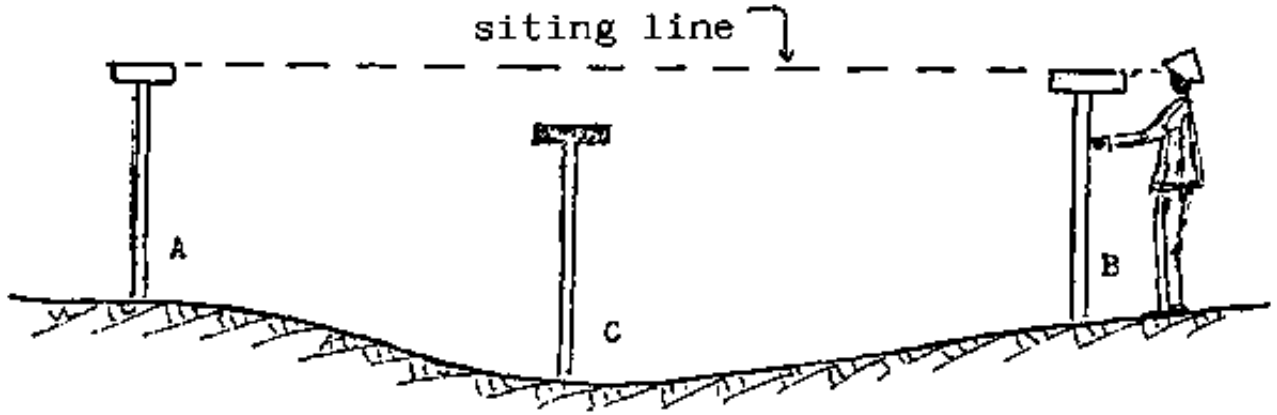
Three such rods are needed, two painted white (A and B) at the top and one black (C).

Rods A and B are positioned at two places where the height of the bank has already been checked.

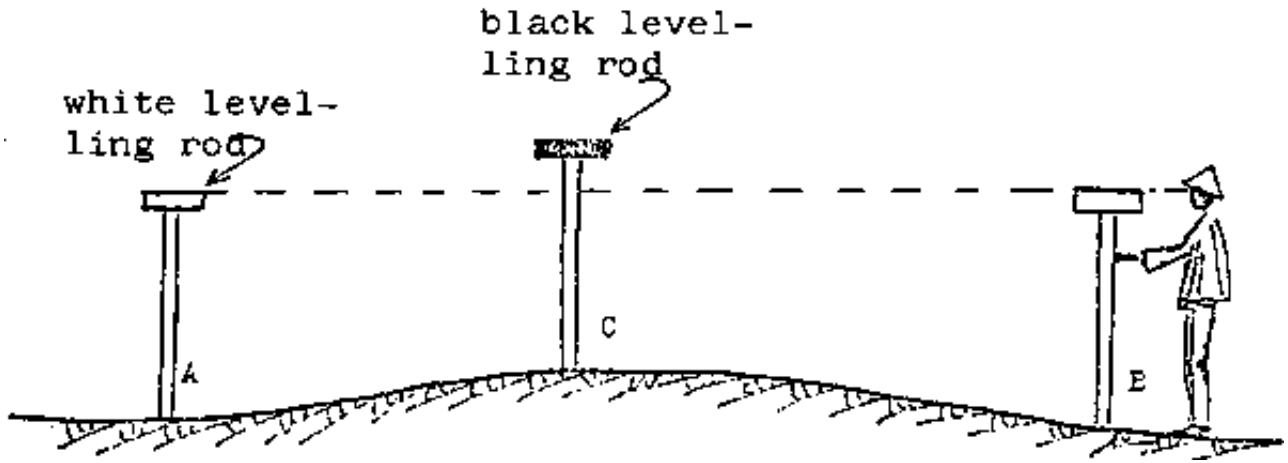
Rod C is moved to various positions between the other two rods, the bank being

horizontal when all three are on the same level. If any places along the bank are found to be too low, they should be levelled up with earth and compacted.

