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Rural Water Supply in Nepal: Construction Design
Course Technical Training Manual No. 5

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RURAL WATER SUPPLY NEPAL

**TECHNICAL TRAINING
MANUAL no. 5**



CONSTRUCTION DESIGN COURSE

*Prepared and Published by
Local Development Department, Ministry of Home and Parishayat
SATA - Swiss Association for Technical Assistance
UNICEF - United Nations Children's Fund*

Katmandu 1978

CONSTRUCTION DESIGN COURSE

<u>Table of Contents</u>	<u>Page</u>
<u>Preface</u>	1
<u>1. The Water Source</u>	
1.1 Spring Catchment - General Points	2
1.2 The Catchment Area	3
1.3 Spring Catchment Installation	3
1.4 Trench Catchment	5
1.5 Small Spring Catchment	8
1.6 Small Stream Catchment	12
1.7 Inspection Chamber	17
<u>2. Water Quality</u>	
2.1 Water Treatment in the Rural Situation	21
2.2 Filtration	21
2.3 Sedimentation and Methods	22
2.4 Elements of Tank Design	23
<u>3. Storage Tanks</u>	
3.1 General Points, and Hygienic and Operational Requirements	32
3.2 Siting the Tank	33
3.3 Design and Capacity	33
<u>4. Pressure Reducing Installations</u>	
4.1 Pressure Reducing Pipe	45
4.2 Break Pressure Tank	45

Table of Contents (Cont'd)

Page

5. Distribution: The Pipeline

5.1	General Points	54
5.2	Air in the Pipeline	55
5.3	Chambers for Valve and Tap Connections	59
5.4	Pipe Passing Through Walls	64
5.5	Velocity of Water and Pressure Loss	65
5.6	Laying HDP Pipe, Trenching and Embankment	65
5.7	Backfilling and Tamping	67
5.8	Pipeline Testing	71
5.9	Marking the Pipeline	71
5.10	Finishing and First Chlorination	73

6. Stand Pipes, Tapstands and Public Fountains

6.1	General Points	74
6.2	Construction	75

<u>Figures</u>	<u>Page</u>
1. <u>The Water Source</u>	
1.1 Spring Catchment - General Arrangement	4
1.2 Intake Details	6
1.3 Intake Across a Slope	7
1.4 Small Spring Catchment - General Arrangement	9
1.5 Small Spring Catchment - Cross Section	10
1.6 Fittings Used in Figure 1.5	11
1.7 Small Stream Catchment - Plan View	13
1.8 Small Stream Catchment - Cross Section	14
1.9 Small Stream Catchment - Cross Section	15
1.10 Small Stream Catchment - Fittings	16
1.11 Inspection Chamber with Manhole	18
1.12 Inspection Chamber with Door	19
1.13 Inspection Chamber for Several Intakes	20
2. <u>Water Quality</u>	
2.1 Wrong Tank Inlet and Outlet Position	23
2.2 Tank Shape - Example	24
2.3 Inlet - Plan View	25
2.4 Inlet - Cross Section	26
2.5 Outlet - Cross Section	27
2.6 Sedimentation Tank - Plan View	28
2.7 Sedimentation Tank - Cross Section	29
2.8 Sedimentation Tank - Cross Section	30
2.9 Sedimentation Tank - Cross Section	31

<u>Figures</u>	<u>Page</u>
3. <u>Storage Tanks</u>	
3.1 9 Cubic Metres Capacity - Plan & Cross Section	34
3.2 9 Cubic Metres - Cross Sections	35
3.3 9 Cubic Metres - Fittings for Inlet	36
3.4 9 Cubic Metres - Fittings for Outlet Overflow and Cleaning	37
3.5 22 Cubic Metres Capacity - Plan View	38
3.6 22 Cubic Metres - Cross Section	39
3.7 22 Cubic Metres - Cross Section	40
3.8 22 Cubic Metres - Fittings for Outlet	41
3.9 22 Cubic Metres - Fittings for Inlet	42
3.10 22 Cubic Metres - Fittings for Overflow	43
3.11 22 Cubic Metres - Fittings for Cleaning	44
4. <u>Pressure Reducing Installations</u>	
4.1 Pressure Reducing Installation - Cross Section	47
4.2 Pressure Reducing Pipe	48
4.3 Break Pressure Tank - Plan & Cross Section	49
4.4 Break Pressure Tank - Plan & Cross Section	50
4.5 Break Pressure Tank - Fittings for Inlet, Overflow, Outlet and Cleaning	51
4.6 Break Pressure Tank - Inlet & Outlet	52
4.7 Break Pressure Tank - Overflow & Cleaning	53

Figures

Page

5. Distribution: The Pipeline

5.1	Pipeline Profile - Correct & Wrong	56
5.2	Pipeline Aeration	57
5.3	Air Valve Installation	58
5.4	Valve Chamber - Plan & Cross Section	60
5.5	Main Flow Control Valve Installation	61
5.6	Pipeline Main Connection Installation	62
5.7	Tap Connection Chamber - Plan & Cross Section	63
5.8	Pipeline Passing Through Walls	64
5.9	Embankment - Protecting the Pipeline	66
5.10.1	Laying a Pipeline: Tamping & Backfilling	68
5.10.2	Laying a Pipeline: Tamping & Backfilling	69
5.11	Laying a Pipeline Under a Main Road	70
5.12	Marking the Pipeline	72
5.13	Pipeline Cleaning-Out Installation	73

6. Stand Pipes, Tapstands and Public Fountains

6.1	Public Tapstand - Plan View	76
6.2	Public Tapstand - Cross Section	77
6.3	Public Tapstand - Cross Section	78
6.4	Bazar Tapstand - Plan View	79
6.5	Bazar Tapstand - Cross Section	80
6.6	Bazar Tapstand - Cross Section	81
6.7	Public Fountain - Plan View	82
6.8	Public Fountain - Cross Section	83
6.9	Public Fountain - Cross Section	84
6.10	Fittings for Tapstand Installation	85
6.11	Fittings for Tapstand Installation	86
6.12	Fittings for Public Fountain Installation	87

CONSTRUCTION DESIGN COURSE

Preface

The objective of a water supply system is to collect, on a continuing basis, a sufficient quantity of pure water to satisfy the daily physical needs of all the human consumers in a district and their animals and deliver it to them in the most convenient way possible at the most convenient location.

There are therefore three major elements or processes to a water supply system, which will be dealt with in turn in the course. They are:

- Establishing a source of water.
- Ensuring the quality of the water (maintenance.)
- Arranging storage and distribution.

This course covers the constructions necessary for accomplishing all these processes. In designing the installations of a water supply system we should also bear in mind the need to repair and maintain the installations themselves as part of an ongoing process of water supply.

1. THE WATER SOURCE

1.1 Spring Catchment - General Points

The Spring Catchment is the term we use for the place where water is gathered in sufficient quantity to form the basis of a water supply. Some of these types of sources are:

- Water bearing soil
- Existing streams or rivers
- Rock fissures, which allow underground water to be released on the surface.

The type of spring catchment installation to be built depends on three factors: the topographical situation, the structure of the ground and the type of source.

Here are some general points which should be considered before, and during, the construction of a spring catchment installation.

- a. The catchment area should be clearly marked on the terrain with mark - pillars.
- b. This intake-area, as it is called, should be declared a protected zone during building and after completion to minimise factors which may cause pollution.
- c. No attempt should be made to change the spring's natural flow. If there is any obstruction the water will try to find way around it, and the spring may get dirty. The free flow of the water must be guaranteed during the construction.
- d. The installation has to be built carefully, to prevent the possibility of leakages and water pollution whether by accident, negligence or even malice.
- e. The construction of the catchment installation, and its depth, will depend on several considerations. Some of these are:
 - geological considerations - the type of rocks and terrain in the district,
 - the type of matter or soil which covers the water bearing earth,
 - hygiene consideration
- f. The spring catchment should be built right up to the impermeable stratum, which should not be broken.
- g. Plastering near a spring should be avoided.

1.2 The Catchment Area

As we said before, the intake area should be declared a protected zone. Unless they are directly working on the project people should be prohibited from entering it, and actively prevented from doing so. Within this area there should be no farming, building or other activities.

As a preparation for building, the boundaries of the area should be marked on the ground by stones or concrete pillars, and the direction of the flow of water from the catchment installation itself should also be marked in this way.

It is a good idea to plant grass over the installation after it has been completed, and to keep it short by cutting it regularly. Trees can be planted to provide shade, and protect the water, but they should not be closer than 10 metres to the catchment installation itself. This is so that their roots do not grow to interfere with the source.

Drains should be constructed to divert or drain off any surface water that collects within the area, so that there is no possibility of pollution from this source.

Refer to page 4 for the relevant diagram.

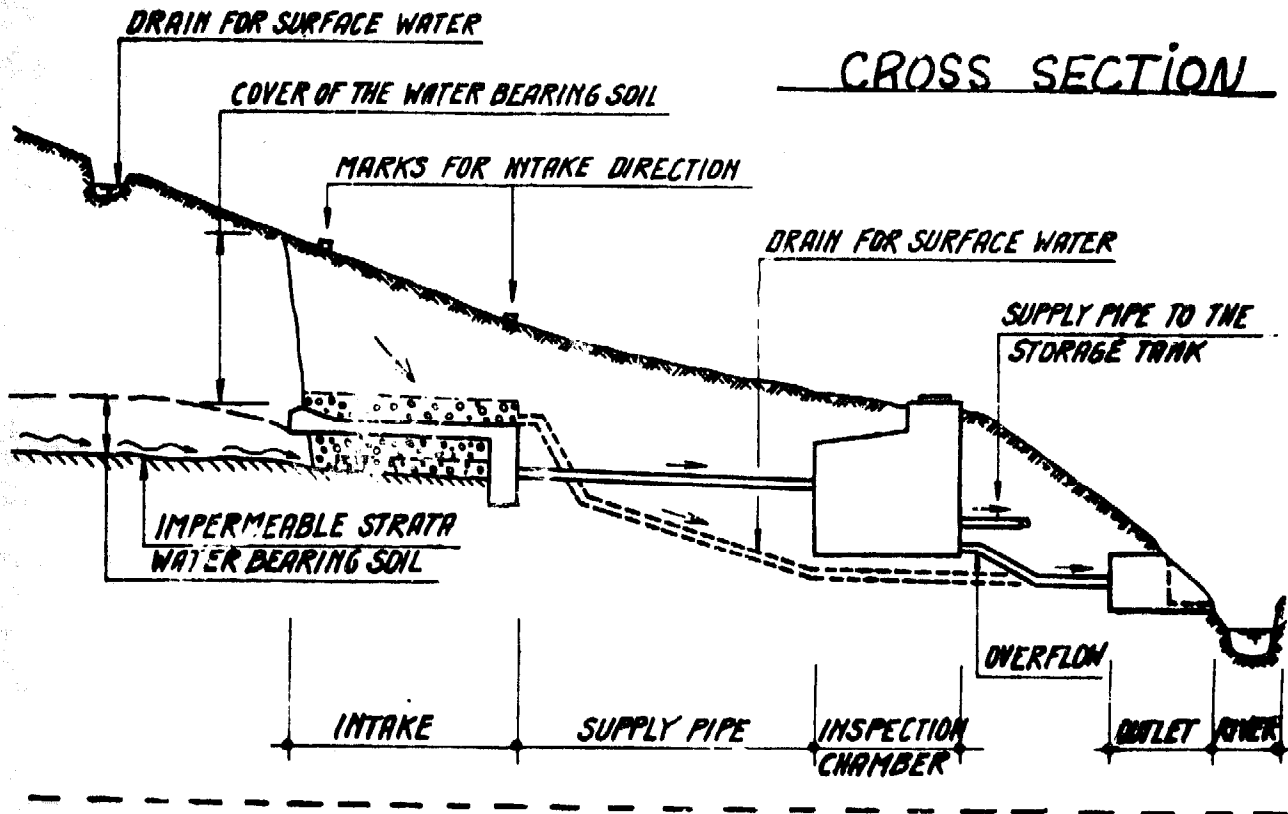
1.3 Spring Catchment Installation

There are three elements which comprise a spring catchment installation: (see page 4).

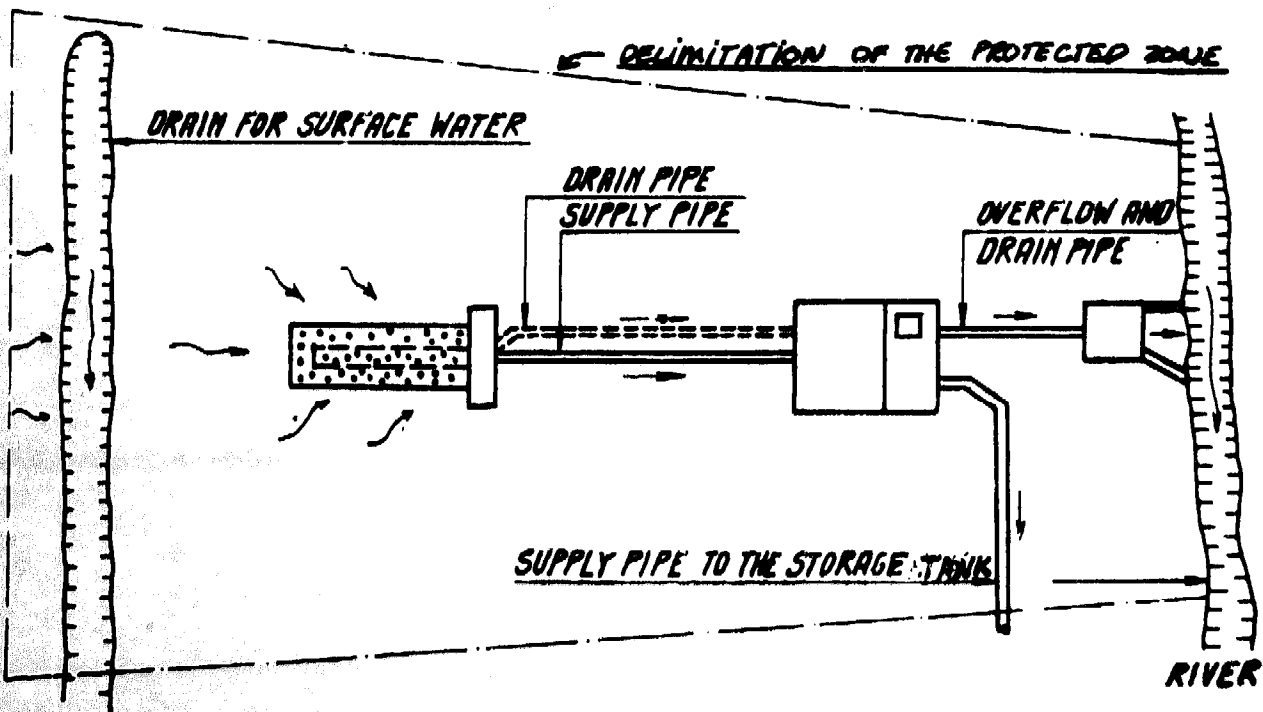
- a. The catchment itself made by perforated pipes within a trench or by a dry wall channel.
- b. The supply pipe to the inspection chamber.
- c. The inspection chamber. This consists of an entrance basin for the spring water and an operation chamber. Its purpose is to help in controlling the water's quantity and quality. Sometimes it can also serve as a sedimentation chamber, but it should not be confused with the storage tank.

FIGURE 1.1

Spring catchment - general arrangement



PLAN VIEW



1.4 Trench Catchment

The simplest type of water catchment installation is a trench, containing a perforated pipe, which allows water from water bearing soil to seep into the pipe, through the perforations, and collect there. Alternatively a dry-wall channel can be built, (i.e. a channel constructed without the use of cement which would make it water-tight). This will function in the same way. For many situations in Nepal this is the best method, as it can be constructed using local materials without having to bring in special pipes.

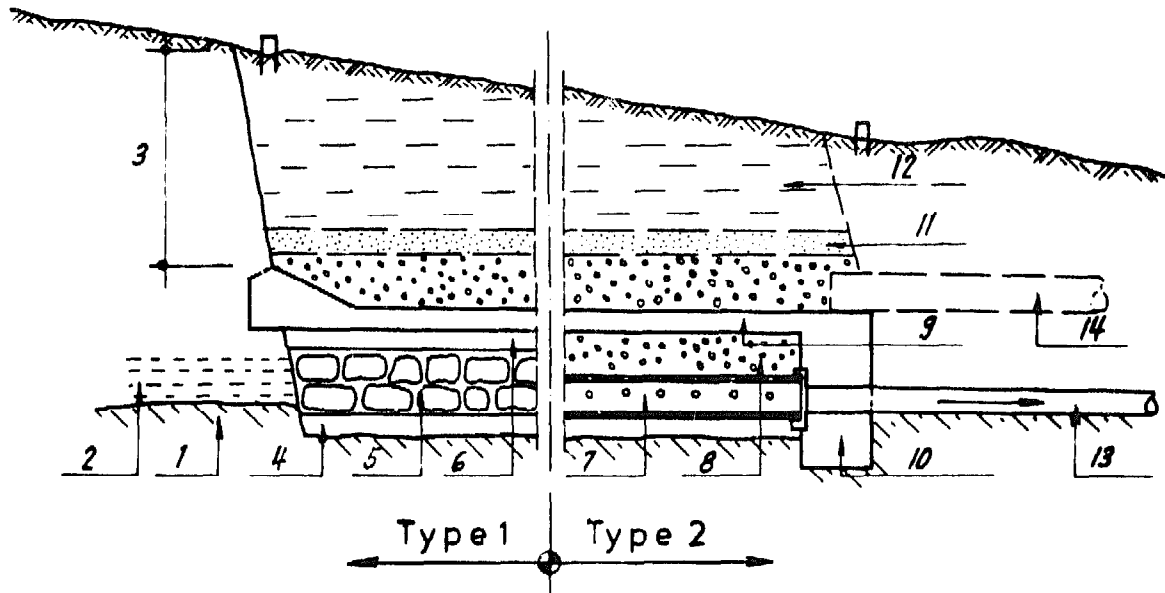
The diagrams on pages 6 and 7 give more details. The sectional elevation Type 1 shows a cross section of a catchment installation using a drywall channel. Type 2 shows a cross section using perforated pipe. The plan shows the overhead view.

Some points to remember

- The distance between the trench and any trees in the area should be large enough to ensure that no roots can enter the catchment.
- The cross section of the catchment drain or dry wall channel should be large enough to ensure that the amount of water drained off is the maximum possible. If it is too small it will obstruct the natural flow of the spring or water-bearing soil.
- A small dam or barrage (10) should be constructed below the lowest water outlet. This marks the end of the catchment trench and the beginning of the supply pipe to the inspection chamber. The barrage should be built into the impermeable stratum, as well as into both side-walls of the trench, to prevent the water from finding a way around it.
- If perforated pipe is being used, the sides of the ditch around it and the first 30cm. above the pipe should be filled with gravel. The size of the gravel - its minimum diameter - should be related to the size of the holes in the perforated pipes. If a dry wall channel has been adopted as method of catchment it should be roofed with slabs, with gravel around the sides, the size of the gravel again being related to the size of the spaces in the dry wall. People should be forbidden to walk on the gravel during construction.
- The drain or dry wall channel and the layer of gravel need a watertight cover of concrete which extends on both sides, 10 to 20cm. above the walls. Surface water reaching this cover should be drained off at the dam.
- It is important to construct the catchment trench itself very carefully, because it will no longer be accessible after completion of the work. This is because the hole will be filled with layers of backfill, (12) to protect it from above.
- The supply pipe material will need to be resistant to corrosion.

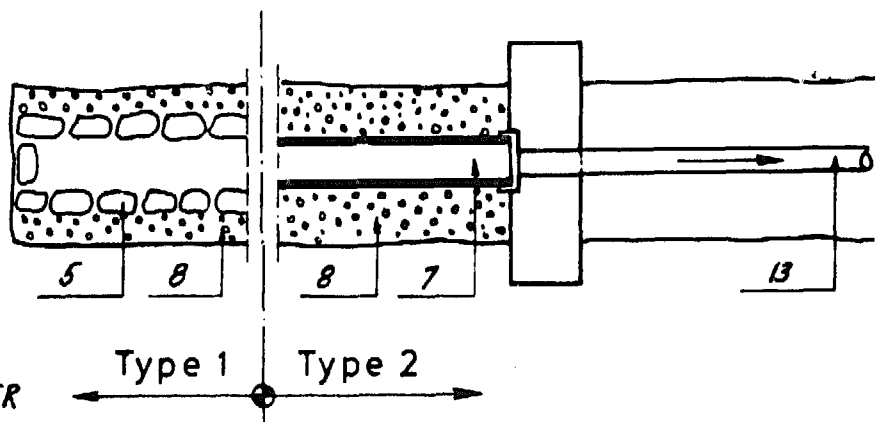
Intake--details

Sectional Elevation

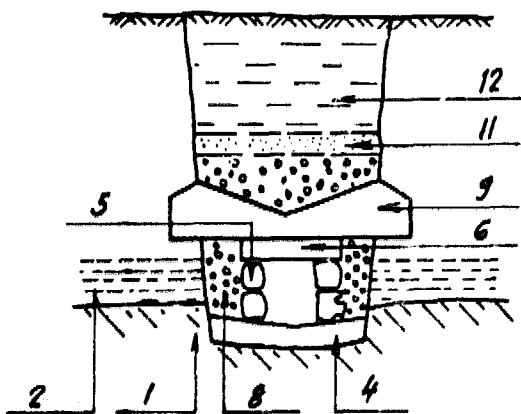


- 1 IMPERMEABLE STRATA
- 2 WATER BEARING SOIL
- 3 COVER OF WATER BEAR. SOIL
- 4 BED PLATE
- 5 DRY WALL
- 6 SLABS
- 7 PERFORATED PIPE
- 8 GRAVEL
- 9 WATERTIGHT COVER
- 10 DAM
- 11 PERMEABLE MATERIAL
- 12 IMPERMEABLE BACK FILL.
- 13 SUPPLY PIPE
- 14 DRAIN FOR SURFACE WATER

Plan



Cross section type 1



Cross section type 2

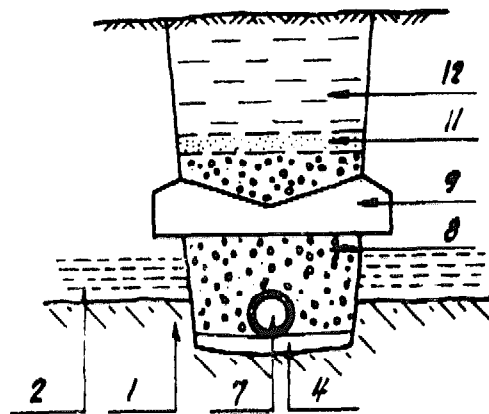
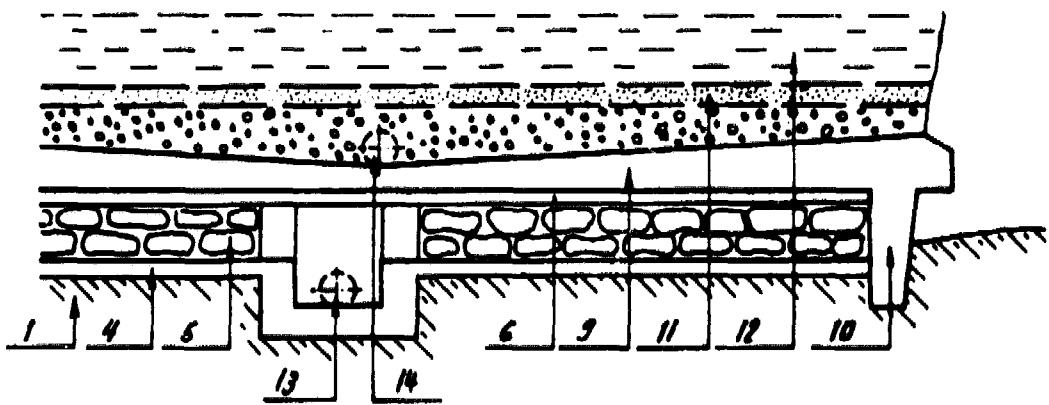