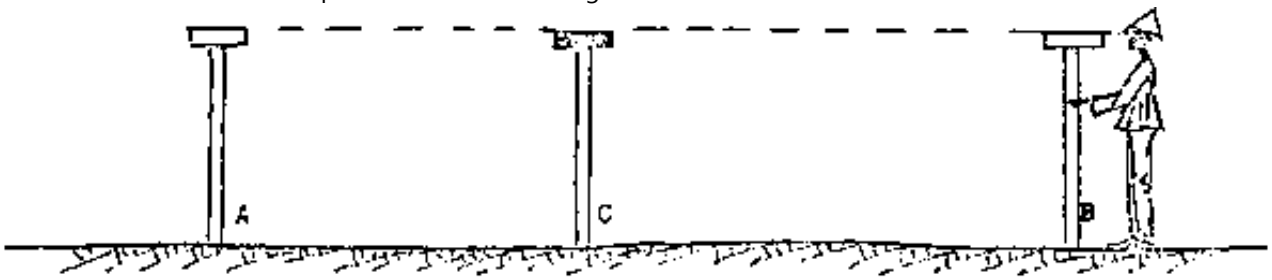
CHECKING THE HORIZONTALITY OF THE RETAINING BANKS



TOO LOW



TOO HIGH

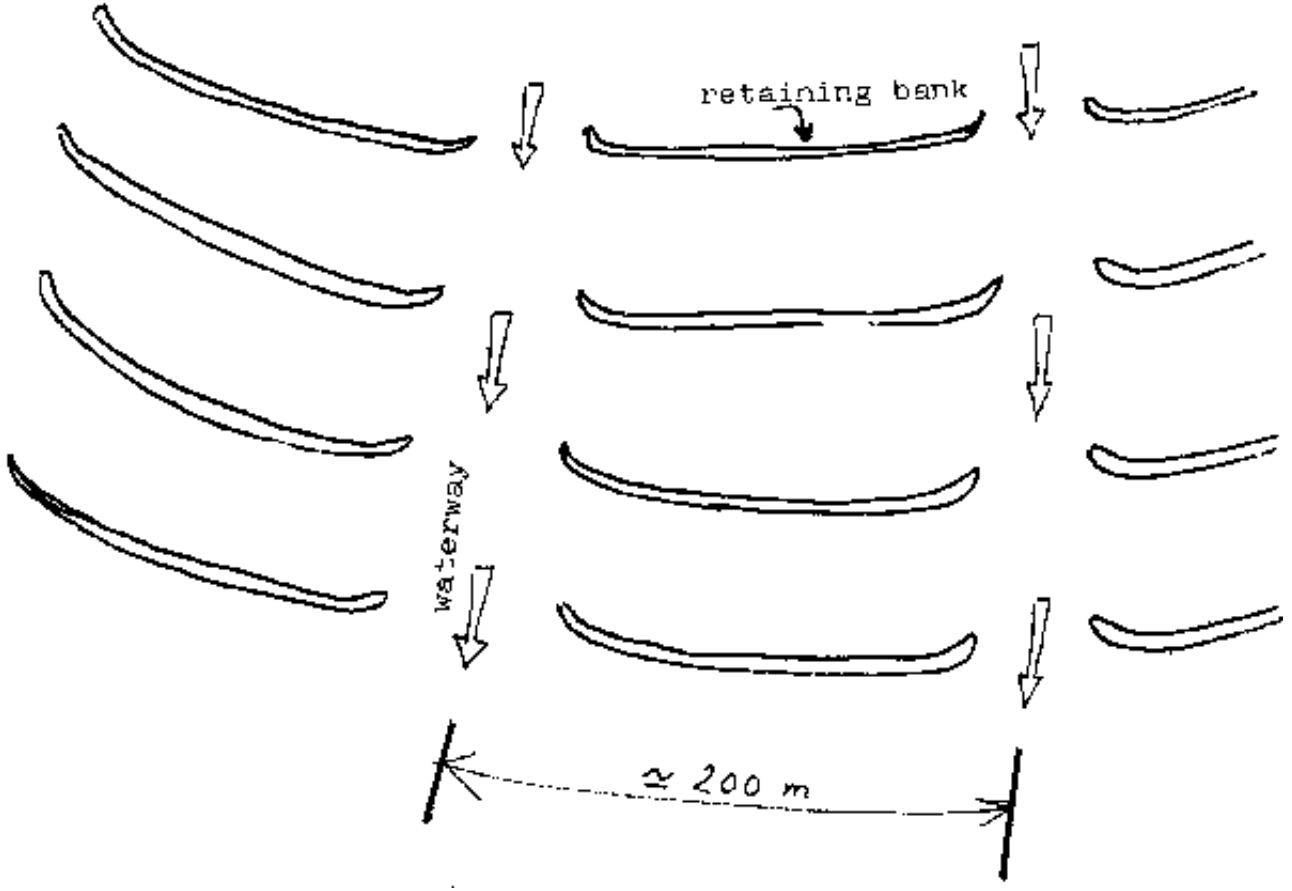


LEVEL

5.9 Improving the waterways

At regular distances along the retaining banks (about 200 m), channels should be made to allow excess run-off water to flow into the waterways.

These waterways must be protected against erosion and this will be dealt with in another booklet.



Figure

5.10 Protecting the slopes

Vegetation will protect and consolidate the slopes between the ditches and retaining banks. Steps must be taken to encourage vegetation to establish itself where it is required. This can either be vegetation which seeds itself naturally, cultivated plantations or, alternatively, the area can be grass-seeded.

NATURAL VEGETATION

This consists of grasses and undergrowth which grow naturally on rain-moistened soil. Weeding of the soil should be avoided while the vegetation is becoming established.

Until the vegetation has become thick enough to protect the slope, it can be shielded from the drying effects of the sun by covering the surface of the soil with straw and dried grass - a technique known as mulching.

GRASS-SEEDING

Alternatively, the slopes can be sown with grass seeds. For grass-seeding to be effective, the soil needs to be moist enough to allow the seeds to germinate and the seedlings to take root. Therefore, the best time for grass-seeding to be undertaken is at the beginning of the rainy season.

The soil should be prepared by breaking up the topsoil to a depth of 5 cm and removing stones and the bigger clods of earth, using a RAKE.

RAKE

The grass-seeds should be BROADCAST over the slope. This entails taking a handful of seeds and releasing them in a single wide sweeping movement of the

hand. In this way, the seeds are sown evenly over the surface of the ground. One handful of seeds (about 50 g) will cover an area of 3 m^2. One kilogram of grass-seeds should be allowed for every 20 m^2 of ground to be covered.

Here again, the slope needs to be protected by mulching while the grass is taking root.

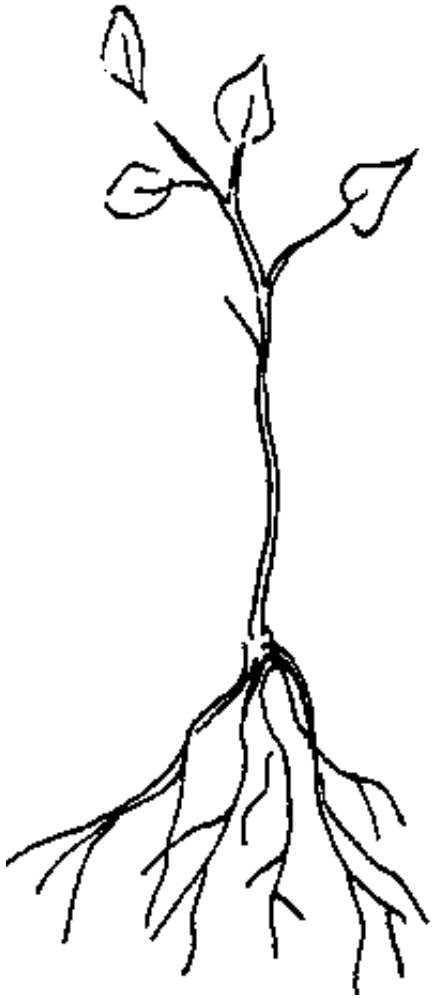
PLANTING OUT

The planting out of plantlets and seedlings should be undertaken at the beginning of the rainy season once the soil of the slope has become moist to a depth of 20 cm, but only after the rains have become sufficiently well-established to avoid any risk of prolonged dry spells.