FIGURE 1-3

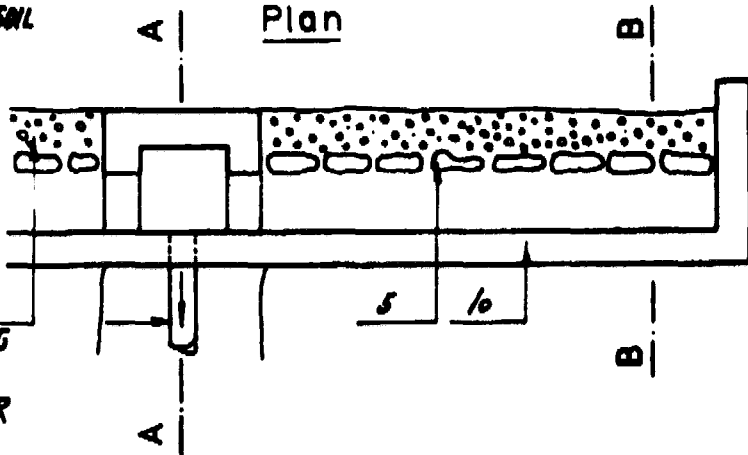
Intake across a slope - details

Sectional elevation

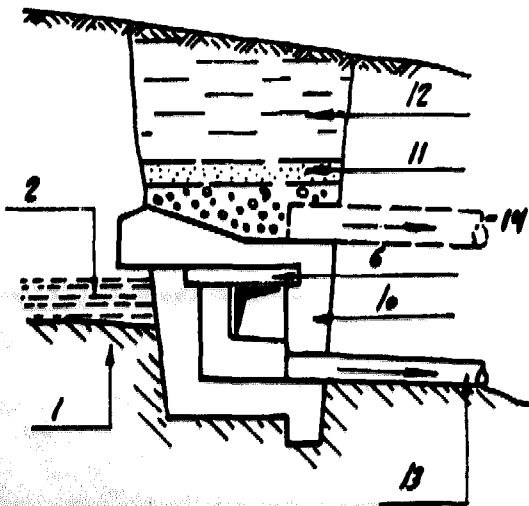


- 1 IMPERMEABLE STRATA
- 2 WATER BEARING SOIL
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- 12 IMPERMEABLE BACKFILLING
- 13 SUPPLY PIPE
- 14 DRAIN FOR SURFACE WATER

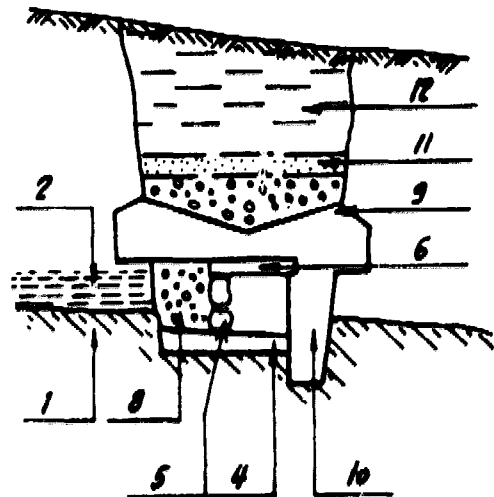
Plan



Section A-A



Section B-B



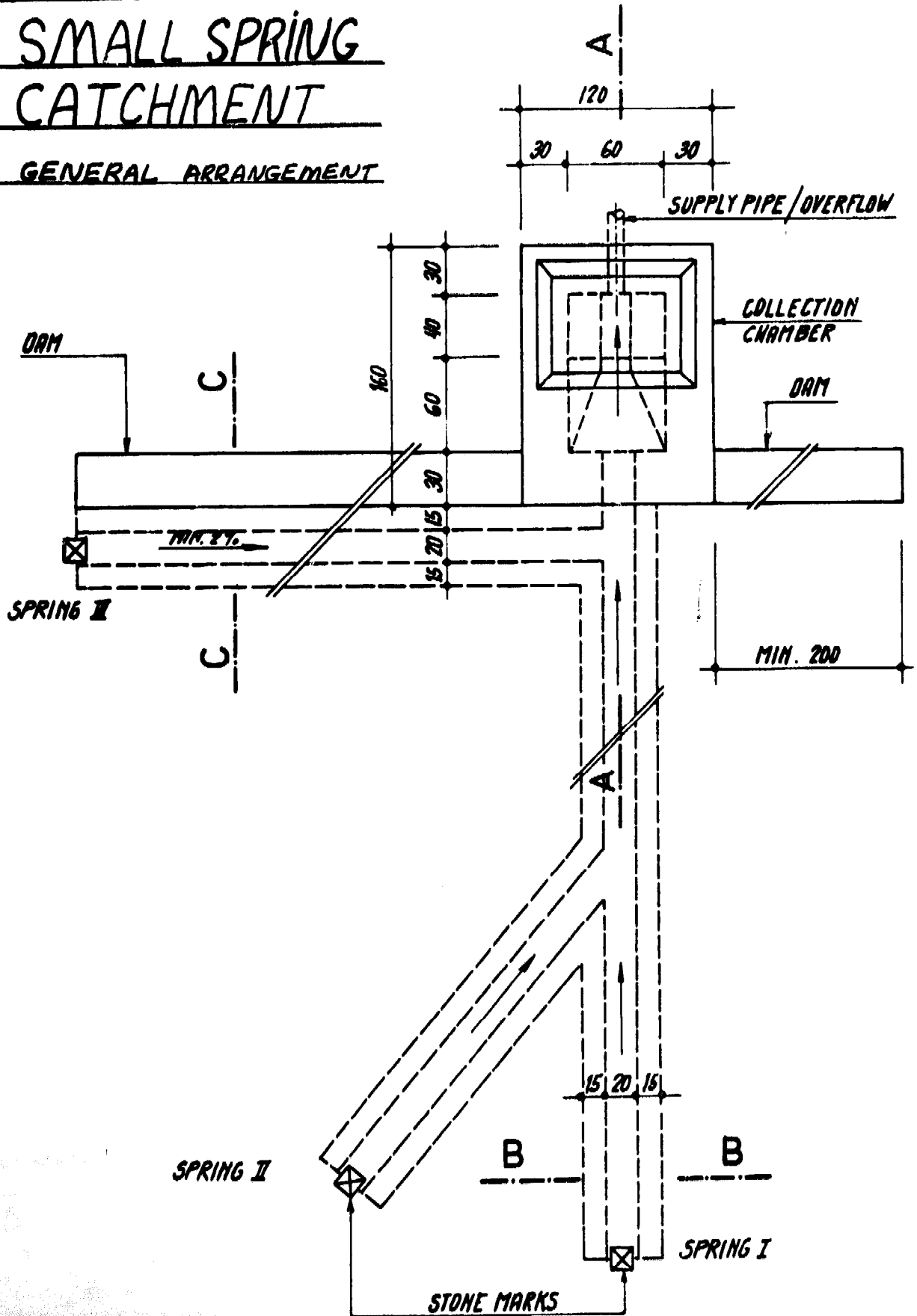
1.5 Small Spring Catchment

This method is suitable for areas where there are small springs - perhaps several of them in close proximity. To be feasible the flow of water from a single spring should not exceed 1 litre per second.

It is a simple construction, consisting of several small trench - catchments made with stone masonry, so that there is a catchment channel for each place where water is coming from the soil. The maximum length of a channel branch should be 20m. If it is more than 20m. a collection chamber (or control chamber) should be built.

The following sketches show the design of this type of catchment installation. The measurements on the diagram are in centimetres.

FIGURE 1.4
SMALL SPRING
CATCHMENT
GENERAL ARRANGEMENT



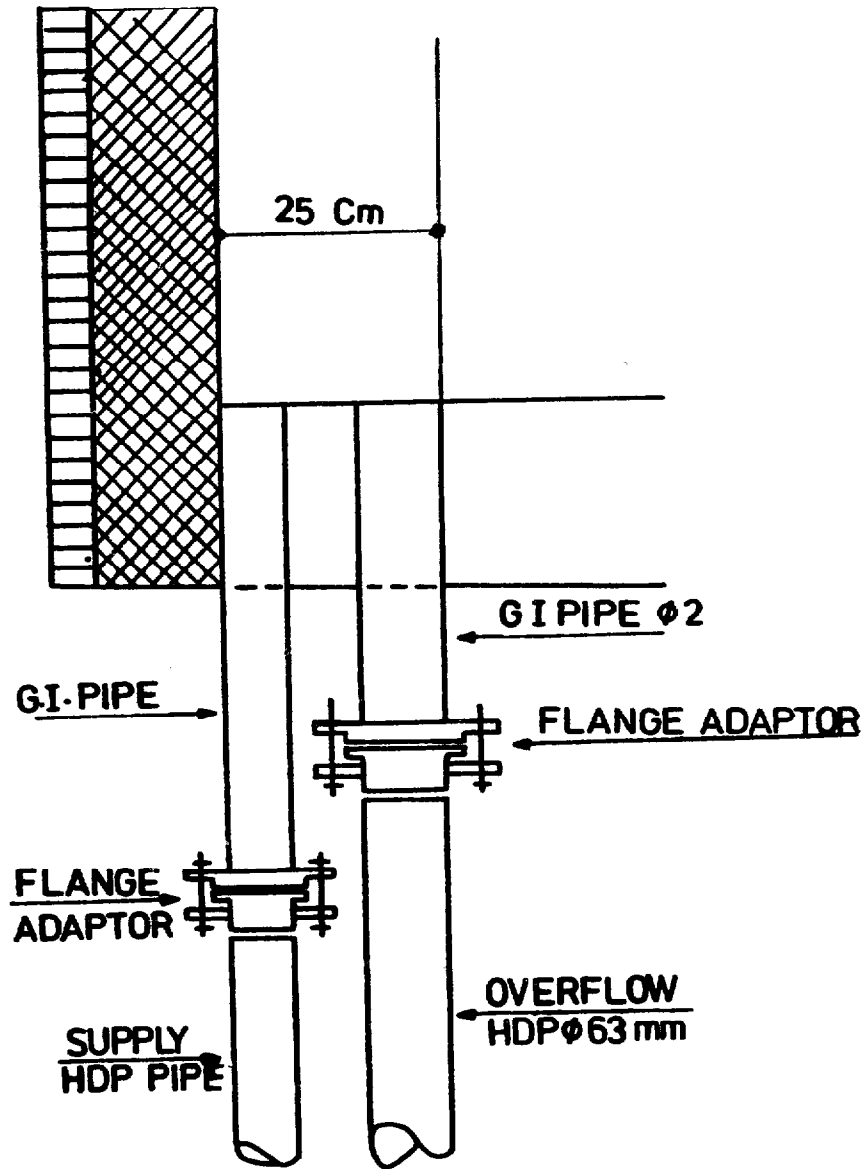


FIGURE 1.6 - DETAILS OF FITTINGS USED
IN FIGURE 1.5

1.6 Small Stream Catchment

In certain cases, especially in high, rocky country, the possibility of trapping water from one spring does not exist. Often in these cases, water comes from between rocks at places which are distant from each other, and at each spot the yield of water is very small. To ensure an adequate quantity of water for a supply therefore, we must first direct all the available water into a stream. In other cases water seeps out of the ground over a large surface area, for example a river bed. Here, too, there is no specific spot at which to trap the water.

In such cases, a small stream catchment installation must be built. This consists of the following elements:

- A dam across the stream.
- A spillway at the dam.
- An intake chamber.
- Protective walls on each side of the intake chamber.
- A cleaning out valve.
- A supply pipe with control valve.

For details of this, look at the diagrams on pages 13, 14, 15 and 16. Study them and ask the instructor if anything is unclear to you.

When a project uses this type of water source, we recommend that a sedimentation tank and slow sand filters be built to ensure the quality of drinking water is up to standard. There may be impurities in the stream water.

FIGURE 1.7

SMALL STREAM CATCHMENT DETAIL

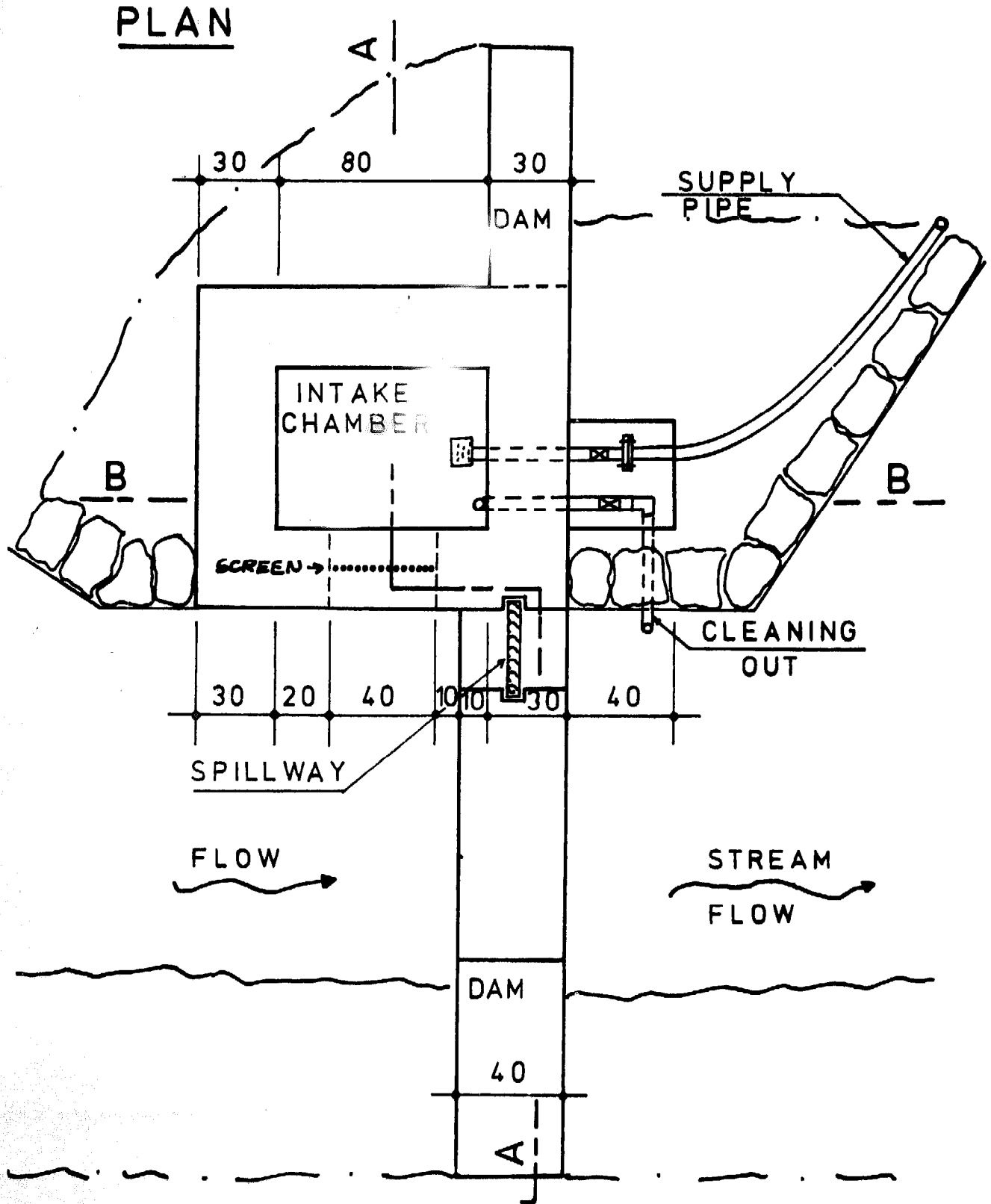


FIGURE 1-8

SMALL STREAM CATCHMENT DETAIL

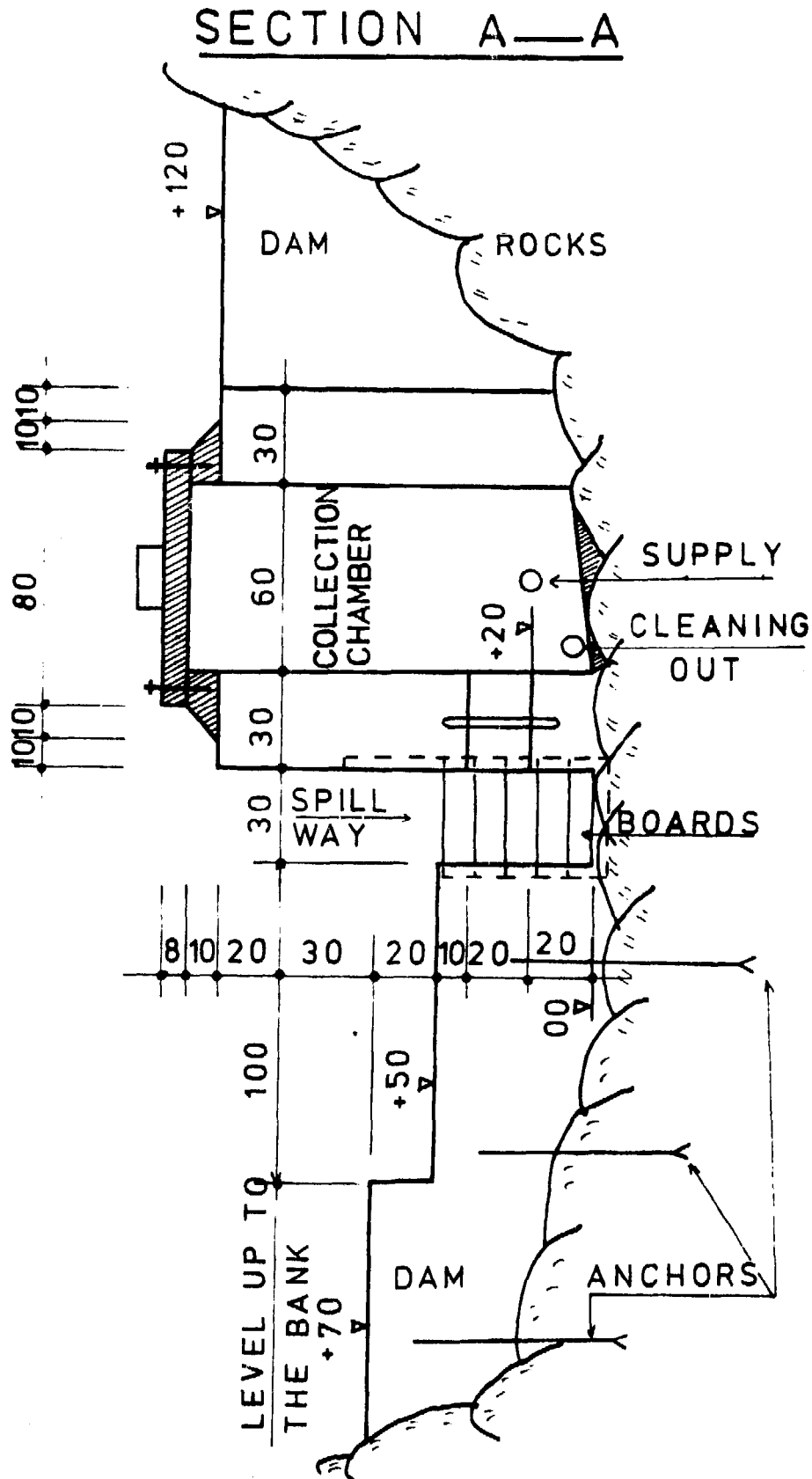


FIGURE 1.9

SMALL STREAM CATCHMENT DETAIL

SECTION B—B

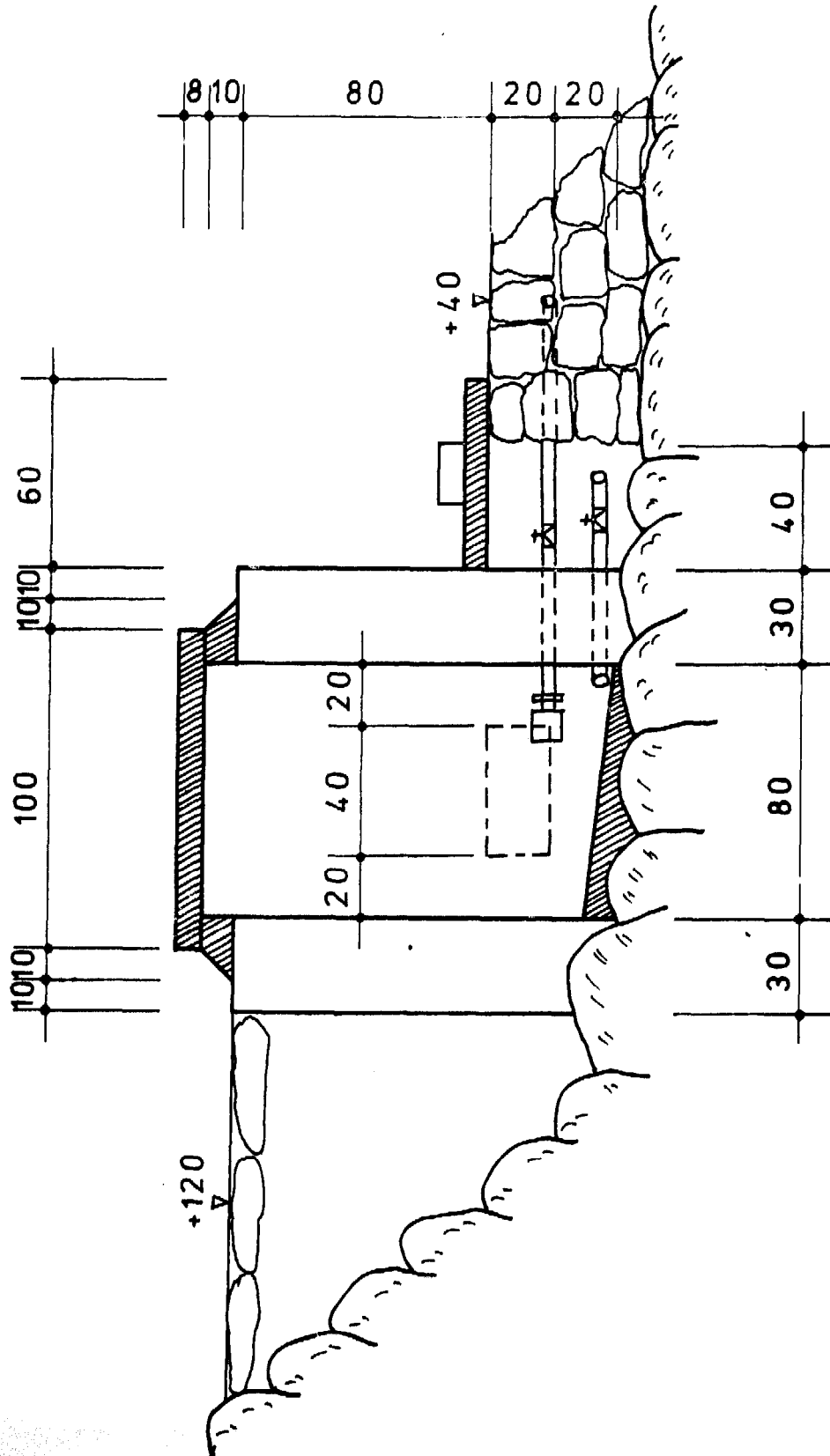
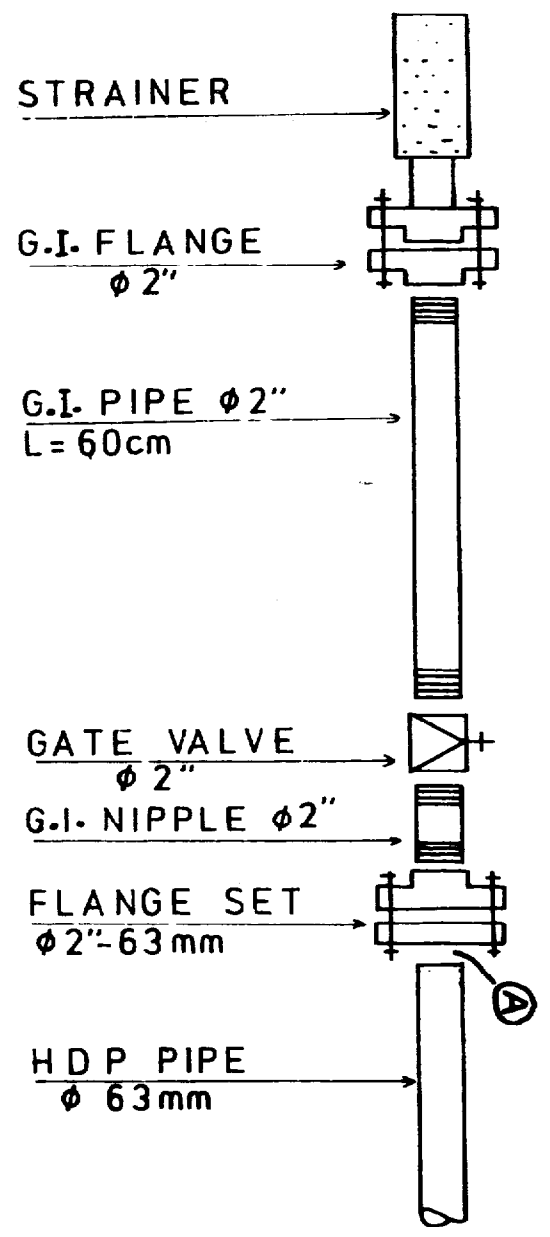