OBTAINING THE PLANTLETS

The plantlets are obtained from tree nurseries and are supplied either with bare roots or contained in plastic pots or bags.

YOUNG PLANTS



With bare roots

in containers

STORING THE PLANTLETS

If the plants are not to be used immediately, care should be taken to prevent them drying out.

To store the plantlets for three or four days, they should be kept out of the sun in

a shed and covered with damp sacking.

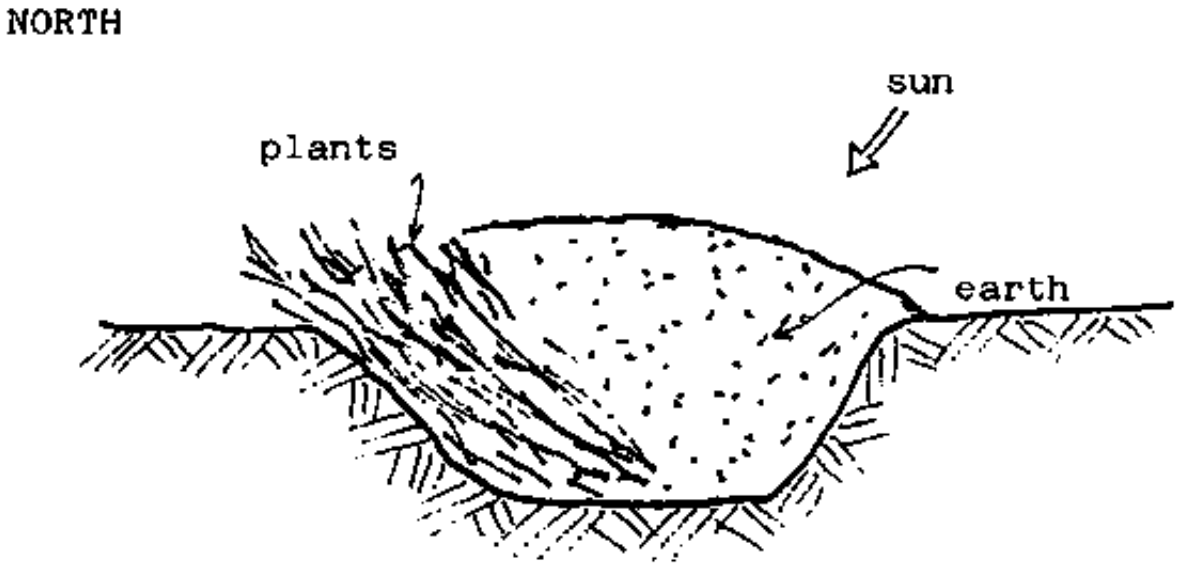
If they have to be stored longer than a few days, the plants must be <u>HEELED IN</u>. This involves:

- digging a trench in the earth;

- placing the plants side by side in the trench, at an angle facing north, roots at the bottom;

- covering the roots with moist earth up to the first branches.

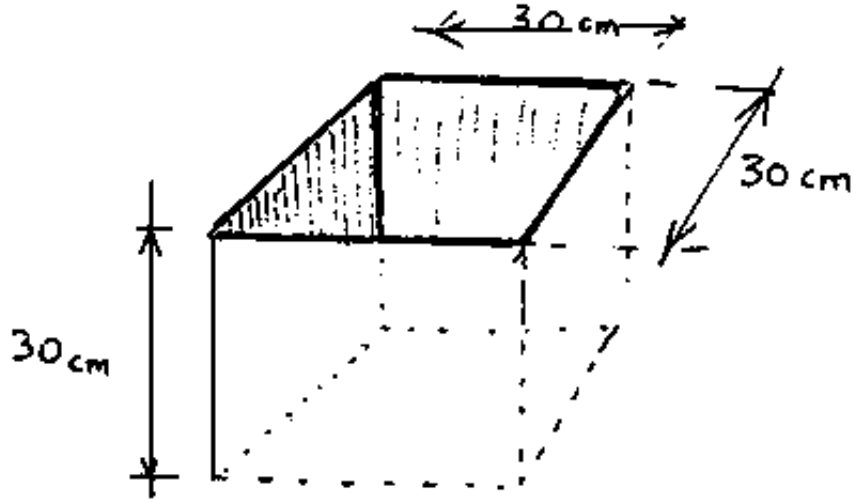
During very dry periods, the earth should be covered with dry leaves, branches or dampened sacking.