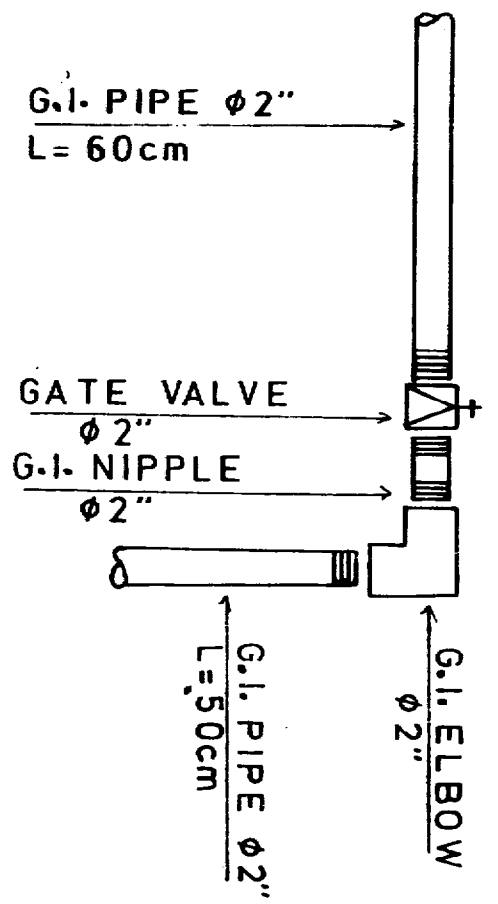
FIGURE 1.10
SMALL STREAM CATCHMENT INSTALLATION DETAILS

OUTLET



NOTE: IF THE DIAMETER OF THE PIPELINE IS SMALLER THAN THE CUTLET DIAMETER, A HDP REDUCER SHOULD BE USED AT POINT (A)

CLEANING OUT



1.7 Inspection Chamber

The function of an inspection chamber is to control the quality of the water before it is stored or distributed. It consists of an entrance basin, where water collects, and an operation room.

It is important for hygienic reasons that timbers (wood) are not used as building materials and that no timber is left in the catchment installation or inspection chamber. The timber will get rotten and will become a breeding place for insects and micro-organisms leading to pollution of water. Concrete and stone masonry are the most suitable building materials for a long-lasting spring catchment installation and inspection chamber.

The inspection chamber should be built at a level lower than the spring, so that there is no obstruction to the flow of water. (See page 4)

If there are two or more catchment trenches, each spring catchment installation will need its own entrance basin, from which the water flows into a collection basin. It should be possible to drain each basin so that a single spring, if necessary, can be cut off from the supply. (See page 9)

The chamber should be ventilated, if possible in combination with a drain pipe or an entrance. It should not be built too small, since sufficient room should be allowed for all installations. This is especially important for future maintenance. Enough space should be allowed to swing a wrench easily for valve changing.

The inflow pipe must be 20cm. above the highest possible water level in the entrance basin. The dimensions of the overflow pipes and drains must be large enough to enable the total capacity of the spring to be drained off, without restricting the flow of water from it.

Ventilators and manholes should be placed in the operation room. They should not be located directly above the water. They should be 50cm. above ground-level with foot-steps down at 25cm. intervals. Manhole covers should be locked to prevent unauthorised persons from prying them open. It is advisable to cover the chamber (excluding the entrance) so that the water is not influenced by the outside temperature. All openings (including the overflow and the manhole) have to be constructed in such a way that the possibility of pollution is prevented and so that there is no chance for small animals to enter into the chamber.

Corners and edges have to be rounded and the structure has to be waterproof inside and outside. For details of the fittings for an inspection chamber, see the storage tank diagrams (pages 36, 37, 41, 42, 43 and 44).

FIGURE 1-11

Inspection chamber with manhole - details

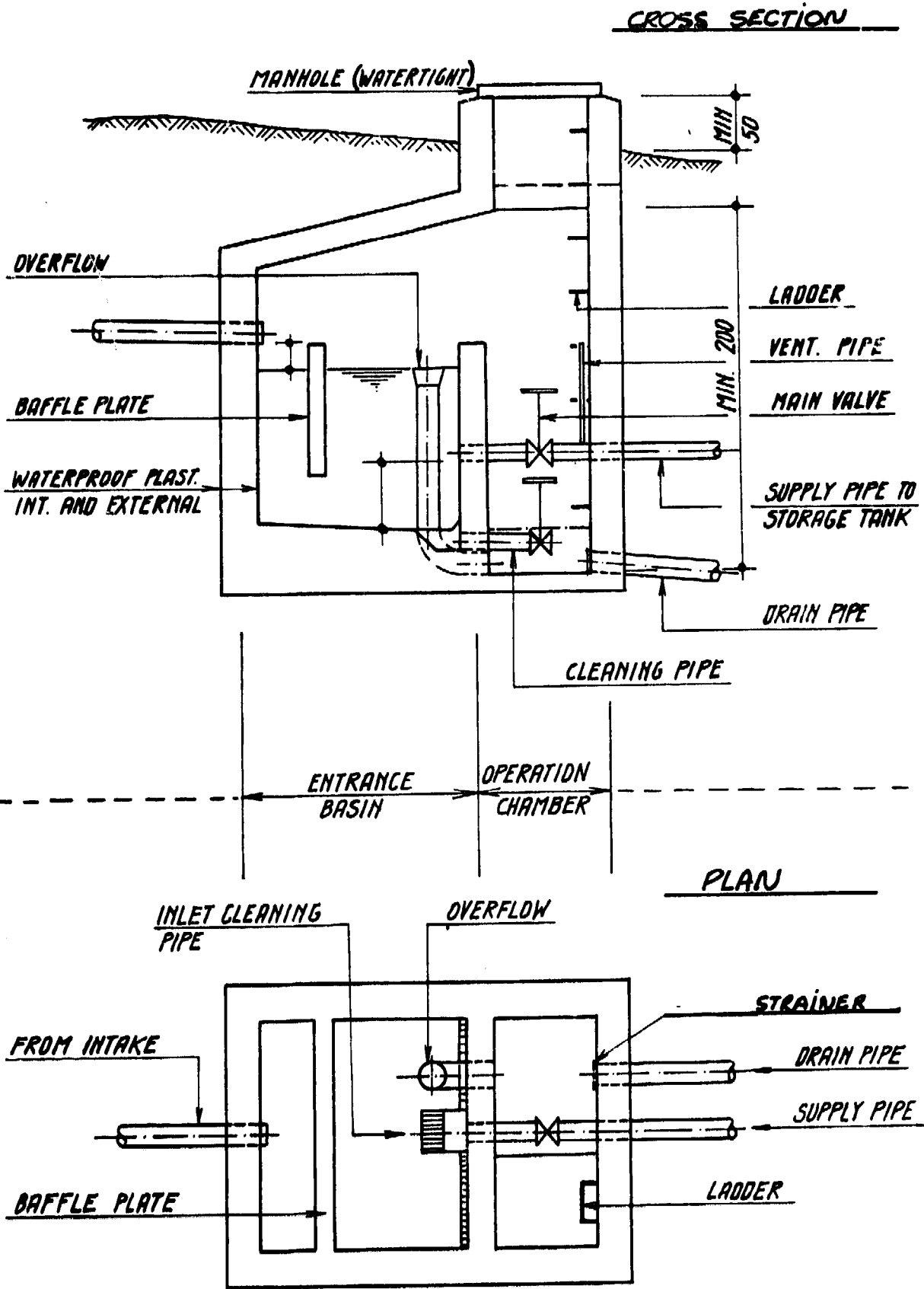


FIGURE 1.12

Inspection chamber with door—details

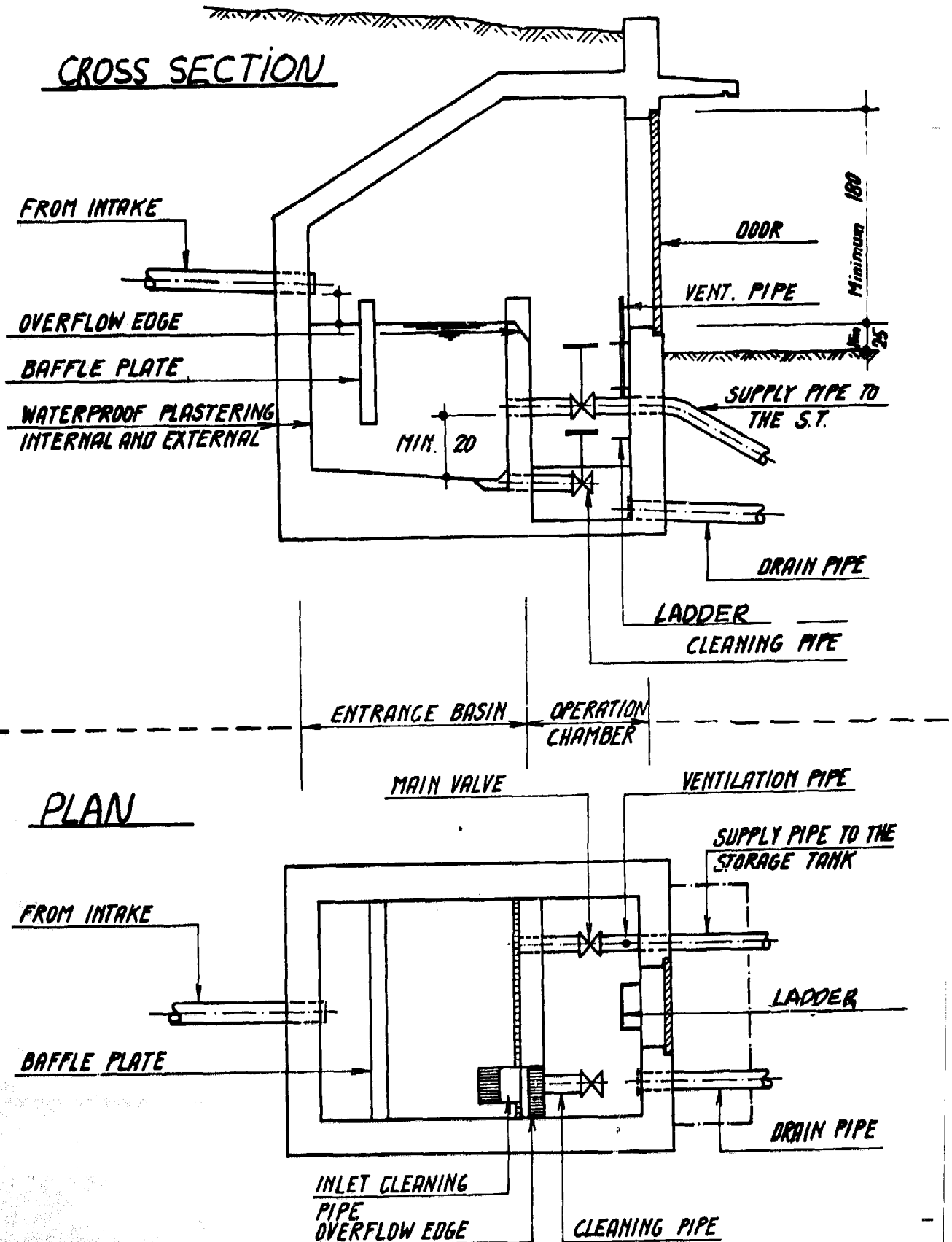
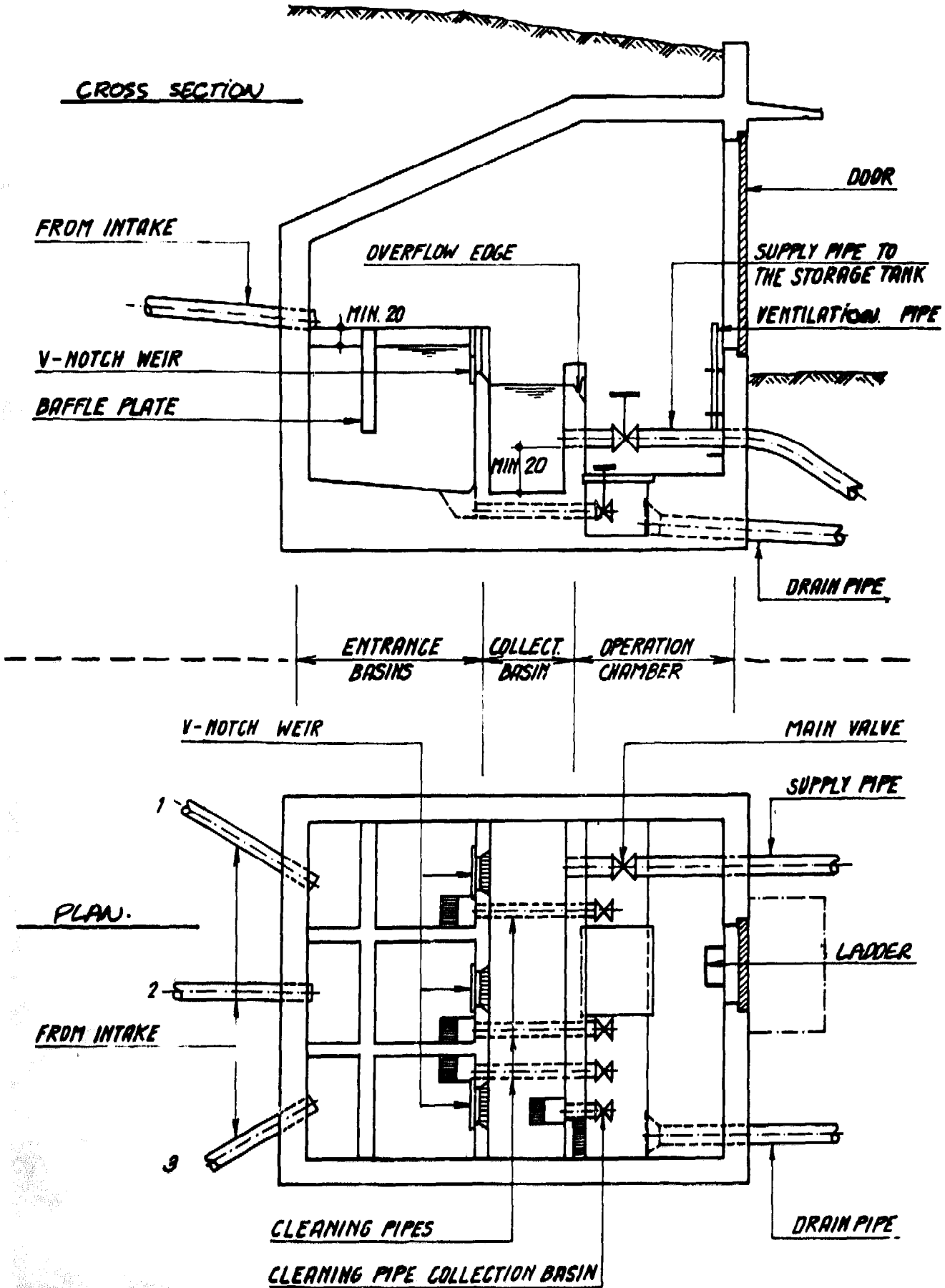


FIGURE 1-13

Inspection chamber for several intakes - details



2. WATER QUALITY

2.1 Water Treatment In The Rural Situation

Having dealt with the installations relating to establishing a water source, this section of the course will deal with the installations which ensure that the water is as pure and clean as possible.

It should always be the policy of the responsible people, in charge of water supplies, to restrict the use of water treatment under rural conditions to those cases where such treatment is absolutely essential, and to those where correct plant operation and maintenance can be secured and supervised.

Projected water supply schemes should be studied carefully, looking at the engineering and economic considerations, so that the relative merits of different schemes can be compared. For example a scheme requiring water treatment must be compared with projects in which long pipelines bring water from a spring which is far away. It would be better to make a large investment at the beginning of a project, using a long pipeline, than to design a scheme in which there will be treatment costs and operational and maintenance problems.

In any case rural water supplies should be designed to safeguard and maintain the quality of the natural water selected, and if a catchment installation is correctly built there should be no need for elaborate treatment.

In many cases if the inspection chamber is constructed with a long basin, sedimentation will occur there. In other cases, however, a special sedimentation basin or chamber will need to be constructed. The objective is to attain the WHO standard for drinking water supplies without elaborate installations or treatment.

2.2 Filtration

Filtration is a process which purifies water of particles or bacteria remaining after the process of sedimentation. The first part of a filter is a bacteriological bed. Bacteria live on this bed and feed on other bacteria in the water passing through the bed. Thus they form a natural, organic process as a result of which bacteria in the water are digested, decomposed and disposed of. There are three main types of filters:

- slow sand filters with slow water velocity during filtration
- rapid sand filters with rapid water velocity during filtration
- pressure filters, contained in pressurised steel vessels, with rapid water velocity during filtration.

2.3 Sedimentation and Methods

Sedimentation is the removal of suspended particles by gravitational settling. It takes place in a special tank, designed for this purpose. In the basin, or tank, large particles of sand have time to settle at the bottom, and thus be eliminated from the water flowing above. Particles originally enter the water because they are washed into it by rain, especially during the heavy rain of the monsoon.

During the course we will be considering only one kind of sedimentation process, "plain sedimentation". There are, however, two other kinds, and all these are briefly described below.

Plain sedimentation - In plain sedimentation impurities are separated from the fluid by gravitation and aggregation, and they sink to the bottom of the special tank. Later this sediment can be cleaned out. "Aggregation" describes the natural tendency of particles to gather together. Plain sedimentation can be most effective when the temperature of the water is high enough to reduce the viscosity of the water, permitting suspended solids to settle out of it more easily.

Coagulation - In the coagulation process chemical substances are added to the water to induce aggregation. These chemicals cause fine suspended matter, large molecules and colloidal substances to settle. By colloidal we mean dissolved substances or compounds.

Chemical Precipitation - When chemical precipitation occurs chemicals are added to precipitate dissolved impurities out of solution in the water, by changing them into insoluble substances. Various factors affect the speed of sedimentation. Some of these are:

- a. The settling velocity. This is related to the mass, shape and density of the particles themselves and the mass, density and viscosity of the water.
- b. The drag force. This is related to the shape of the particles and the velocity, mass and density of the water.
- c. The concentration of suspended solids in the water.

For sedimentation to occur the speed of the water (its velocity) must be reduced. Therefore the water should move very slowly through the tank. Inside, the water surface should look quite still, and no disturbance of the flow should be seen. The slower the water the more particles will settle, especially smaller particles.

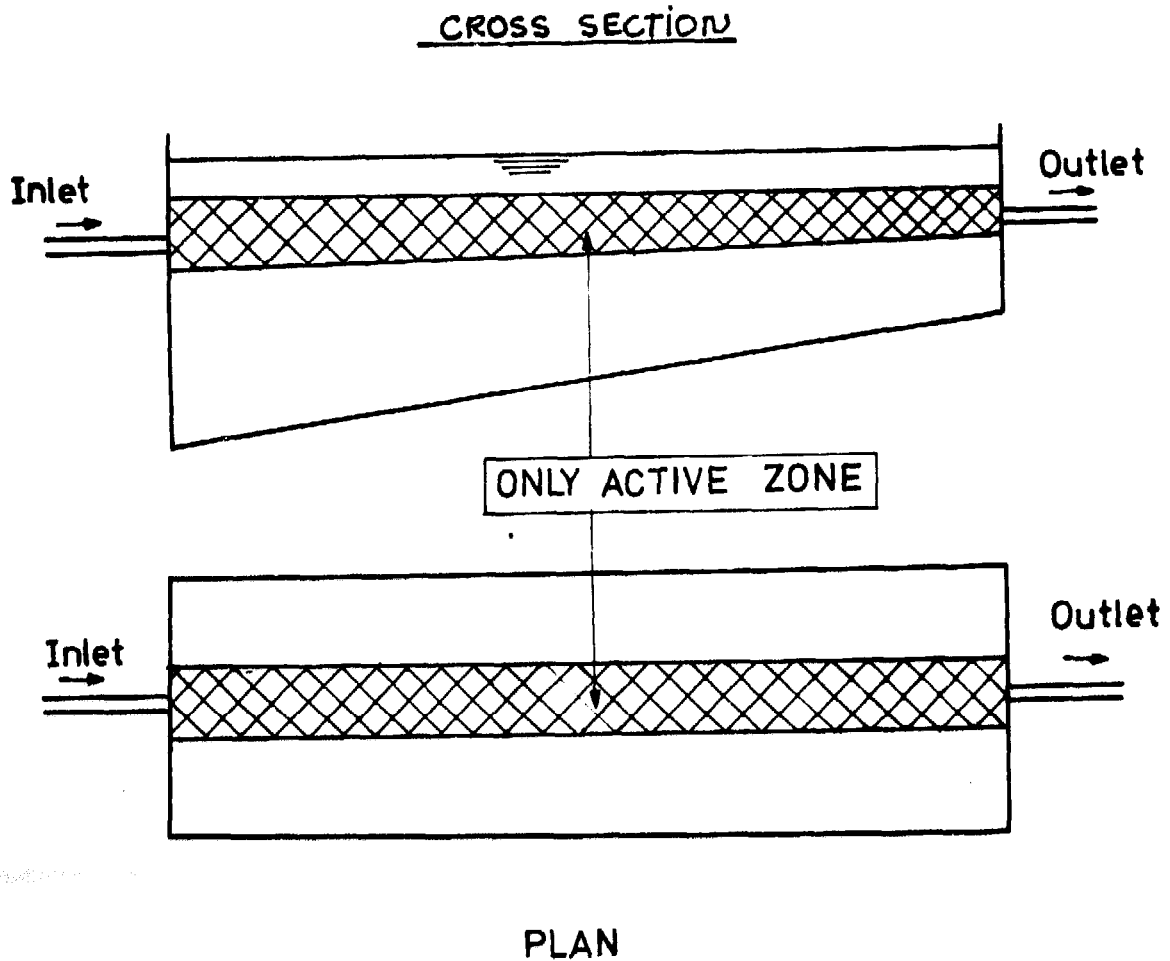
2.4 Elements of Tank Design

Since sedimentation efficiency depends to a greater extent on the design of the tank itself, we should remember the following points:

- The inlet and outlet should be constructed so that the water travels the longest possible distance. Avoid a straight path between inlet and outlet, as shown on the diagram below. A straight inlet creates an equally straight flow to the outlet and this reduces the overall efficiency of the sedimentation tank.
- It is important to achieve a uniform flow of water over the longitudinal section of the tank. Agitation of the water in the tank, caused by the circulation of the water, should be prevented.

WRONG INLET OUTLET POSITION

FIGURE 2.1



Tank Shape

- 24 -

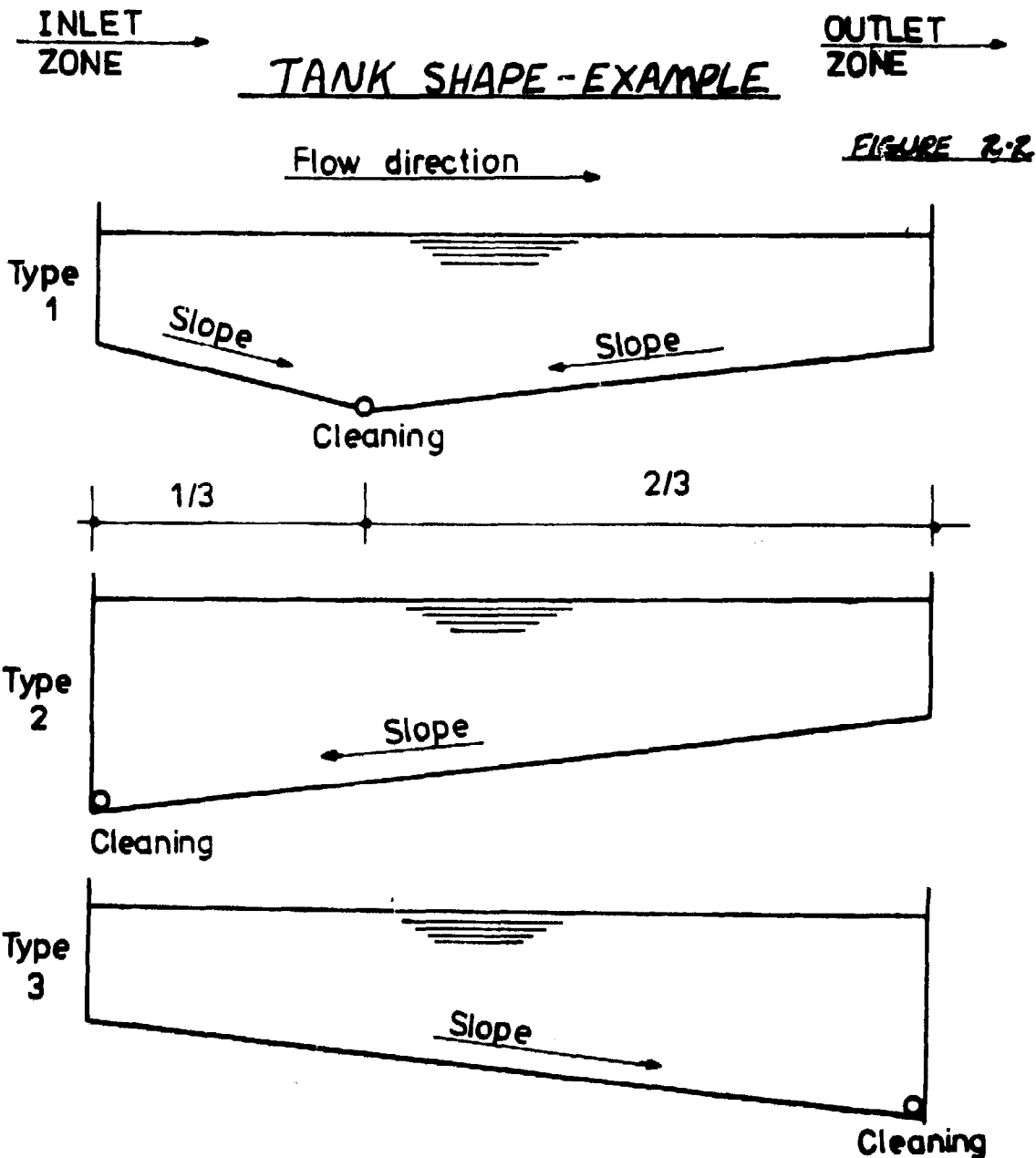
The dimensions of the tank are important as a relation exists between the surface area and the tank's efficiency. The greater the surface area the greater the sedimentation which will occur. The overseer in charge of the project will generally calculate the correct dimensions. The bottom of the tank should be sloping to enable it to be kept clean. Three types are shown below, all sloping.

Minimum slope = 3 degrees

Maximum slope = 8 degrees

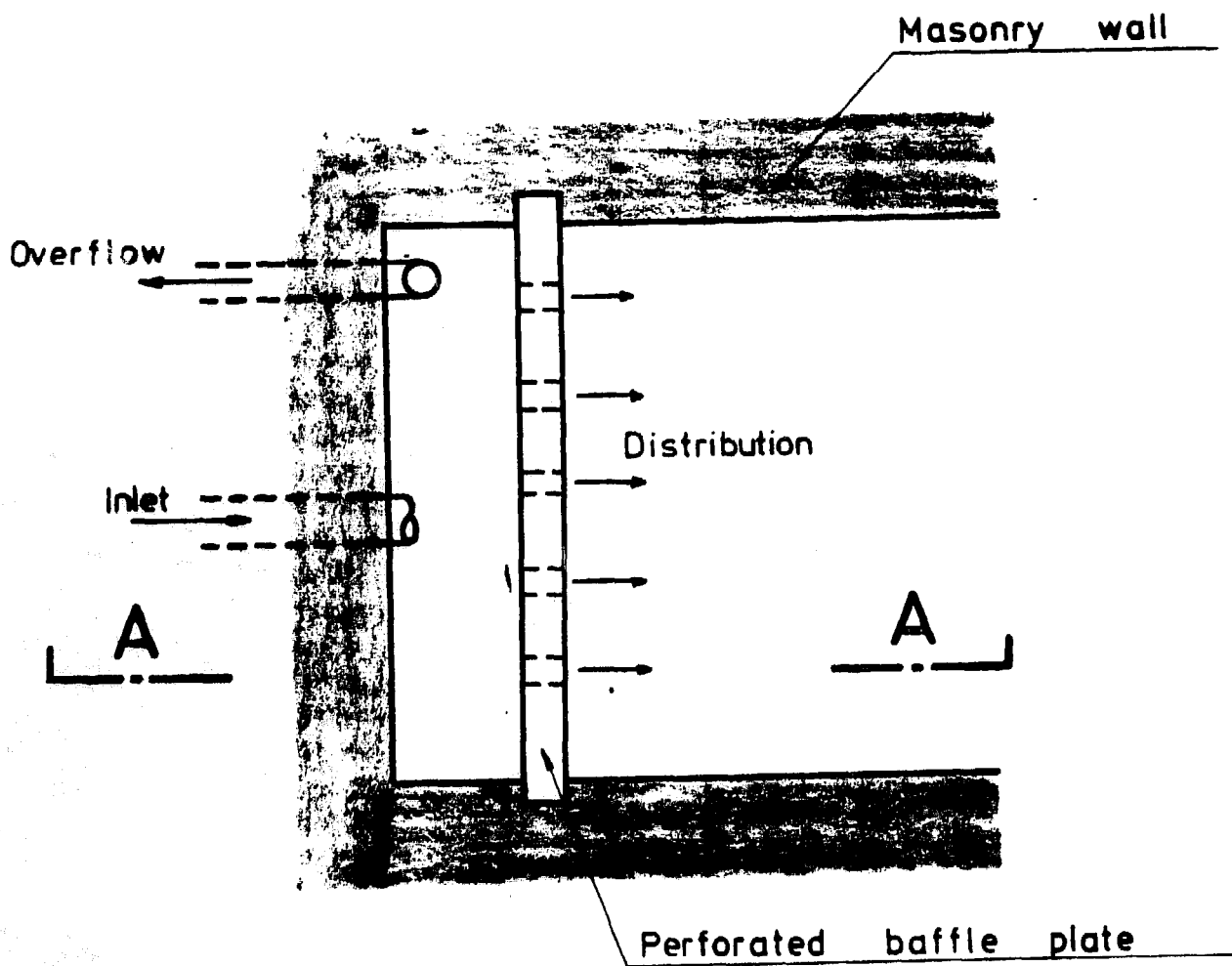
There are two types of sedimentation tanks, circular and rectangular. Rectangular tanks are easier to construct and so this type of tank is the subject of the designs found in the following sections:

Look at them. Ask the teacher any questions you have. Make sure you understand all the functions of each element in the installation. For details of the fittings of a sedimentation tank look at the fittings for storage tanks (section 3.3) and for break pressure tanks (section 4.2).



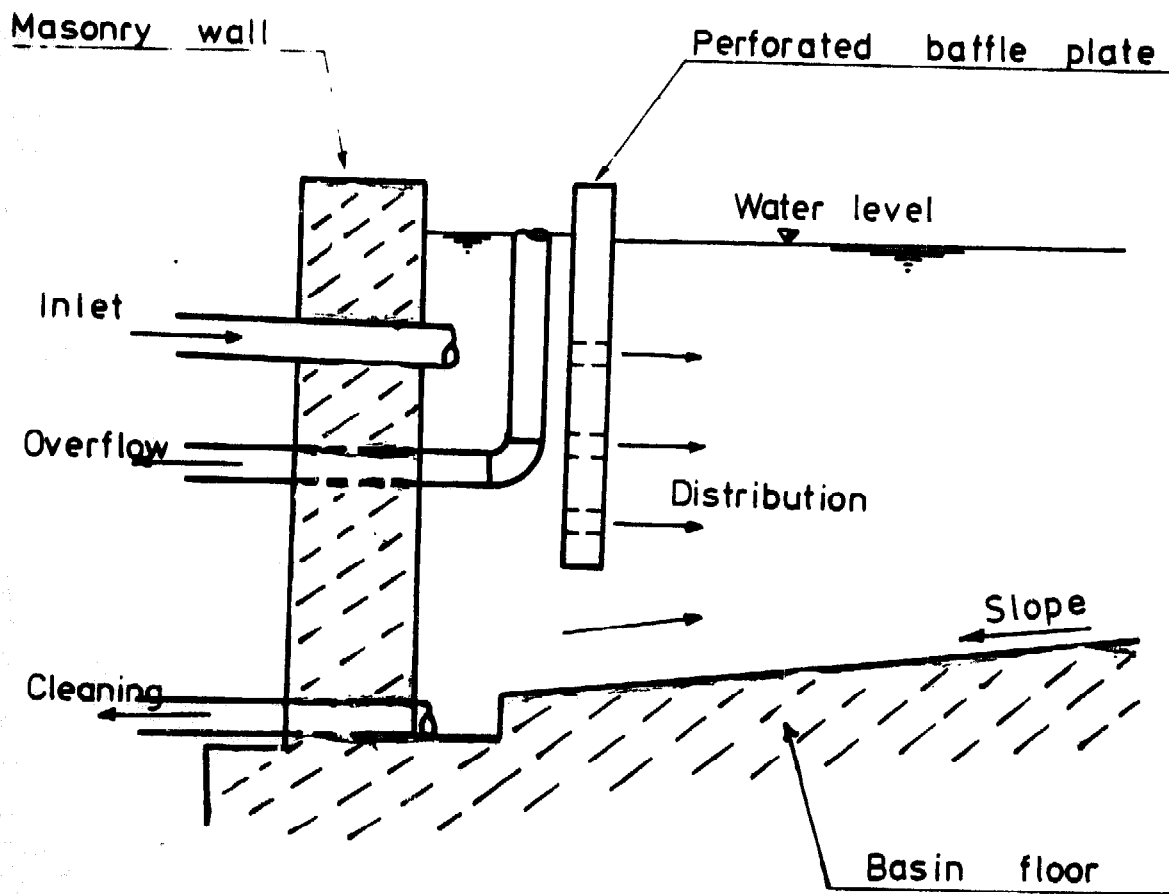
INLET PLAN VIEW

FIGURE 2.3



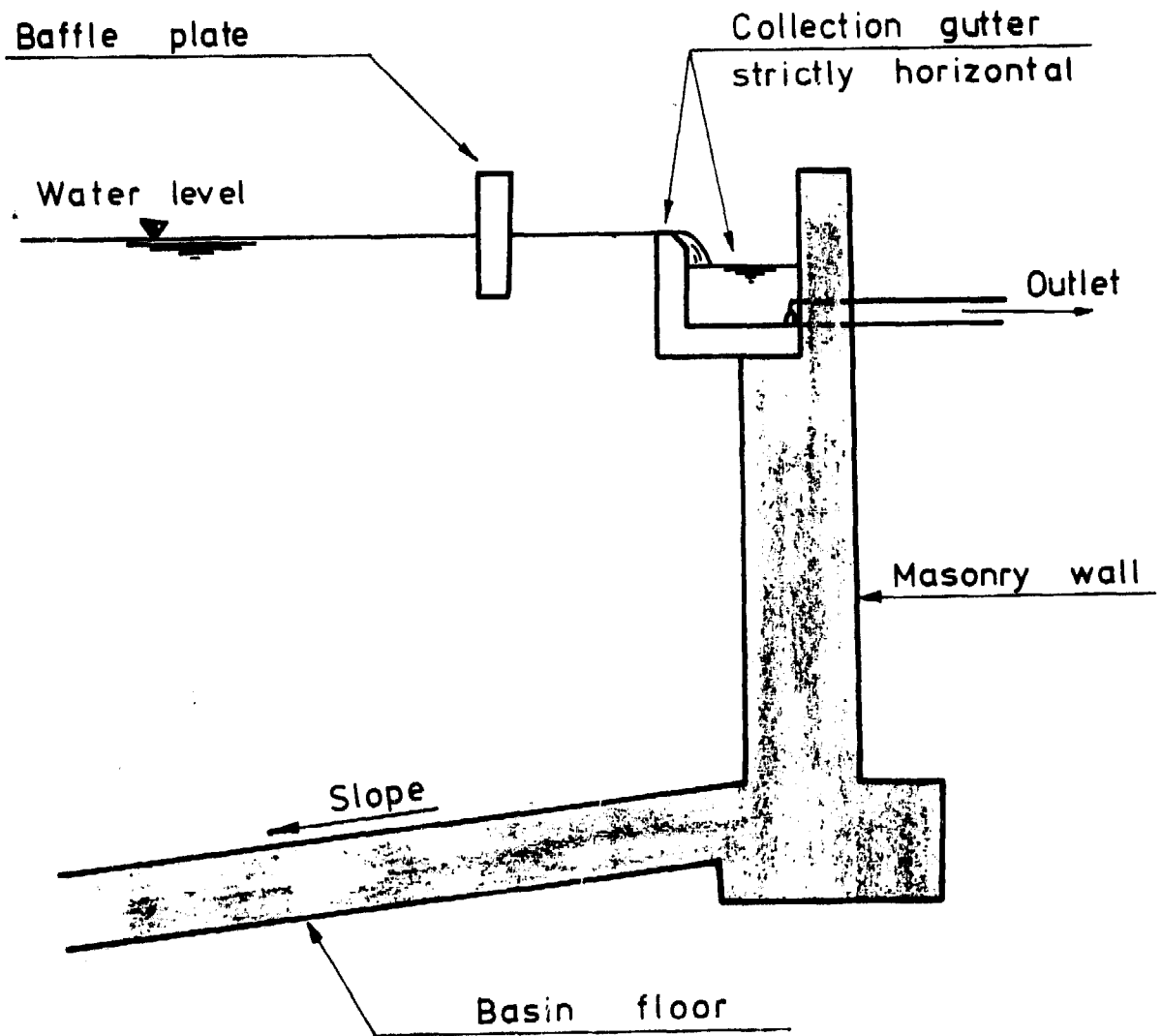
INLET CROSS SECTION A-A

FIGURE 2.4



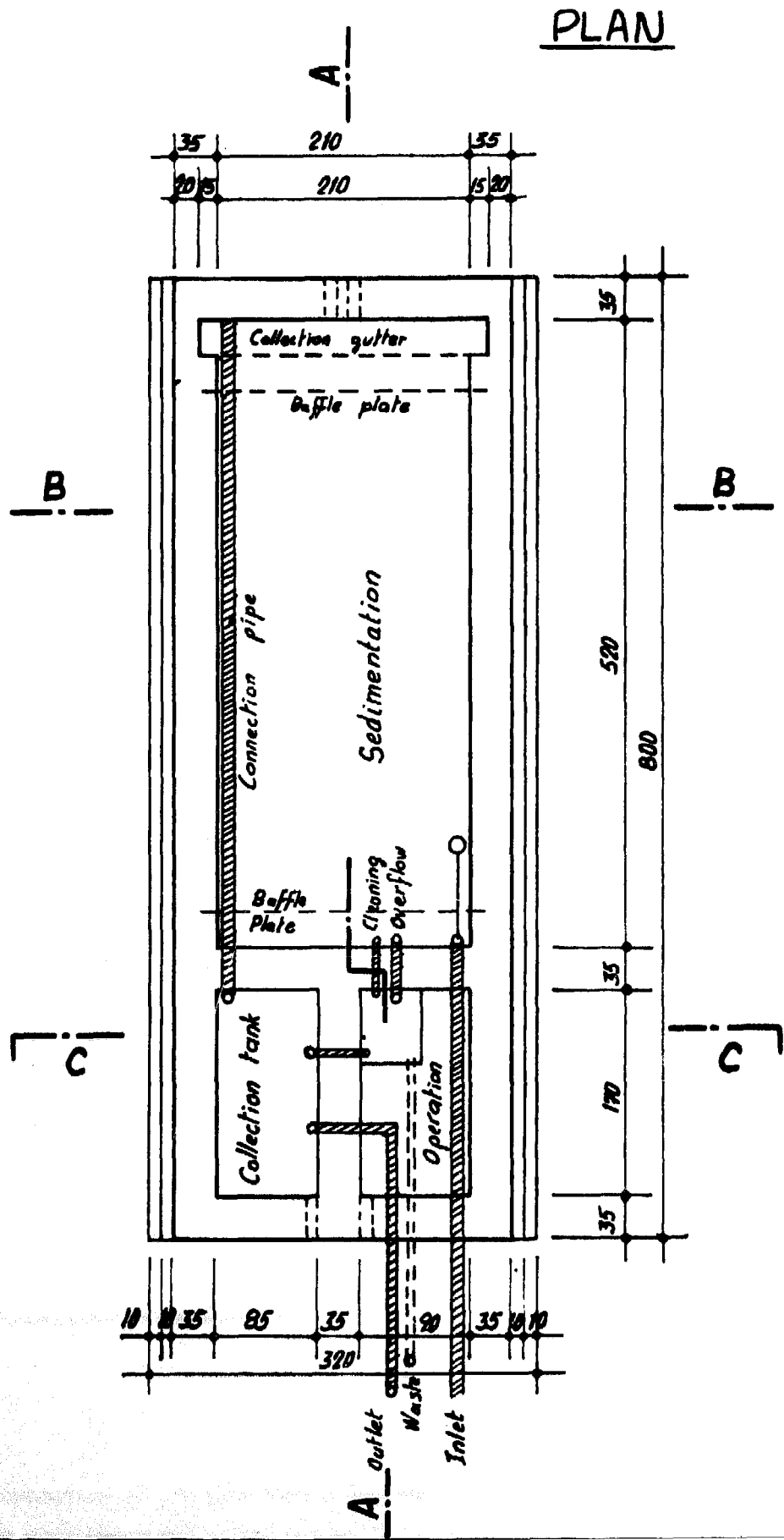
OUTLET CROSS SECTION

FIGURE 2.5



SEDIMENTATION TANK DETAIL

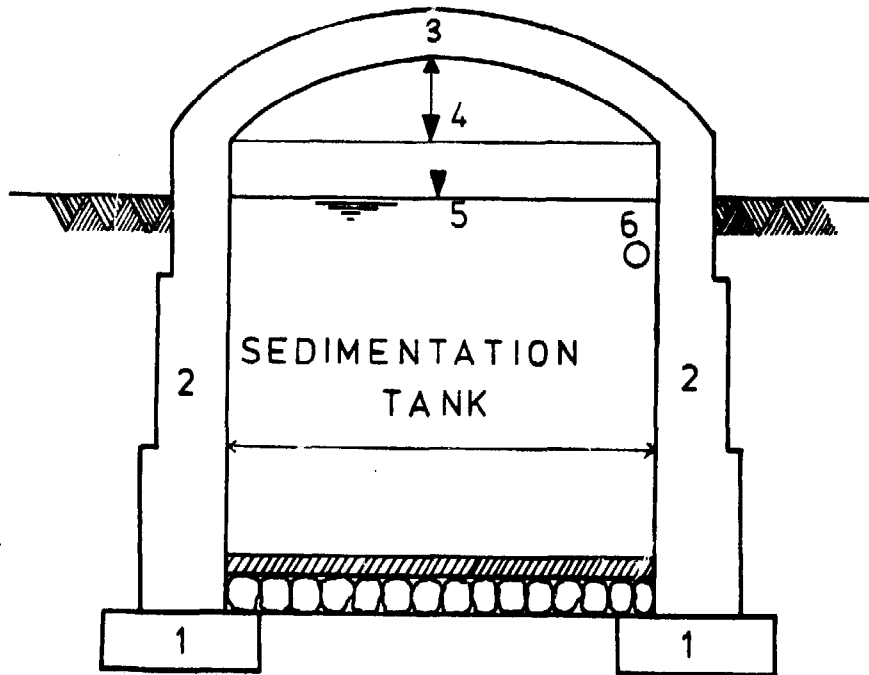
FIGURE 2.6



SEDIMENTATION TANK DETAIL




FIGURE 2-B

CROSS SECTION B—B



- 1-STONE MASONRY FOUNDATION
- 2-STONE MASONRY WALLS
- 3-STONE MASONRY ARCH
- 4-ARCH RISE
- 5-WATER LEVEL
- 6-CONNECTION PIPE

LEGEND:

-  Concrete
-  Hard core
-  Masonry

3. STORAGE TANKS

3.1 General Points, and Hygienic and Operational Requirements

A storage tank should always be constructed in a water supply system, for the following reasons:

- a. To plan for variations in the rate of consumption at different times during the day. The spring will be producing water continuously during 24 hours, but the time during which water is distributed is only about 13 hours, with a high demand in the morning and evening.