<u>HEELING IN</u>

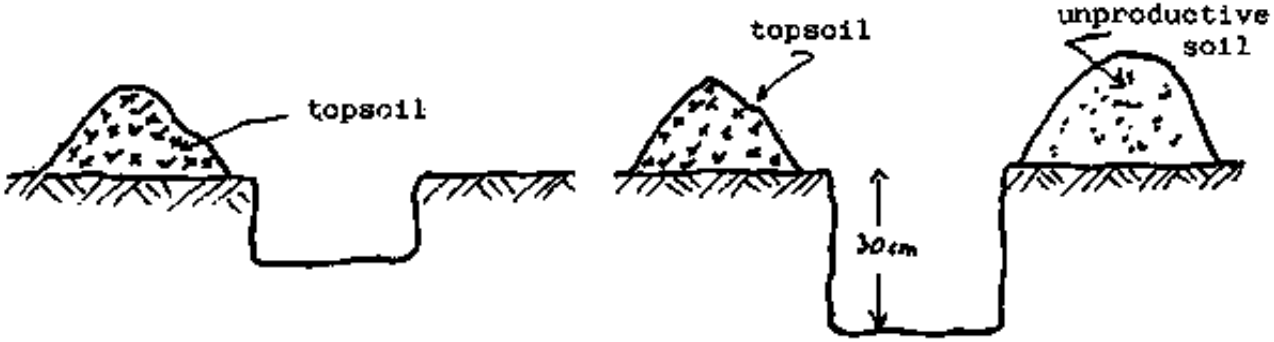
PREPARING PLANTING HOLES

Planting holes are prepared on the sloping top-side of the retaining bank. The spacing of these holes will depend on the species of tree used. For shrubs, it will vary between 0.50 m and 2 m.



Figure

The hole is cube-shaped, at least 30 cm deep and dug out by means of a pickaxe and shovel. The topsoil (to a depth of 20 cm) is placed in a heap to one side of the hole and the remaining 10 cm of earth (unproductive soil) put in a separate heap on the other side.



Figure

TRANSPORTING THE PLANTS TO THE PLANTING AREA

The plants are brought from the sheds to the worksite only when the preparation of the planting area has been completed. They may be transported in wicker baskets or wheelbarrows. It is essential that the plants are not allowed to dry out so they should be covered with damp sacking during transport.

PLANTING OUT

Preparation

Bare-rooted plants:

- **Check the condition of the roots (they should be supple).**
- **Cut off any roots which are too long and any which have dried out.**

Plants in containers:

- **Carefully cut away the plastic container.**

- Handle the plant with care in order to avoid any soil being lost from around its roots.

- Take the plant in one hand, holding it by its collar (the part which separates the root from the stem).