The typical pattern of draw-off in a Nepalese village is as follows, although local customs cause variation in consumption:

<u>From</u>	<u>To</u>	<u>% of daily demand</u>
5 am	8 am	40%
8 am	4 pm	20%
4 pm	6 pm	30%
6 pm	5 am	10%

- b. To enable the pipe line from the catchment area to the storage tank to be cleaned without stopping distribution to the village.
- c. To enable the diameter of the pipe-line from the catchment to be reduced.

The capacity of a storage tank is influenced by two main factors.

- a. The need to cover the peak demand periods.
- b. The need is to provide a reserve of water to cover break-down of supply, or normal interruptions due to maintenance work.

Hygienic Requirements

Water in the tank should be protected against external influences, and a good circulation of water ensured. Ventilation should be provided, but any doors or entrances must be insect proof.

Operational Requirements

An operation chamber as well as the storage room has to be provided. The supply must continue during cleaning work. Therefore tanks bigger than 38 cubic meters should have two independent chambers each with an overflow capable of draining all the incoming water. Each chamber has to be provided with a cleaning outlet to allow complete draining.

3.2 Siting the Tank

A site for the storage tank should be chosen which is as close as possible to the area where the highest consumption will occur. The tank should be between 20m. to 50m. above the area which will be supplied, although this elevation difference is only valid for pipelines which have a working pressure rating of 6kg./sq.cm. or less. In such cases, if the head difference exceeds 60m. break pressure tanks will be necessary.

3.3 Design and Capacity

Storage tanks are constructed square or rectangular. Stone masonry storage tanks are more economical if built in a circular shape. The following designs, however, are all for square tanks $9m^3$ or $22m^3$.

For rural water supply in Nepal storage tank size has been standardised as follows:

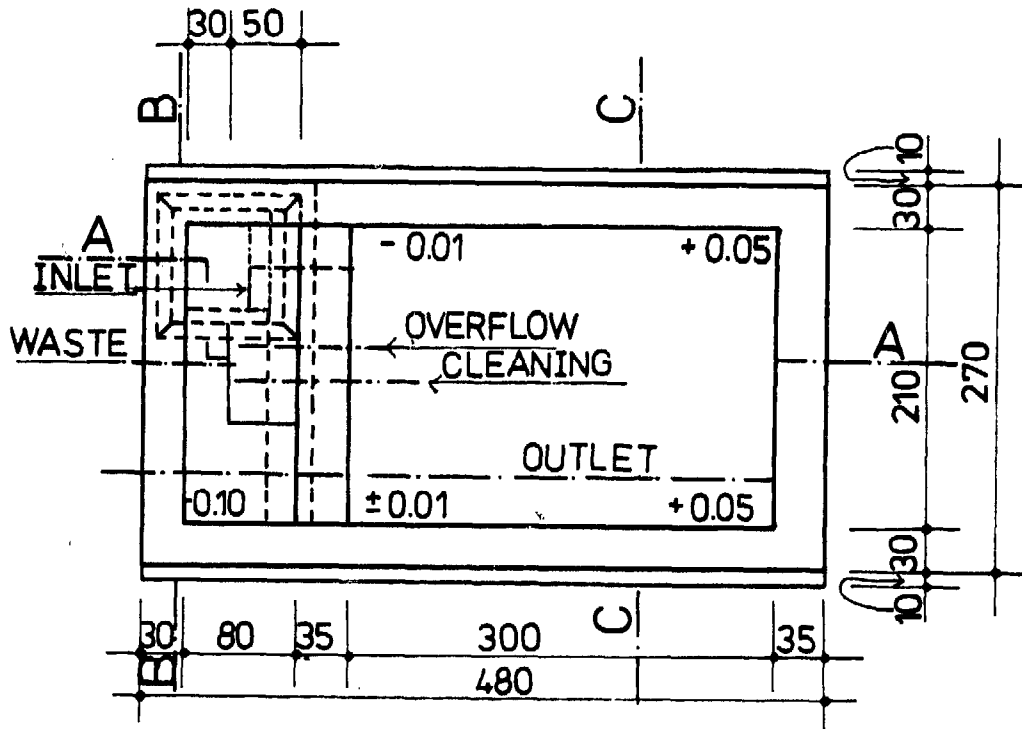
- Storage tank $2.5m^3$
- Storage tank $9m^3$
- Storage tank $16m^3$
- Storage tank $22m^3$
- Storage tank $30m^3$
- Storage tank $38m^3$

The water depth in tanks less than 100 cubic meters should not exceed 2m. by 2.5m.

Pages 34 through 44 describe storage tank design and give details of fittings used.

FIGURE 3-1: STORAGE TANK 9m³ DETAILS

PLAN



SECTION - A-A

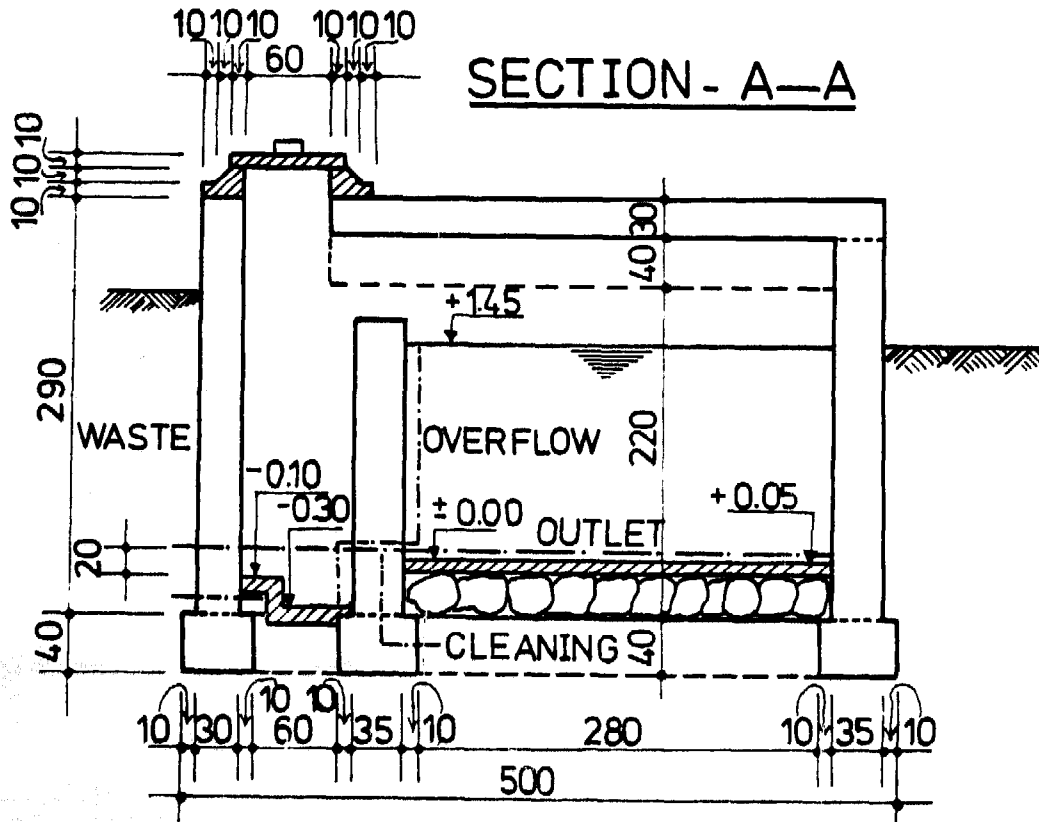
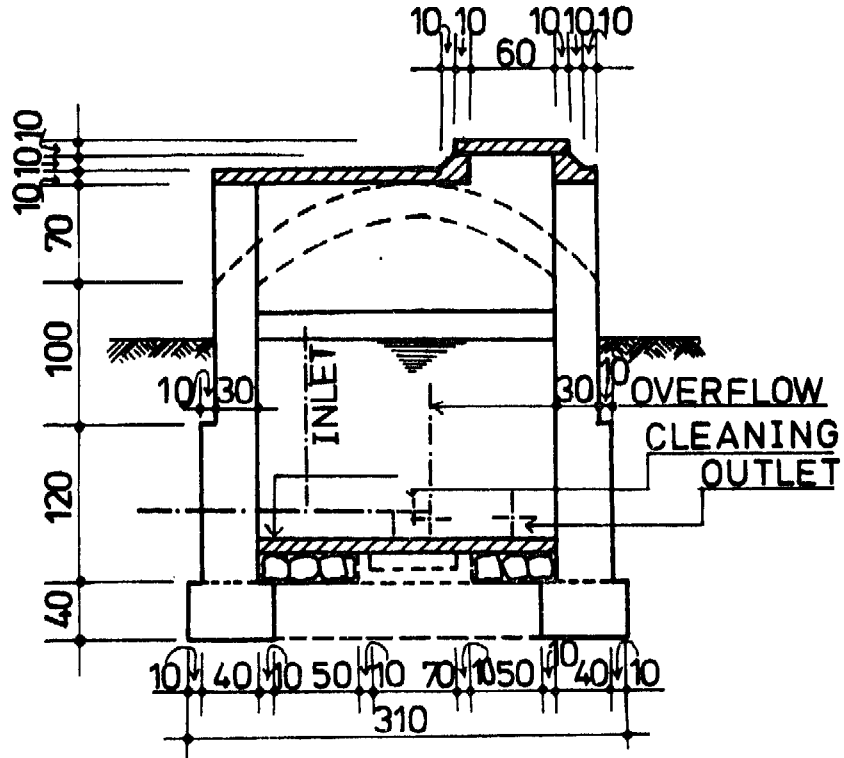


FIGURE 3.2 - STORAGE TANK 9m³ DETAILS

SECTION - B-B



SECTION - C-C

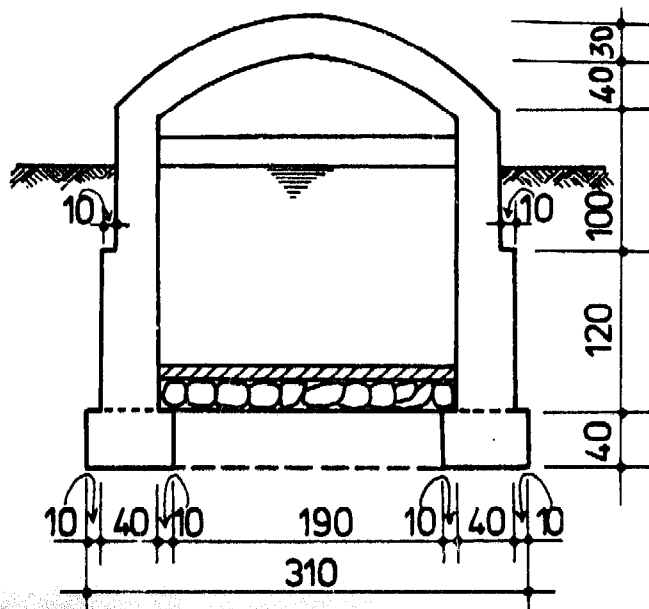
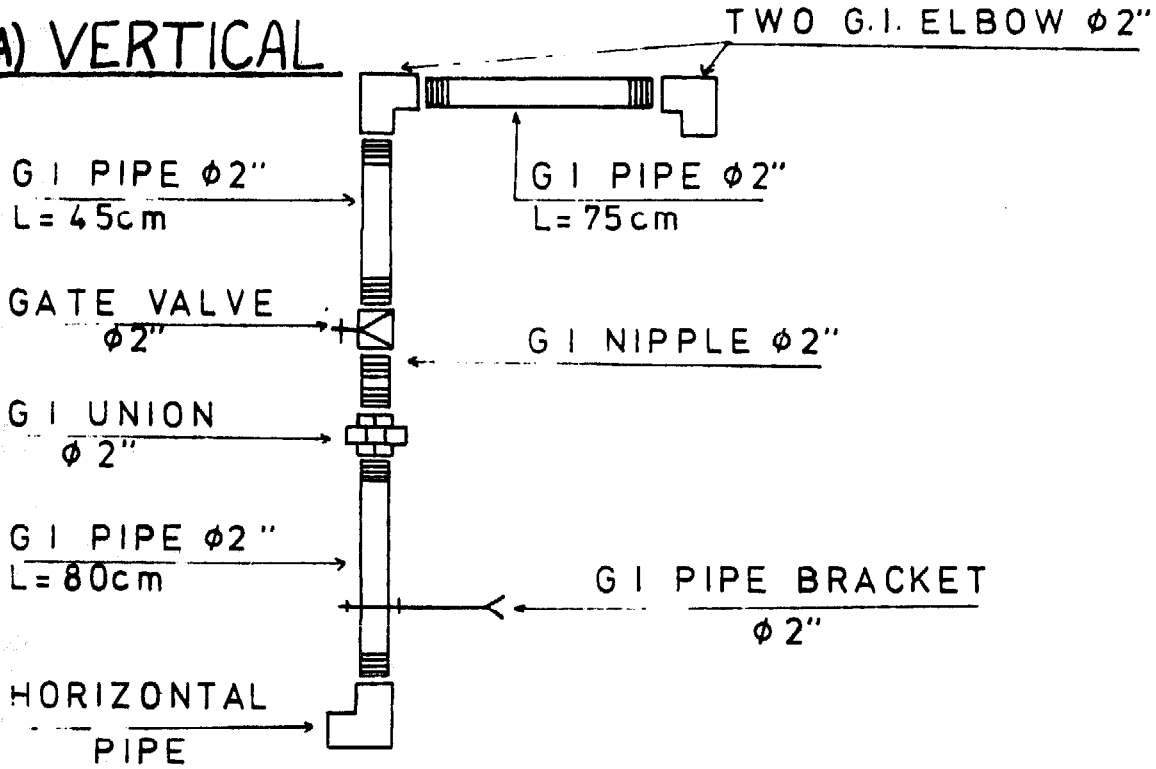