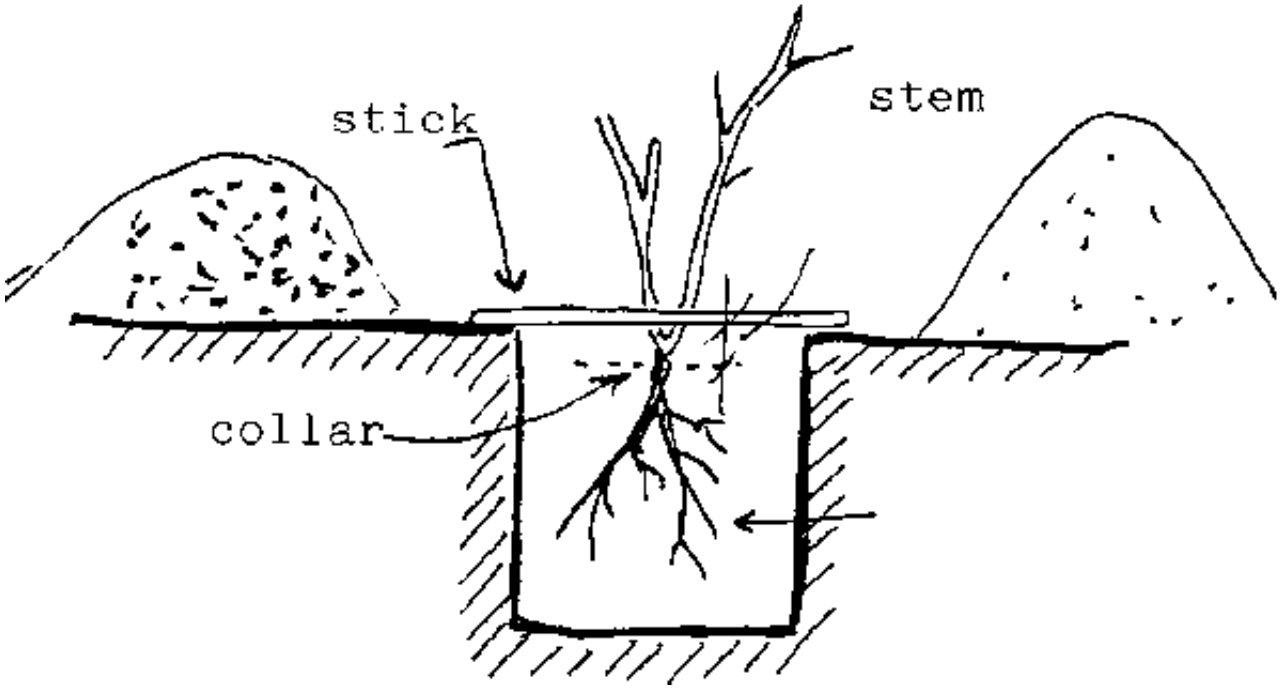
- Place the plant in the hole which has been prepared, so that the collar is a few centimetres above ground level. A stick laid across the hole will help to position the plant correctly. Careful attention must be paid to check that the roots of the plant are not bent under.

- Start filling the hole with fertile soil from the first heap.

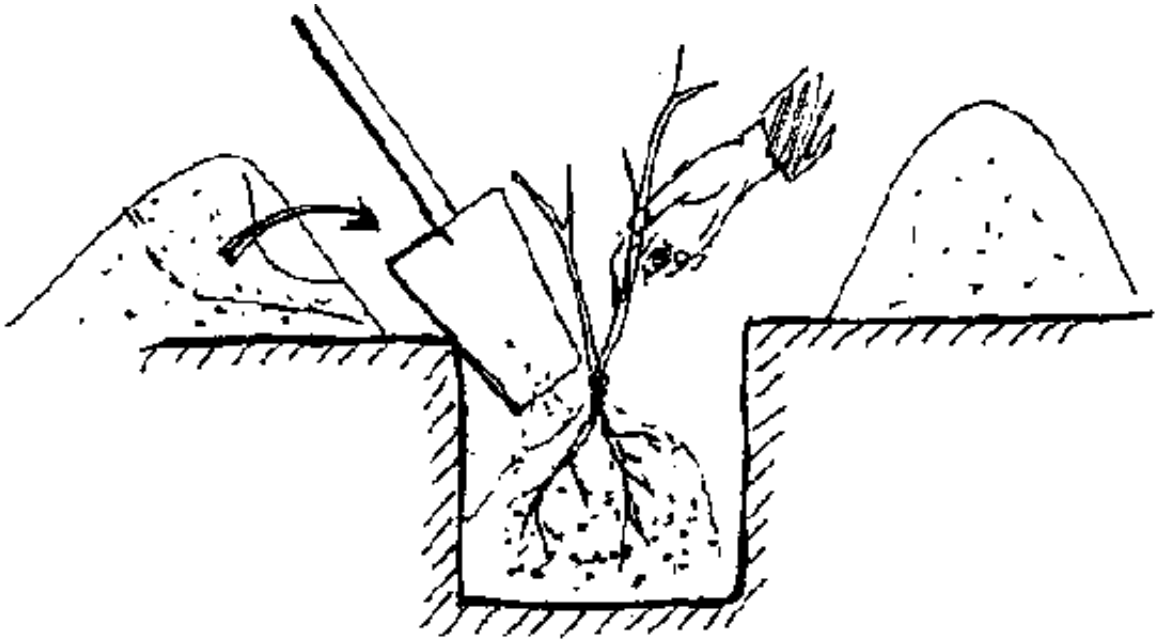
- Press the soil down lightly around the roots of the plant.