FIGURE 3-3 - TANK, 9M³ INSTALLATION DETAILS

INLET

A) VERTICAL



B) HORIZONTAL

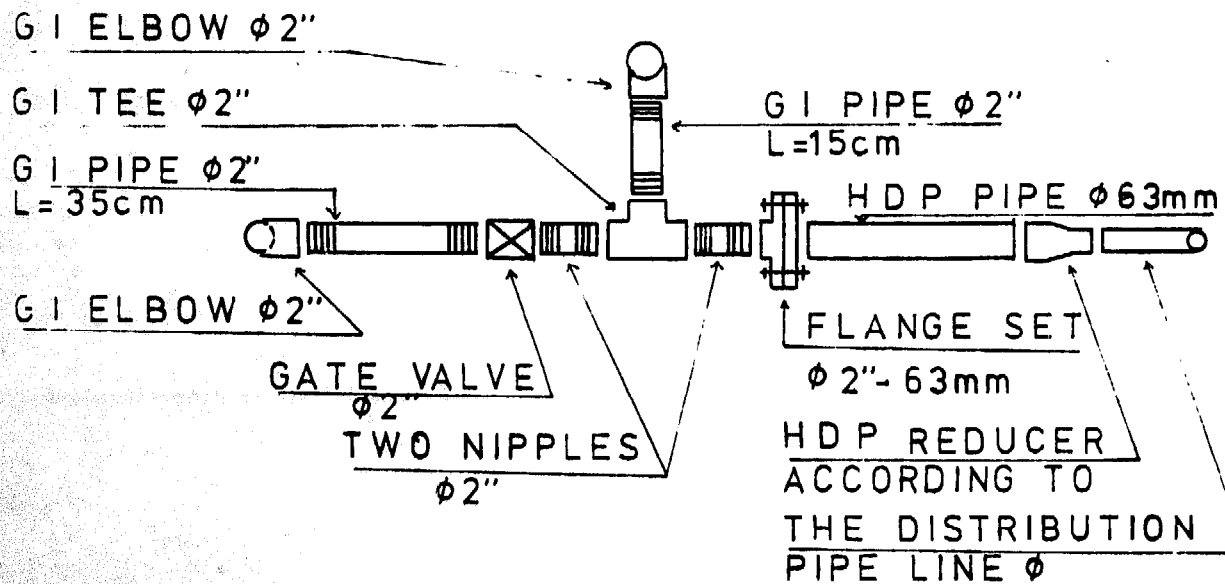


FIGURE 3.4
TANK 9m³ INSTALLATION DETAILS
OUTLET

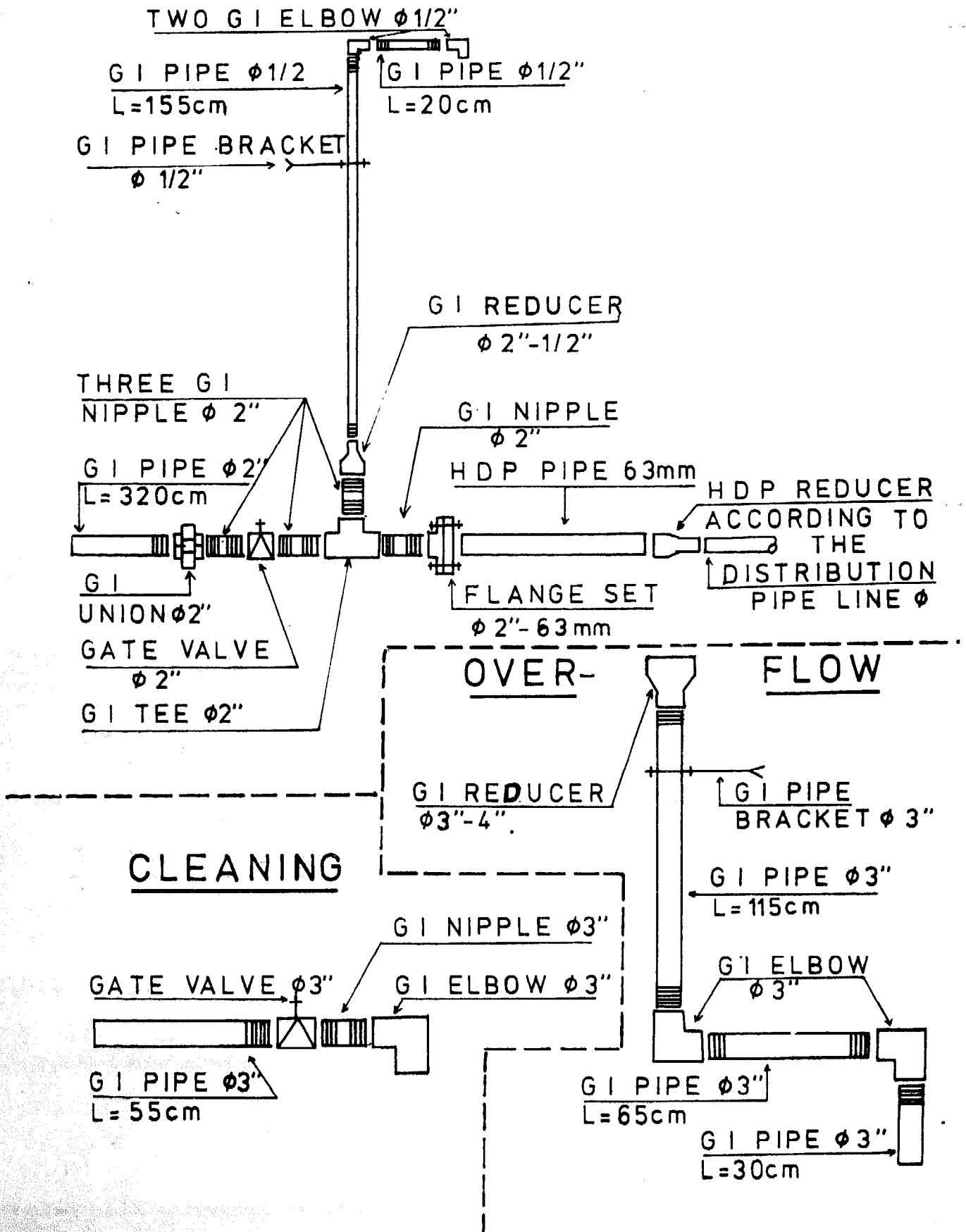


FIGURE 3.5

STORAGE TANK 22m³ DETAILS,

PLAN

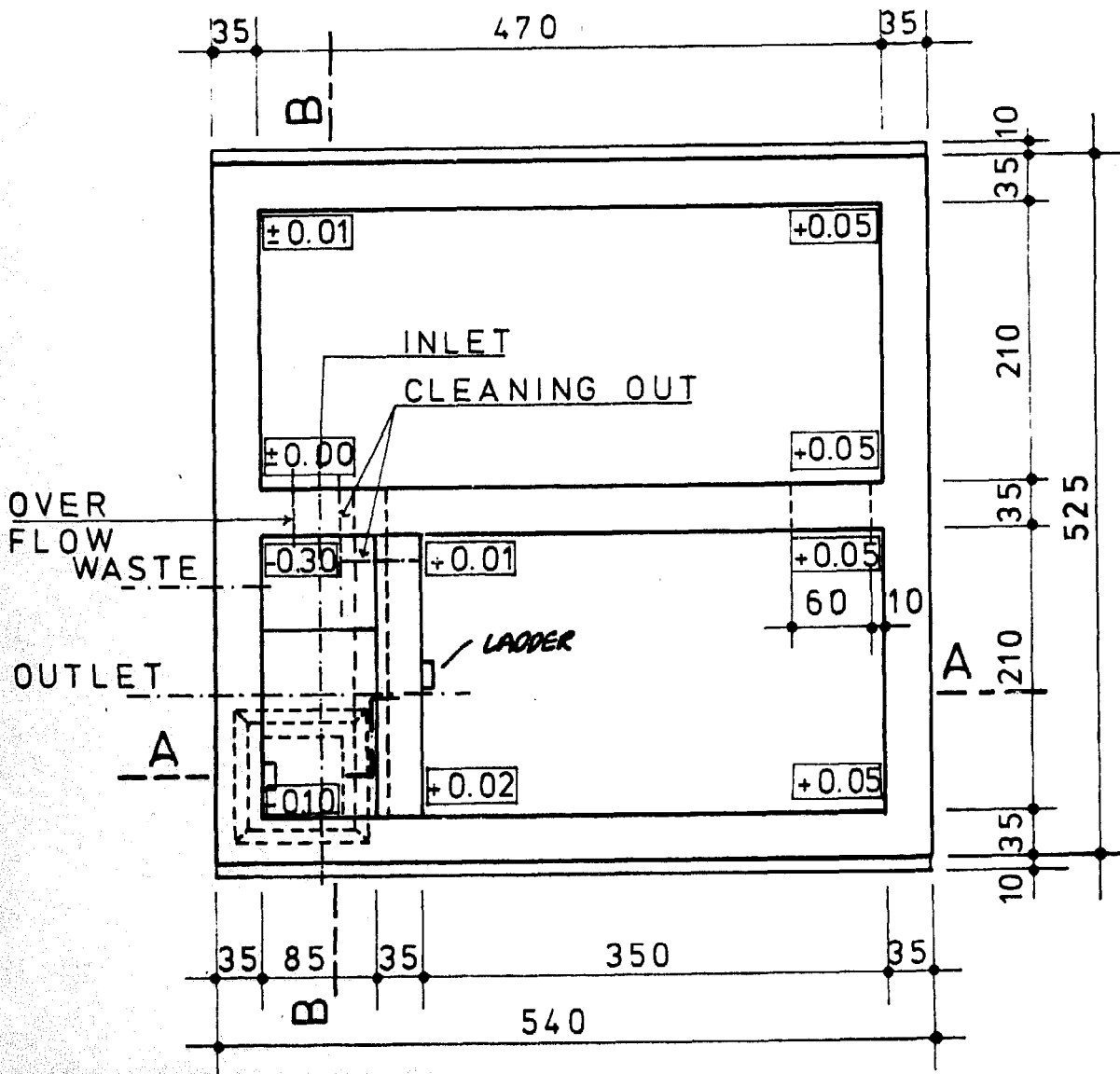


FIGURE 3-6

STORAGE TANK 22m³ DETAILS

SECTION A—A

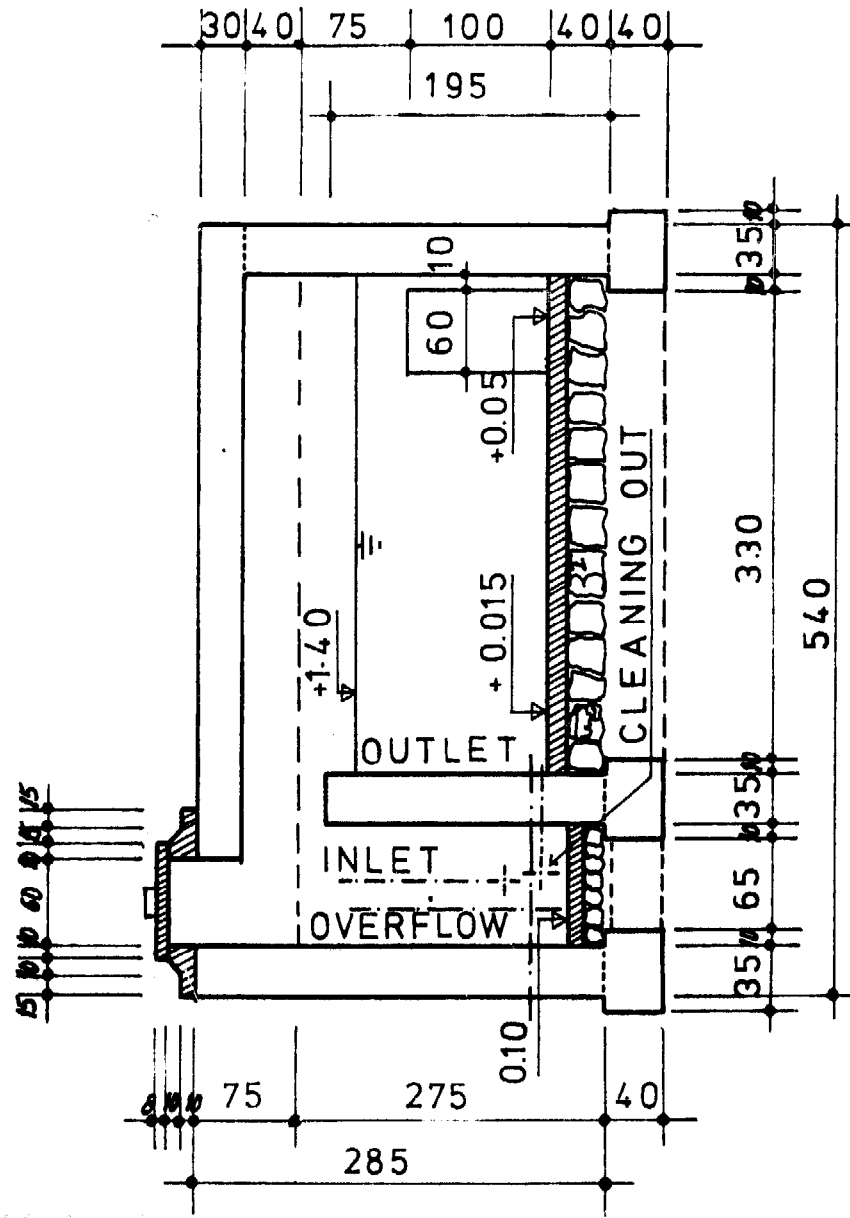


FIGURE 3.8 - TANK 22m³ INSTALLATION DETAILS

OUTLET

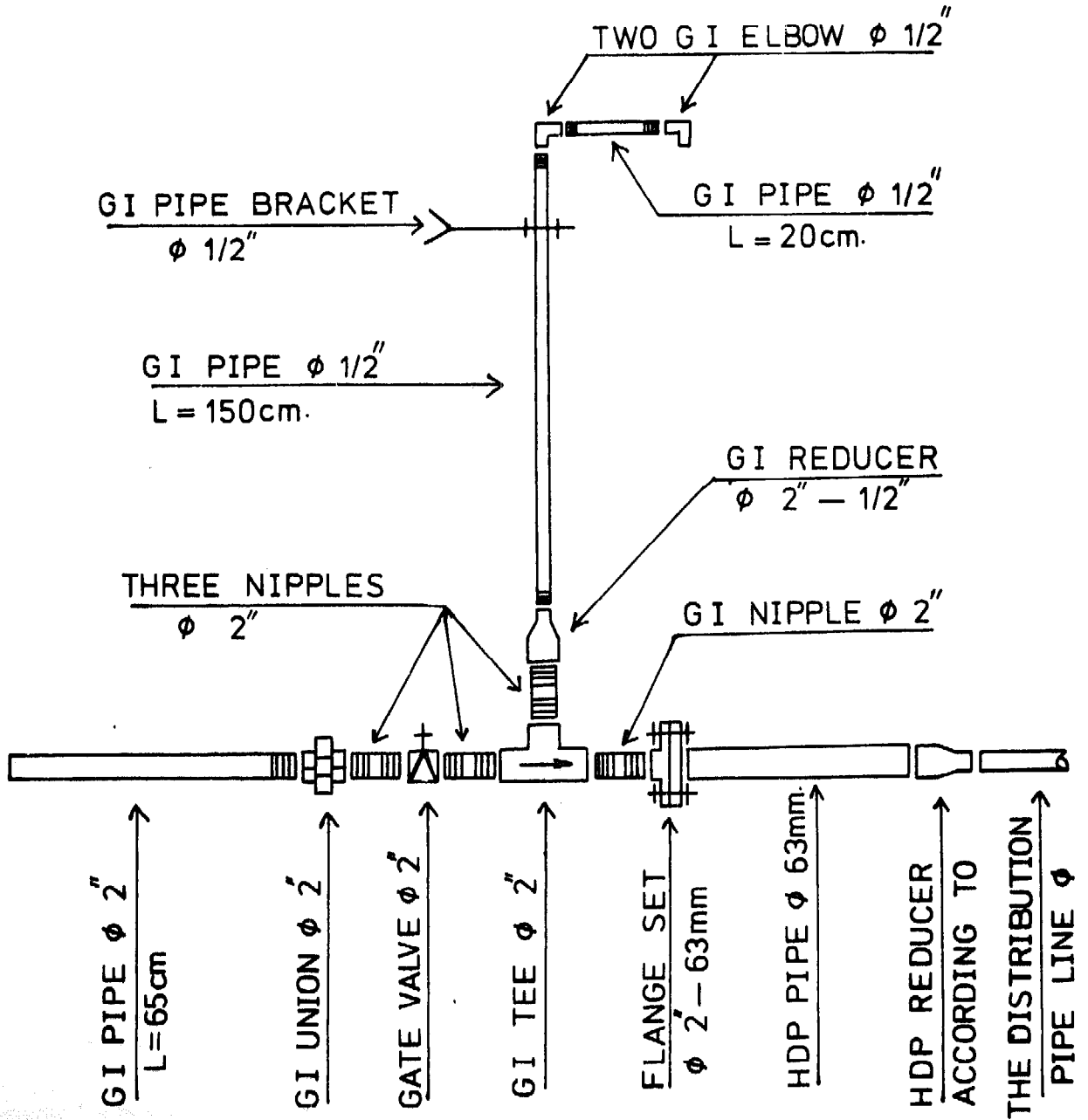


FIGURE 3-9-TANK 22m³ INSTALLATION DETAILS

INLET

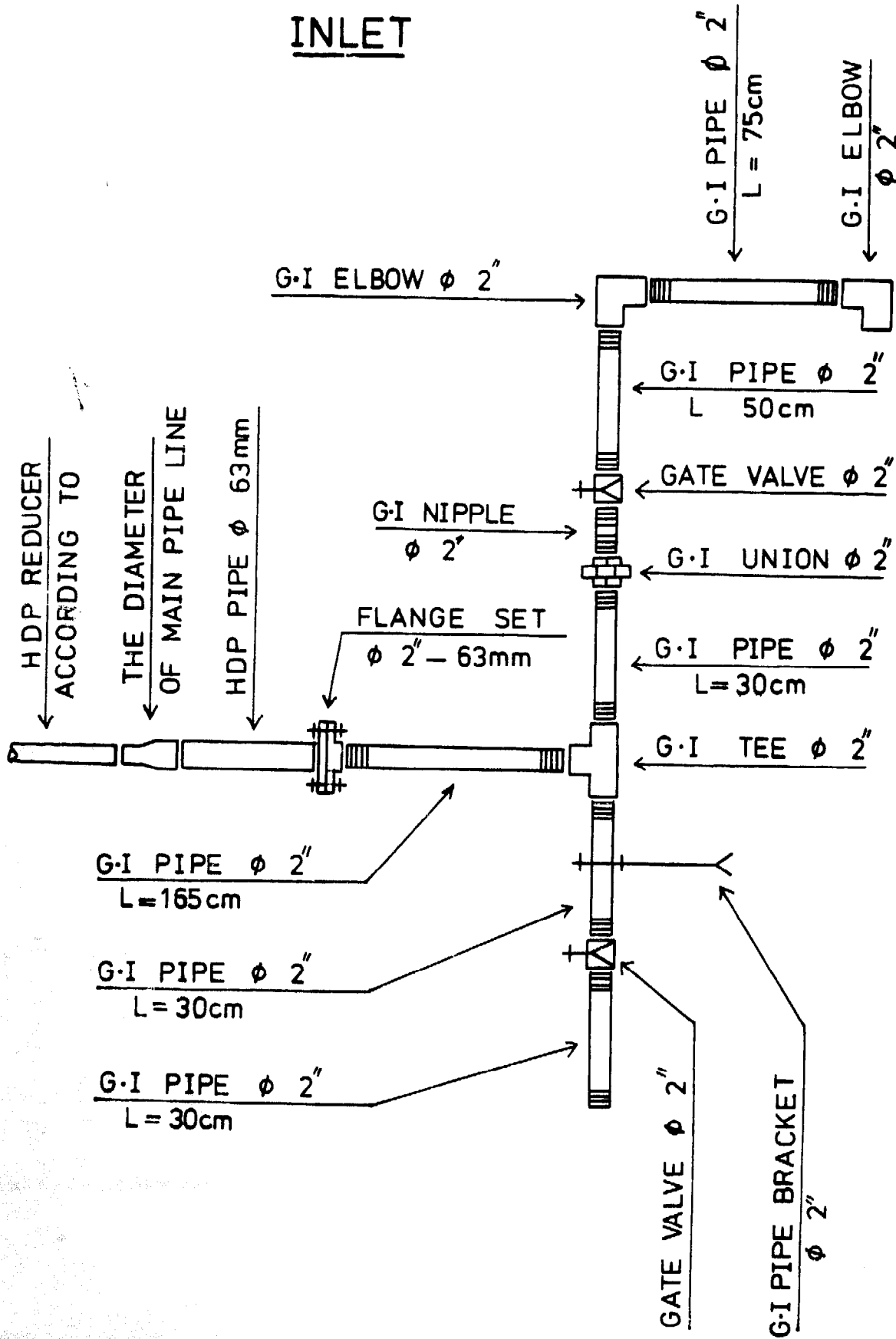


FIGURE 3.10-TANK 22m³ INSTALLATION DETAILS

OVERFLOW

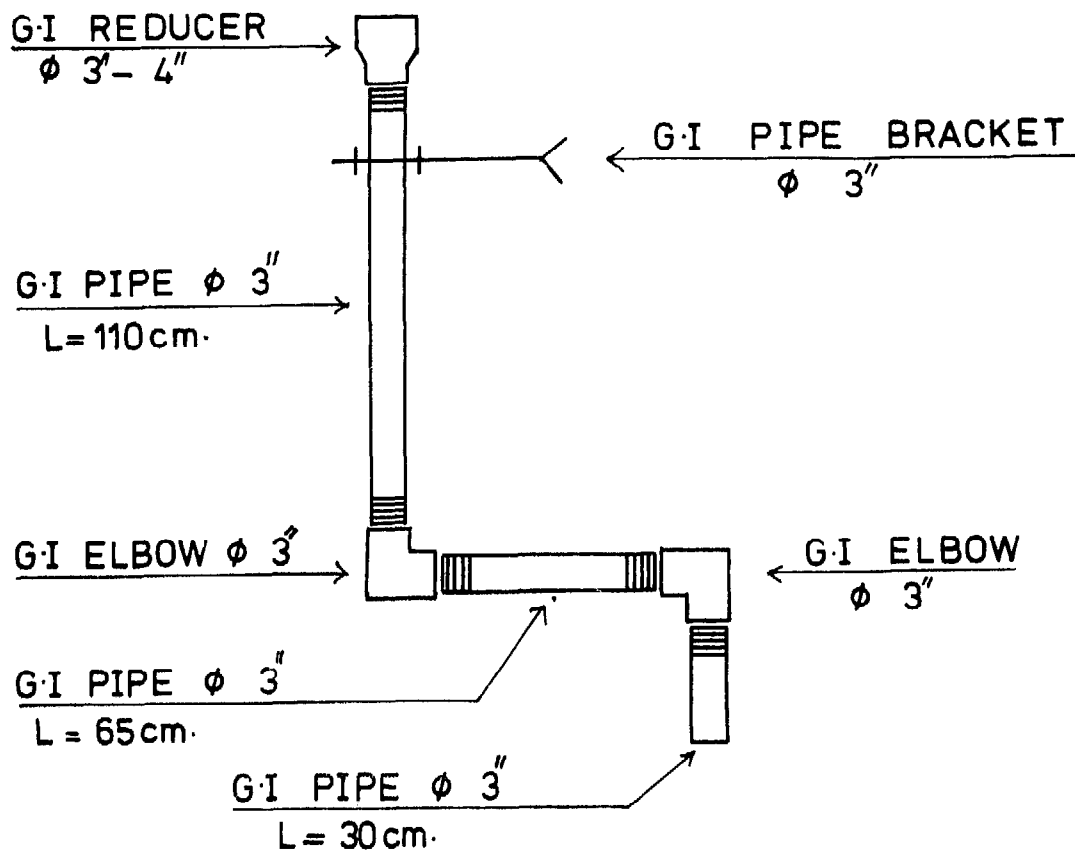
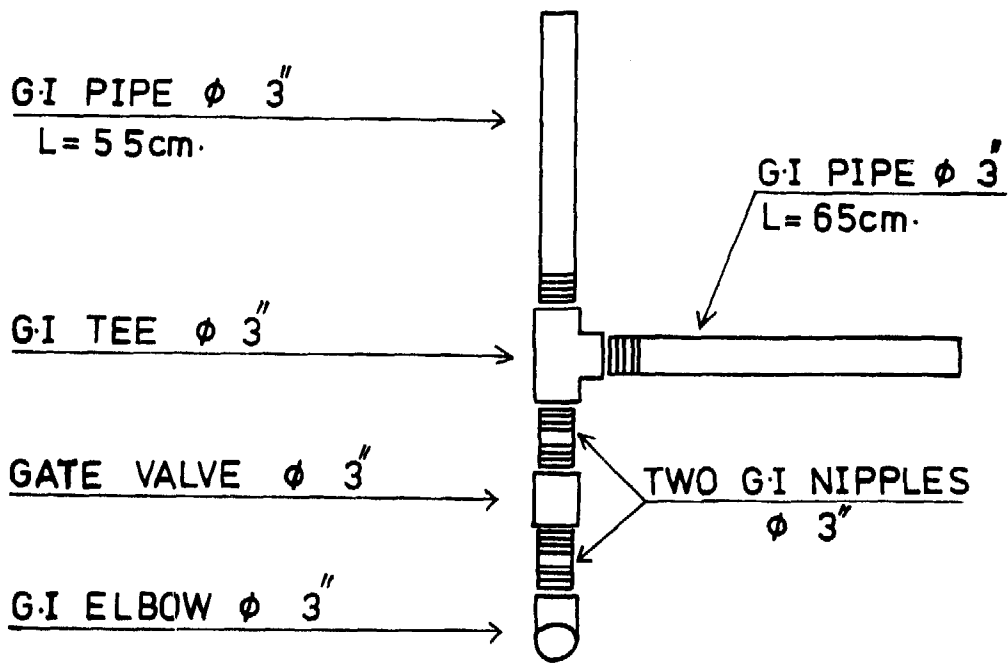


FIGURE 3.11 - TANK 22m³ INSTALLATION DETAILS

CLEANING



4. PRESSURE REDUCING INSTALLATIONS

4.1 Pressure Reducing Pipe

When pressure is too high a pressure reducing pipe can be built. But this should be only done if it is certain that valves cannot stop the pressure in the main. There are two main kinds of pressure reducer.

- a. A special reducing valve,
- b. A construction made from a piece of steel pipe of very small diameter. The length can be varied according to need. This will bring the pressure down to the required value. The exact length and diameter of the small pipe will be given by the engineer in charge of the project.

This second solution is recommended in Nepal, because the special valve needs a high quality of maintenance and spare parts which are not available here. Look at the diagram on pages 47 and 48 for details of the design of a pipe like this.

4.2 Break Pressure Tank

A break pressure tank, or interruption chamber, is built in order to bring the water back to atmospheric pressure. This means that the water pressure (hydraulic gradient) will be reduced to zero.

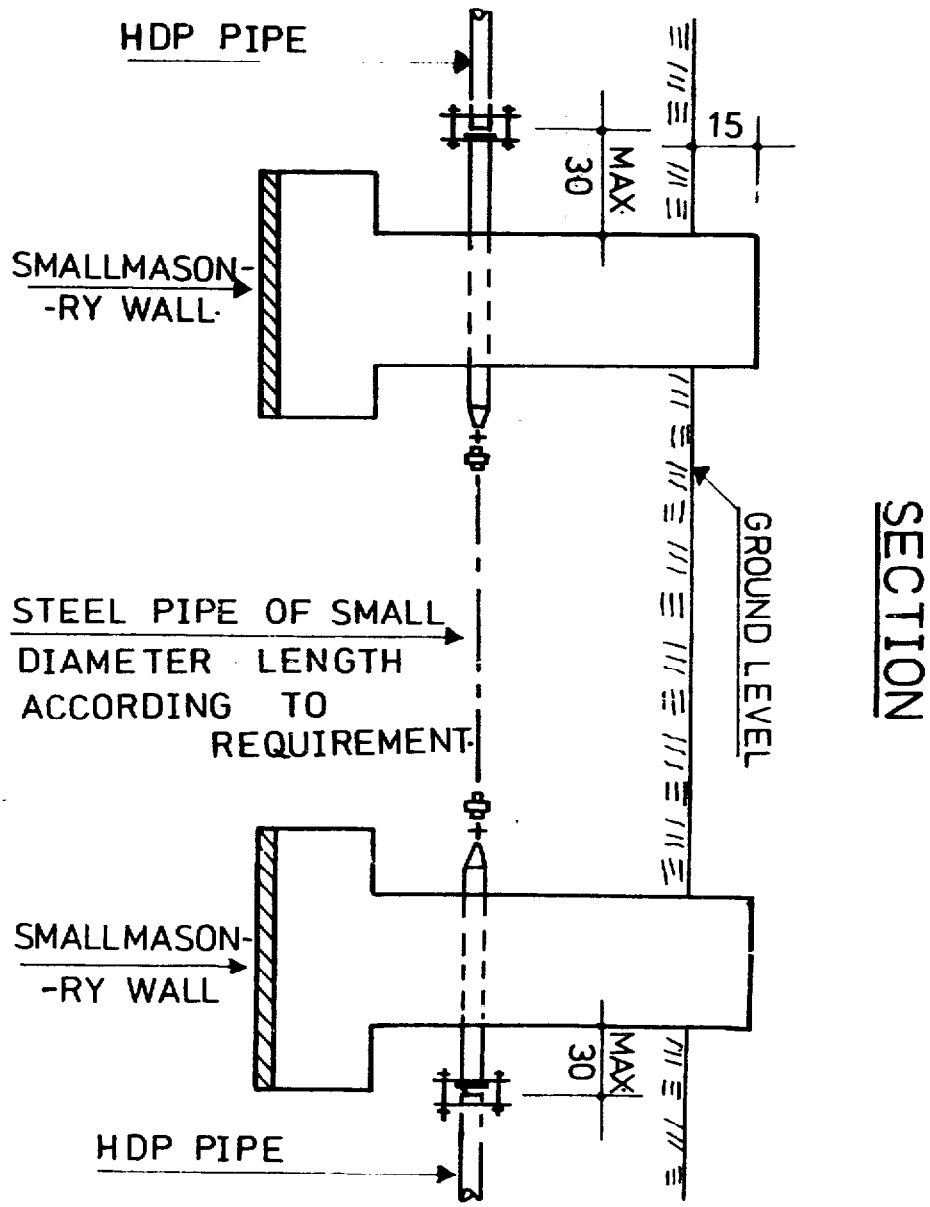
A stone or concrete baffle plate should be located in front of the inflow pipe. This disperses the energy of the water as it comes in under pressure. The plate should be built in such a way that it will be easily removable. The inlet can also be built with a float valve to ensure that water is not wasted. This valve will eliminate the need for a baffle.

As the design on page 49 shows, access to the break pressure tank should be made through the operation chamber, and not from a man-hole directly over the tank. Access from a point directly over the water surface could cause water pollution. GI pipes and fittings should be used as inflow and outflow pipes to and from the tank.

An overflow system with the capacity to remove the maximum quantity of water which is likely to overflow should be included. The overflow water should be disposed of in such a way that it will not cause soil erosion.

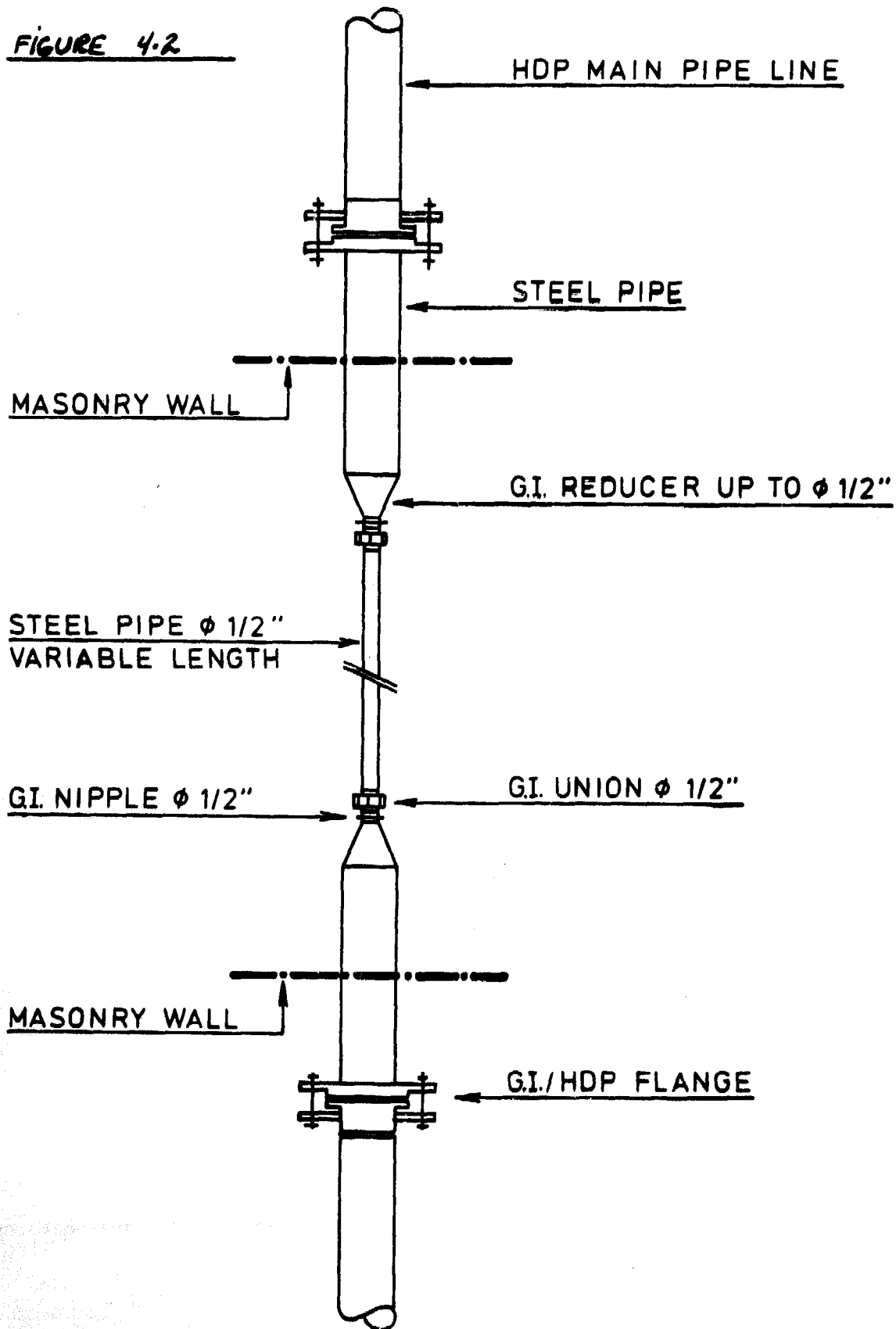
The location of the tank and its technical specifications will be given by the engineer in charge of the project. Details of the tank and its fittings are given on pages 49 through 53.

FIGURE 4.1 - PRESSURE REDUCER



PRESSURE REDUCER

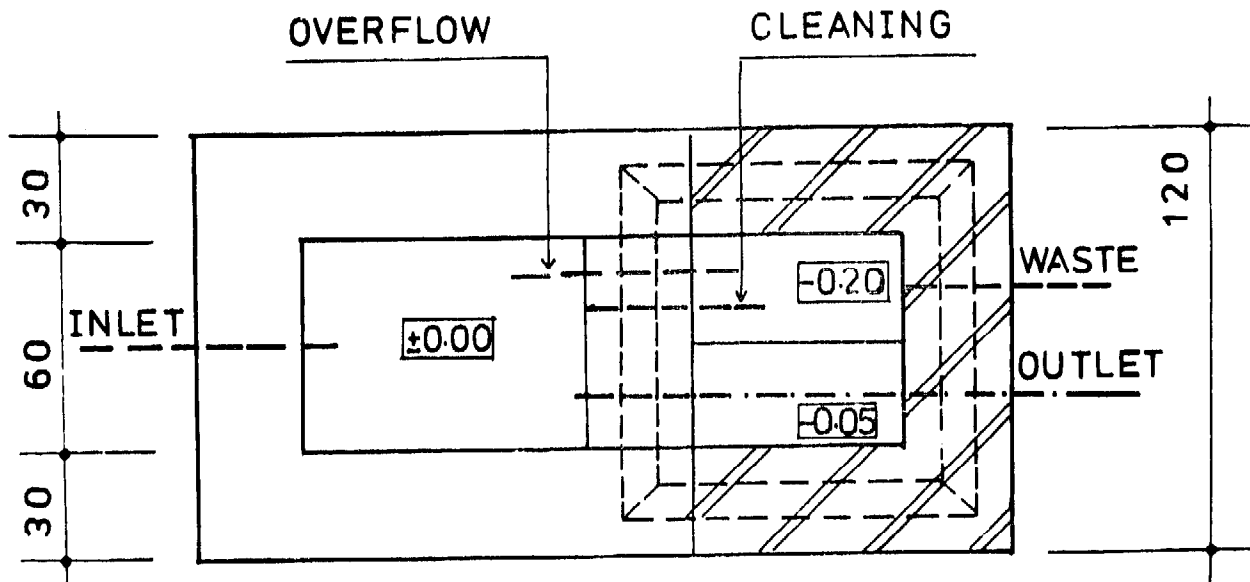
FIGURE 4.2



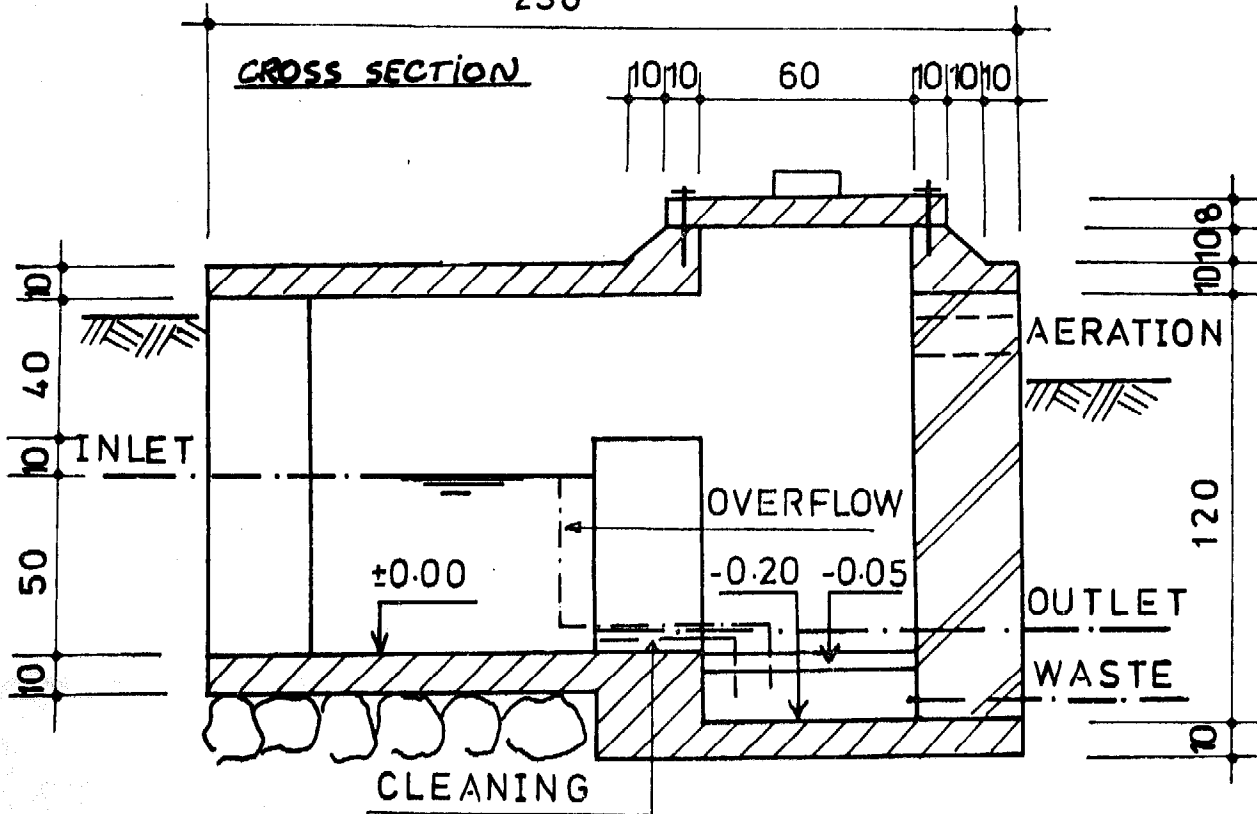
BREAK PRESSURE TANK DETAILS

FIGURE 4.3

PLAN



CROSS SECTION



REMARK INLET INSTALLED WITH FLOAT VALVE

FIGURE 4.4 - BREAK PRESSURE TANK DETAILS

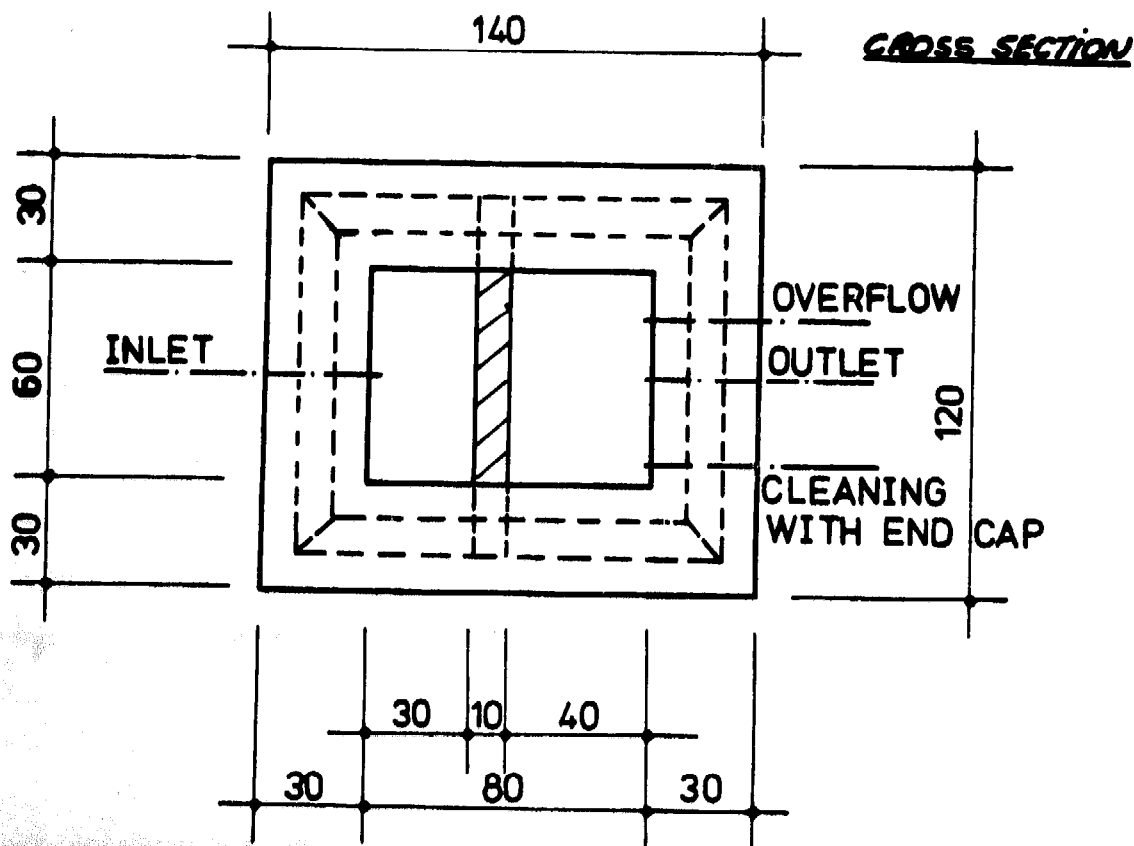
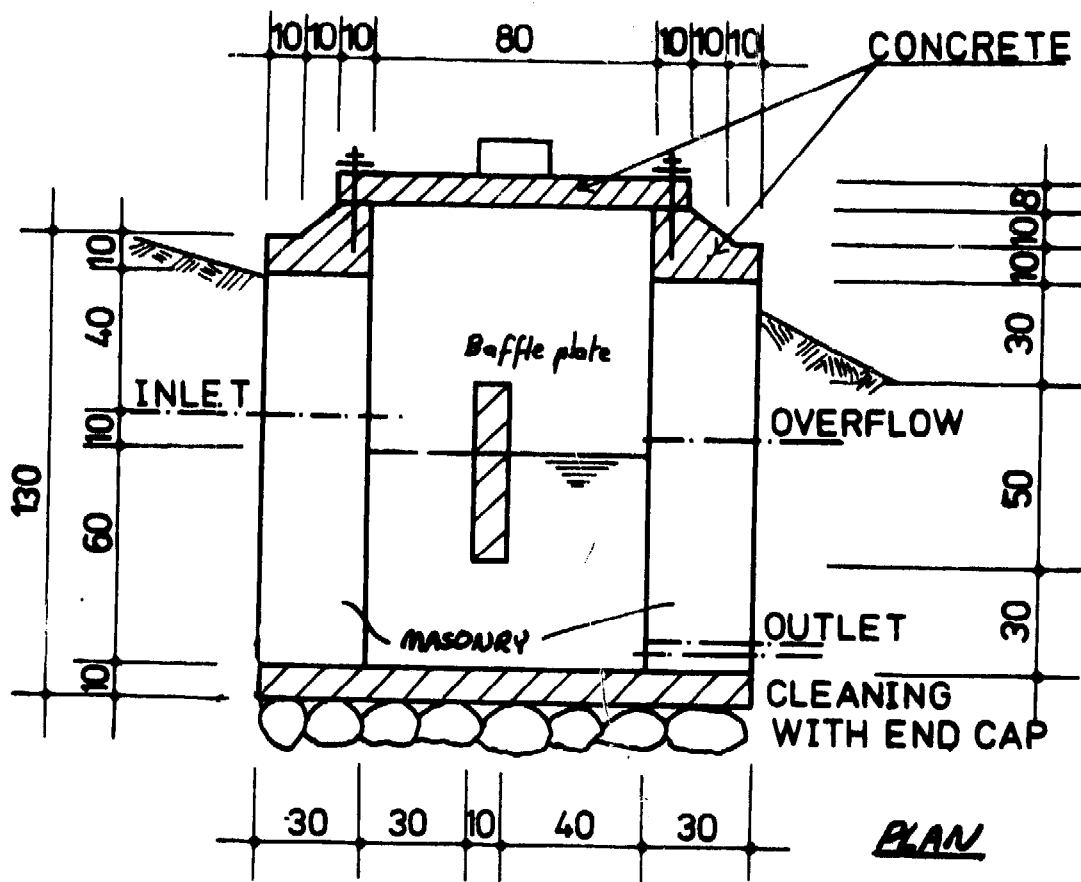
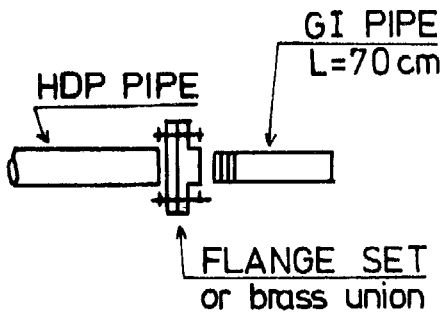


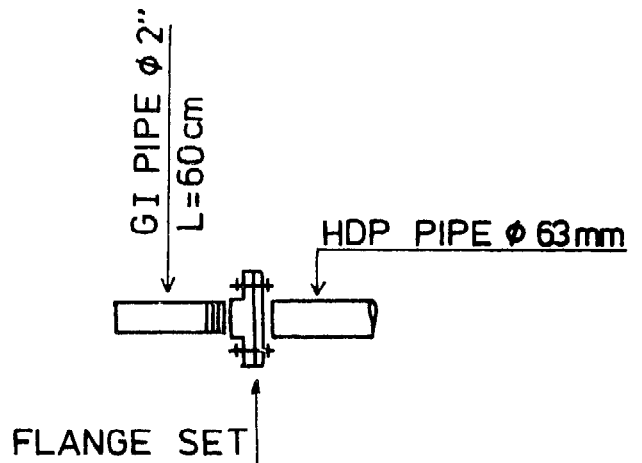
FIGURE 4.5 — BREAK PRESSURE TANK INSTALLATION DETAILS

INLET

ACCORDING TO THE PIPELINE DIAMETER

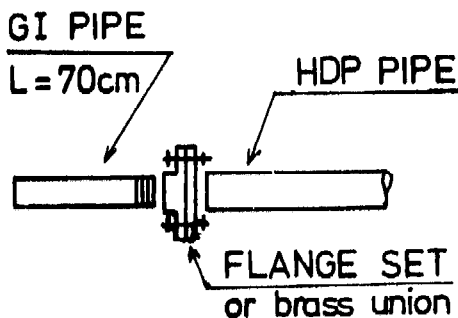


OVER FLOW

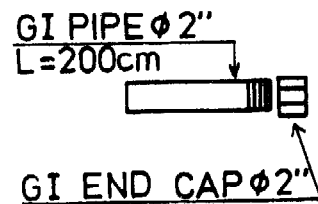


OUTLET

ACCORDING TO THE PIPELINE DIAMETER



CLEANING



BREAK PRESSURE TANK INSTALLATION DETAILS

FIGURE 4-6

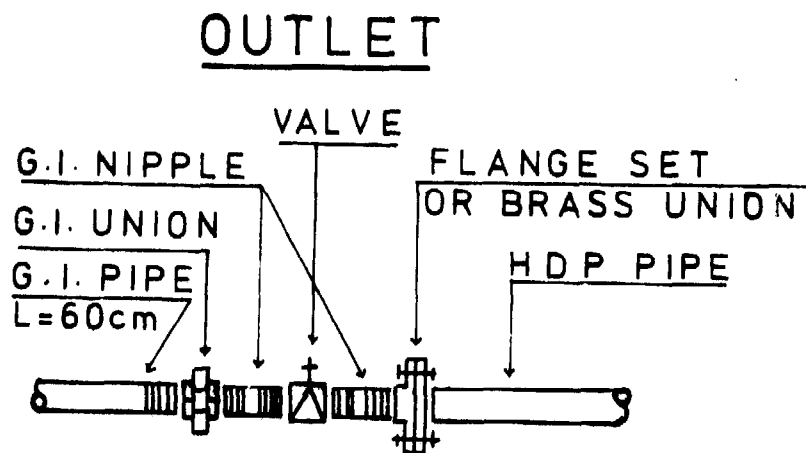
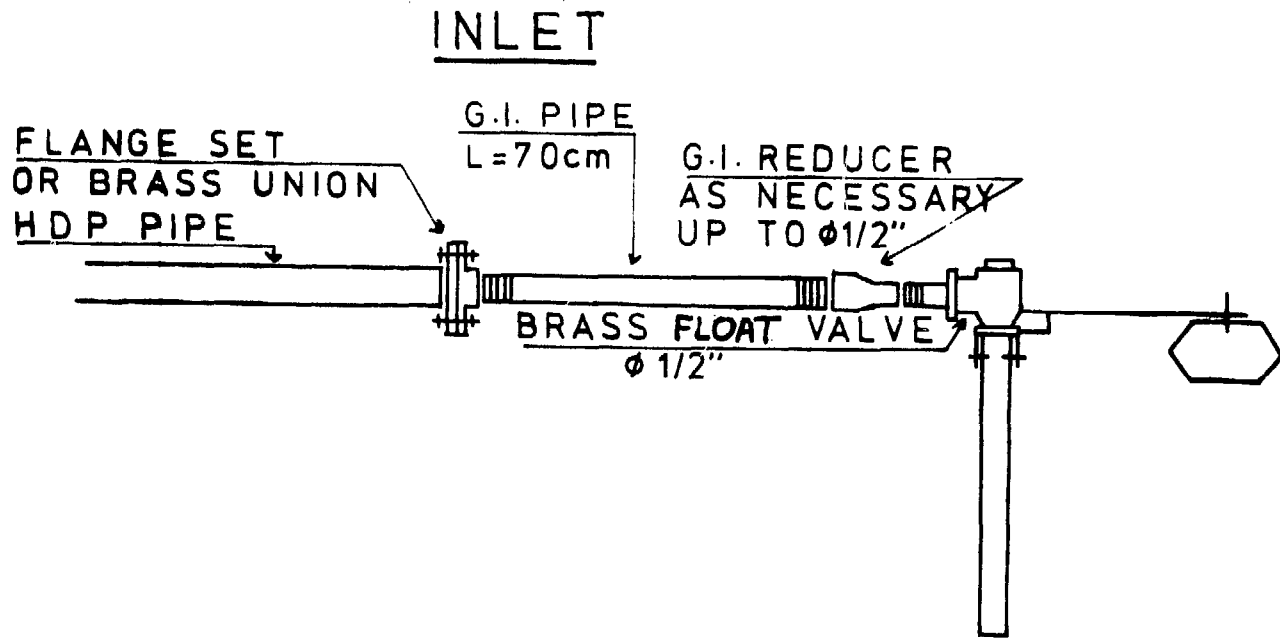
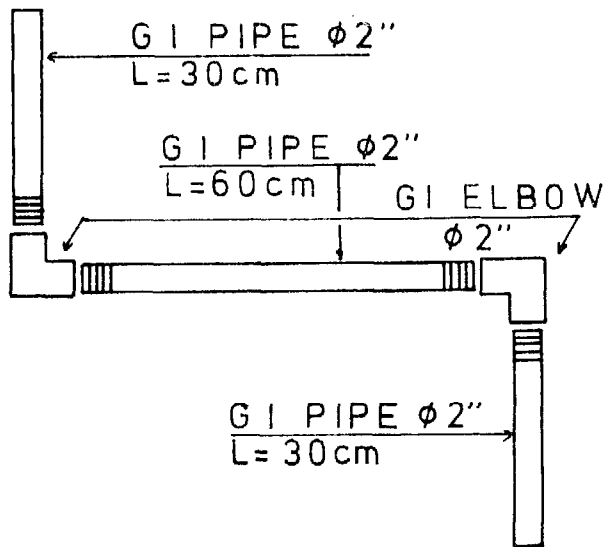
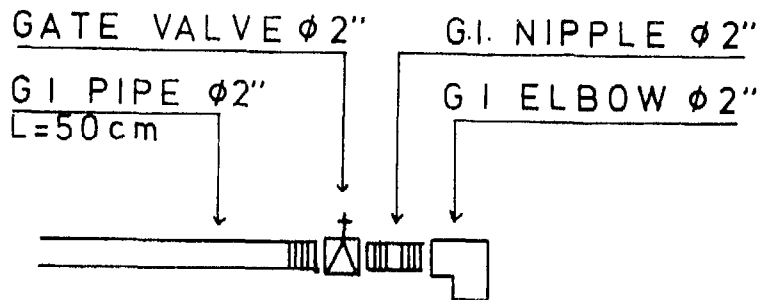


FIGURE 4.7 - BREAK PRESSURE TANK INSTALLATION DETAILS

OVERFLOW



CLEANING



5. DISTRIBUTION: THE PIPELINE

5.1 General Points

The aim of the pipeline is to transport the water safely, without introducing contamination, to the different places of consumption. There can be several problems in trying to fulfill this aim, arising from air pockets, pressure, velocity of water and the need to control the water. Pressure problems have been dealt with. The other subjects will now be dealt with in turn.

There are four different kinds of distribution pipe. Each has a different function.