- Fill the hole up to the collar of the plant with the rest of the soil.

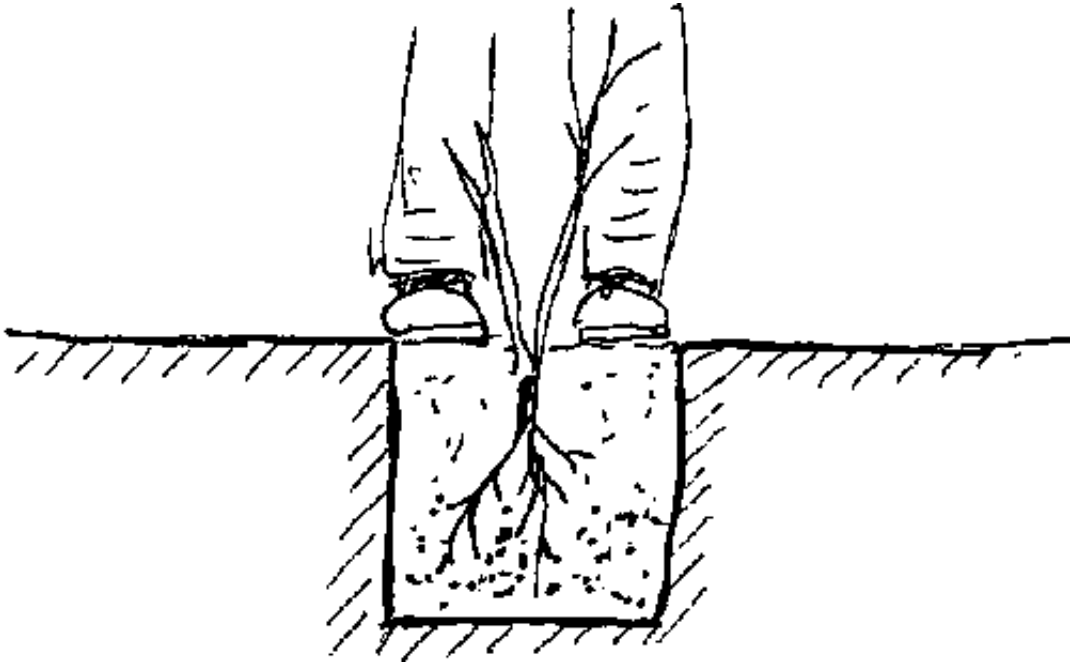
- Tread the earth down lightly.



PLANTING OUT - 1



PLANTING OUT - 2



PLANTING OUT - 3

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Special Public Works Programmes - SPWP - Anti-Erosion Ditches - Training Element and Technical Guide for SPWP Workers, Booklet No. 1 (ILO - UNDP, 84 p.)

- *(introduction...)*
- **1. What is erosion?**

- 2. How to recognise erosion
- 3. Different types of anti-erosion ditches
- 4. Worksite organisation
- 5. Procedure
- 6. Maintenance of the retaining banks

6. Maintenance of the retaining banks

Every year, before the start of the rainy season, the farmer must check the condition of the retaining banks. The main causes of deterioration of the banks are:

- the run-off of rainwater, leading to gullying of the banks;

- the base of the embankment being eroded away by the flow of water (diversion network);

- backfill material becoming packed down;

- gaps forming in the banks due to the water overflowing;

- damage caused by animals crossing over the structures..

Maintenance consists, therefore, of:

- checking that the embankments are still horizontal. Surveying rods can be used for this in the way described earlier in the section dealing with the construction of ditches;

- reinforcing any places where the structure has become weak, by adding earth and compacting as required;

- filling in any gullies or gaps with earth and compacting well.

A close and constant watch should be kept on the slopes to ensure that the protection afforded by grass or vegetation remains adequate.

All weeding and scraping of the surface of the slopes must be strictly avoided. However, if any trees prevent the grass or vegetation growing as it should, they must be cut down.

notes

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ISBN 92-2-107782-9
Price: 10 Swiss francs