- a. Supply main - This is the main pipeline bringing the water from the source to the storage tank. In village water schemes in Nepal, the water flows by gravity.
- b. Distribution main - This is the main pipeline bringing the water from the storage tank to the village for distribution.
- c. Ring main - This is a distribution pipeline which joins two distribution mains to form a ring system. The advantages of constructing a ring main are that it reduces the need for large diameter for the distribution main. It maintains pressure well, gives a good flow of water, and avoids stagnation of water in the dead end of the distribution main. It also gives more flexibility to the distribution system, for example when repairs are necessary.
- d. Service Pipe - This is an individual supply line laid in the ground, going to a stand pipe, a house or a farm.

There are three further requirements for a distribution pipeline. These are as follows:

- It must convey the required quantity of water
- It must be capable of withstanding considerable force resulting from water pressure and movement of the soil which surrounds the pipe.
- It must be durable, that is, be long lasting and tough.

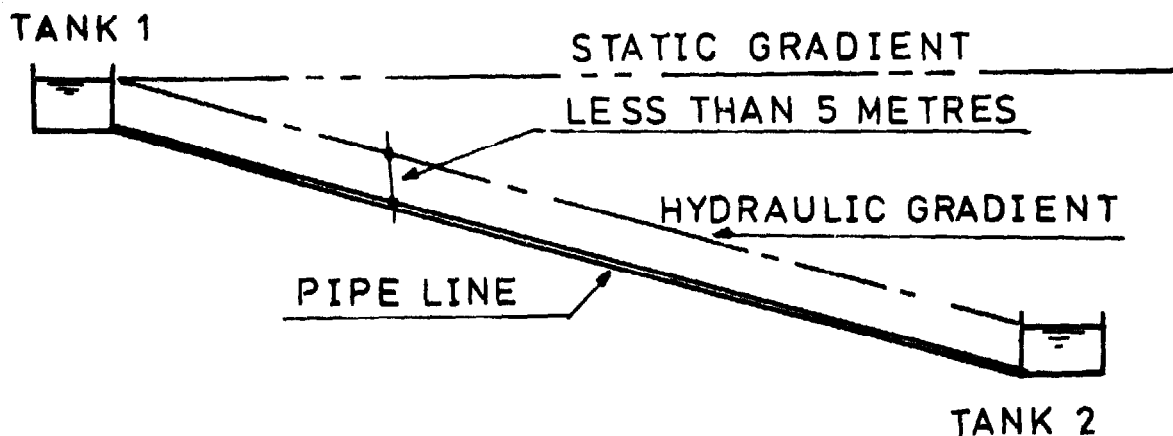
5.2 Air In the Pipeline

Water always carries air bubbles and the presence of air in the pipeline can cause serious blockages of water flow, even when a pipe has a big diameter. Air-blocks can happen for the following reasons:

- a. Where the static gradient is lower than 5 meters. (See the diagrams on pages 56, 57 and 58 for an illustration of this).
- b. At high points in the pipeline.
- c. If there is no air outlet after the storage tank outlet.
- d. If the pipe is too large. The pipeline should not be bigger than either the size of the inflow or the source of the water supply. If it is, tanks will become empty very quickly, then when the top of the outlet pipe is not covered with any water, air will be sucked into it. This reduces the capacity of the pipeline until inflow to the tank becomes bigger than outflow again. Then the water level in the storage tank gradually increases until it is level with the pipeline, and water flows out again. Since the capacity of the outflow remains greater than inflow the process repeats itself again and again. Then the caretaker will have to be constantly opening airvalves to release the accumulated air.

FIGURE 5.1 - PIPELINE PROFILE

WRONG PROFILE



CORRECT PROFILE

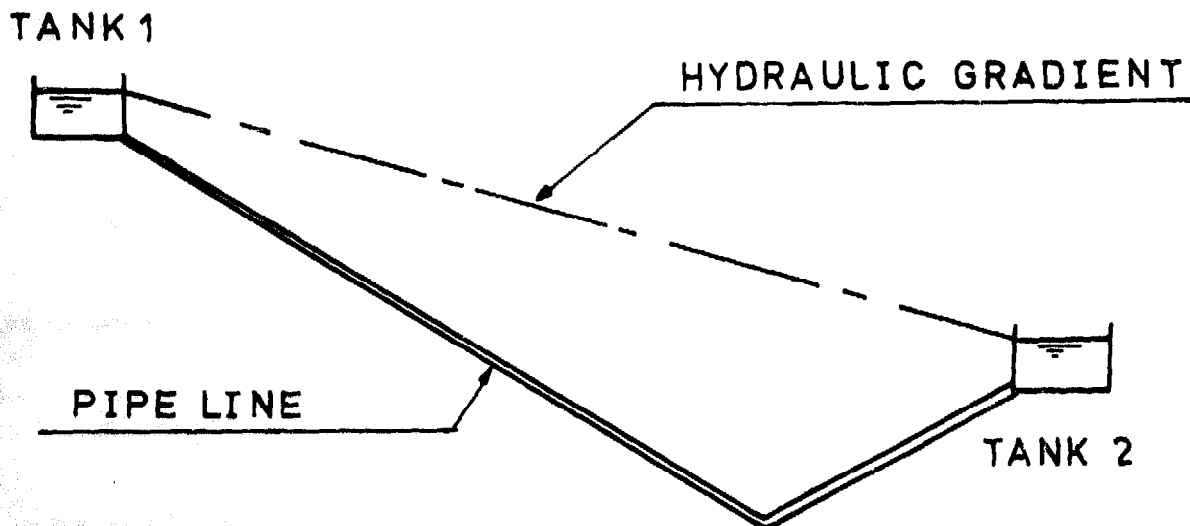
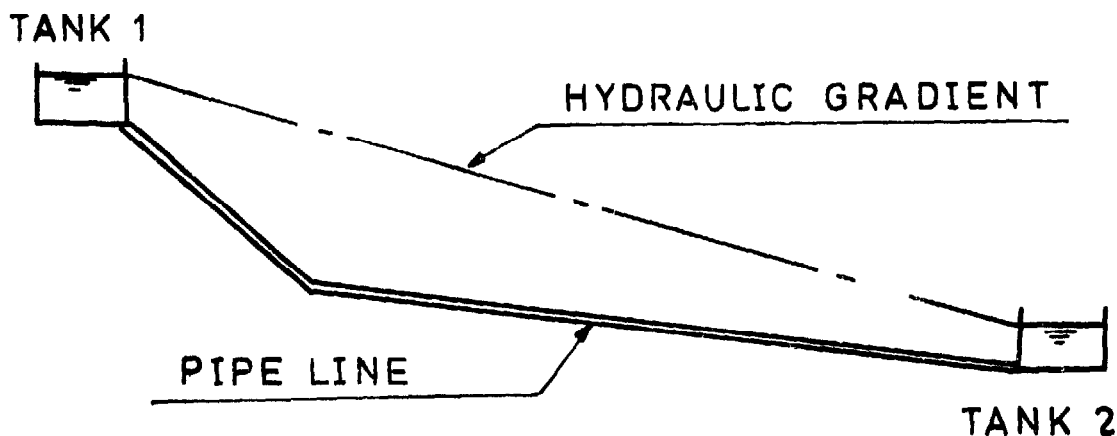
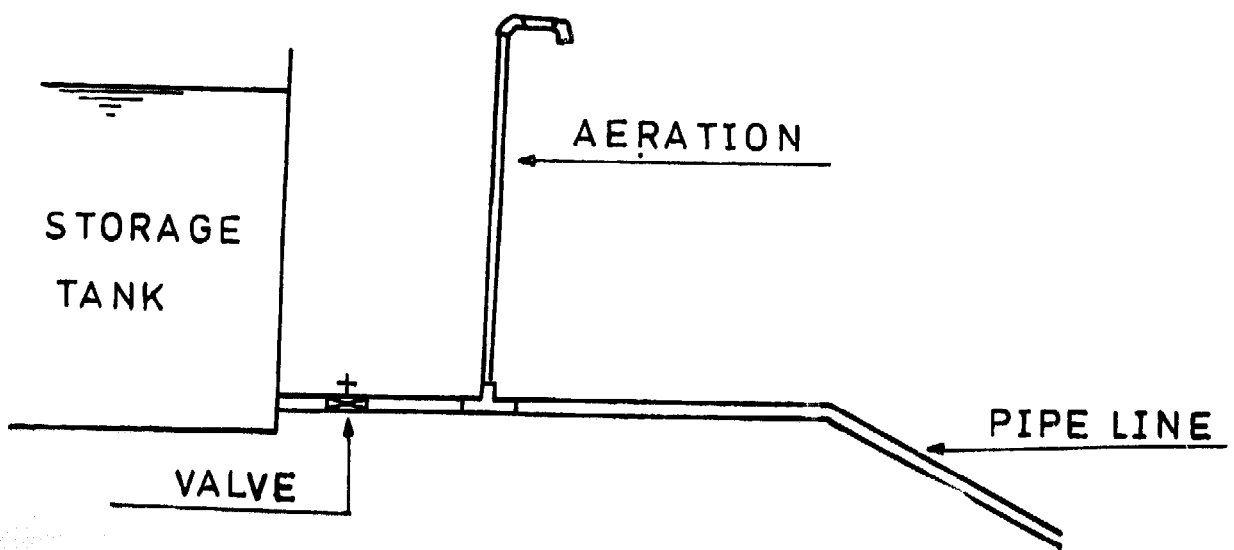
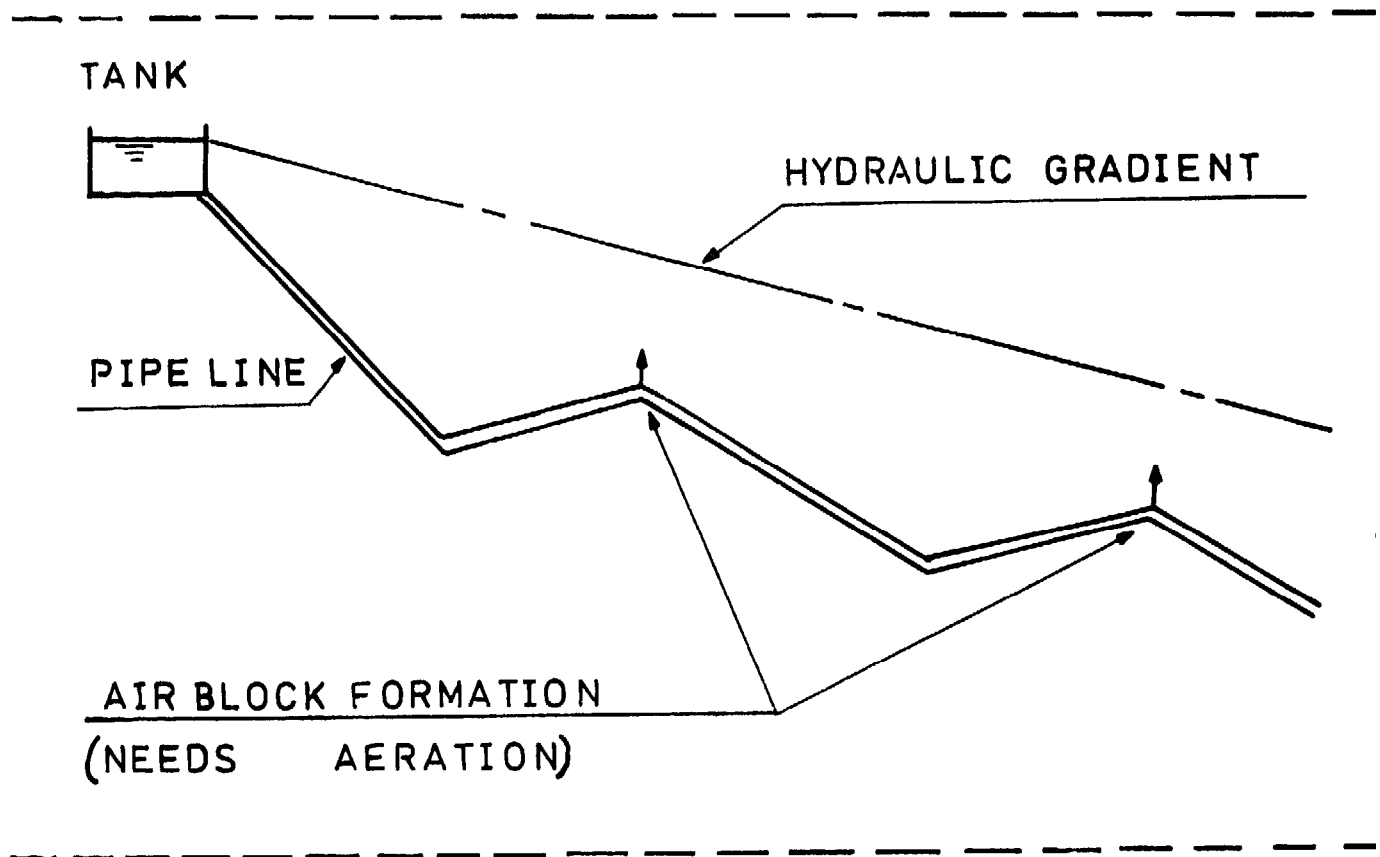
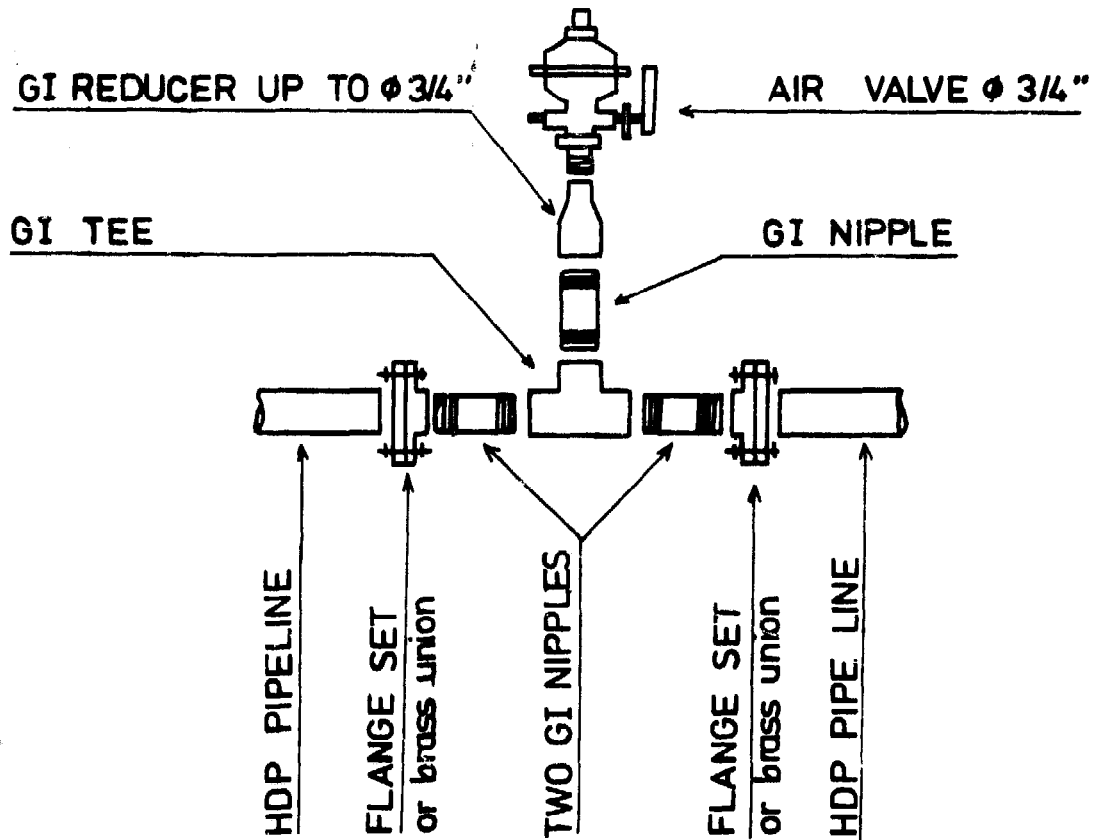


FIGURE 5.2 — PIPELINE AERATION



AIR VALVE INSTALLATION DETAILS

FIGURE 5.3



NOTE: IN ORDER TO MAKE THE AIR-VALVE FIT THE PIPELINE, ONE OR MORE G.I. REDUCERS MAY HAVE TO BE USED.

5.3 Chambers for Valve and Tap Connections

Valves are used to control the flow of water. They should be located in a special chamber, which is referred to as a "valve box". They will be installed at intervals along a pipe line and at branches in it.

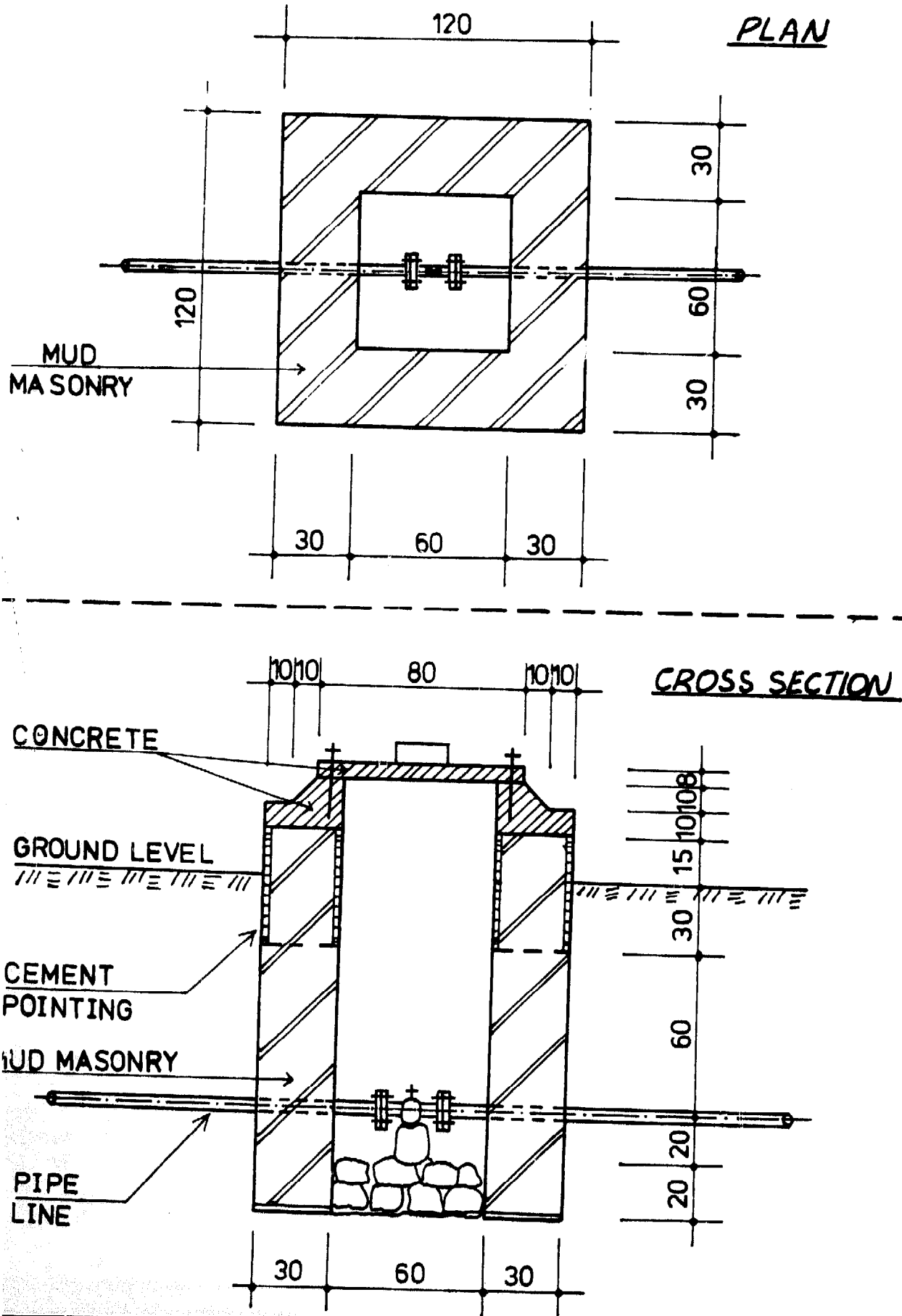
Look at the diagram on page 60 for drawings of a valve chamber. The details on pages 61 and 62 show how pipe-line connections are constructed, using valve boxes.

Stand pipes are connected to the main distribution pipe-line by small diameter pipe called a "service pipe". (See page 63). A stopcock should be fitted to the service pipe to allow the water to be controlled at the stand pipe. This stopcock should be installed directly after the connection from the distribution main.

This stopcock and the connection fittings are protected in a valve box which is referred to as "tap connection chamber". (See page 63).

VALVE CHAMBER

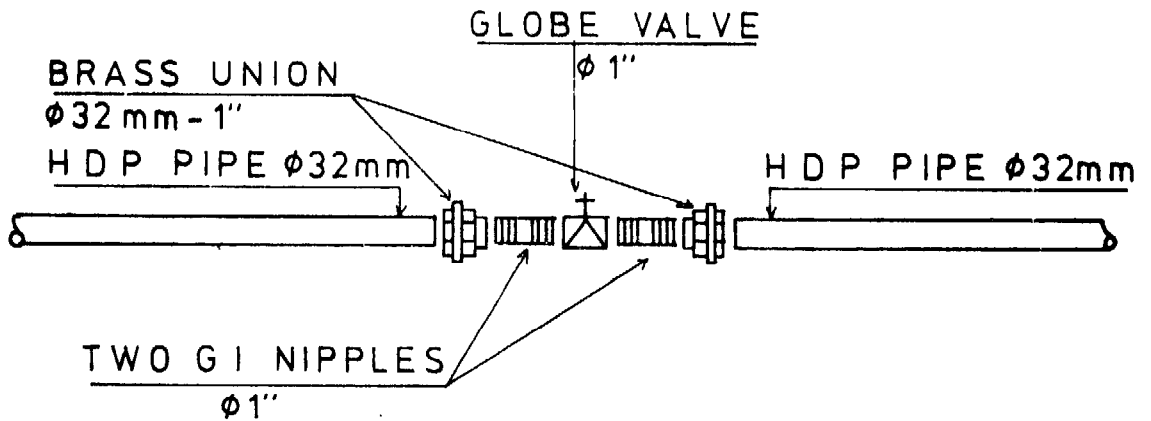
FIGURE 5.4



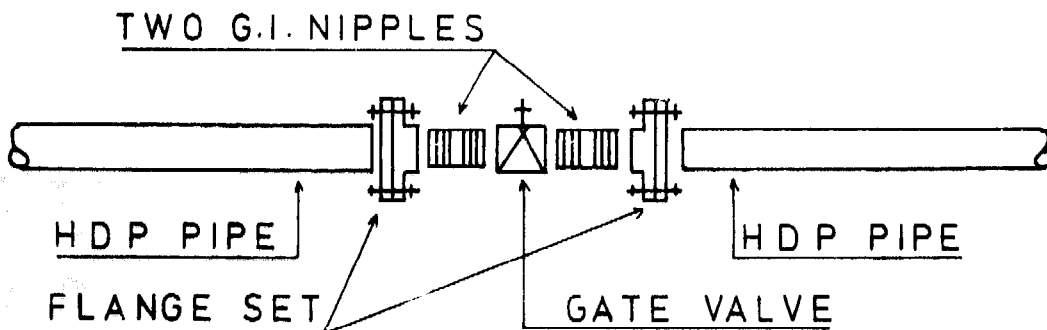
MAIN FLOW CONTROL VALVE INSTALLATION DETAIL

FIGURE 5.5

FOR PIPE LINE $\phi 32$ mm

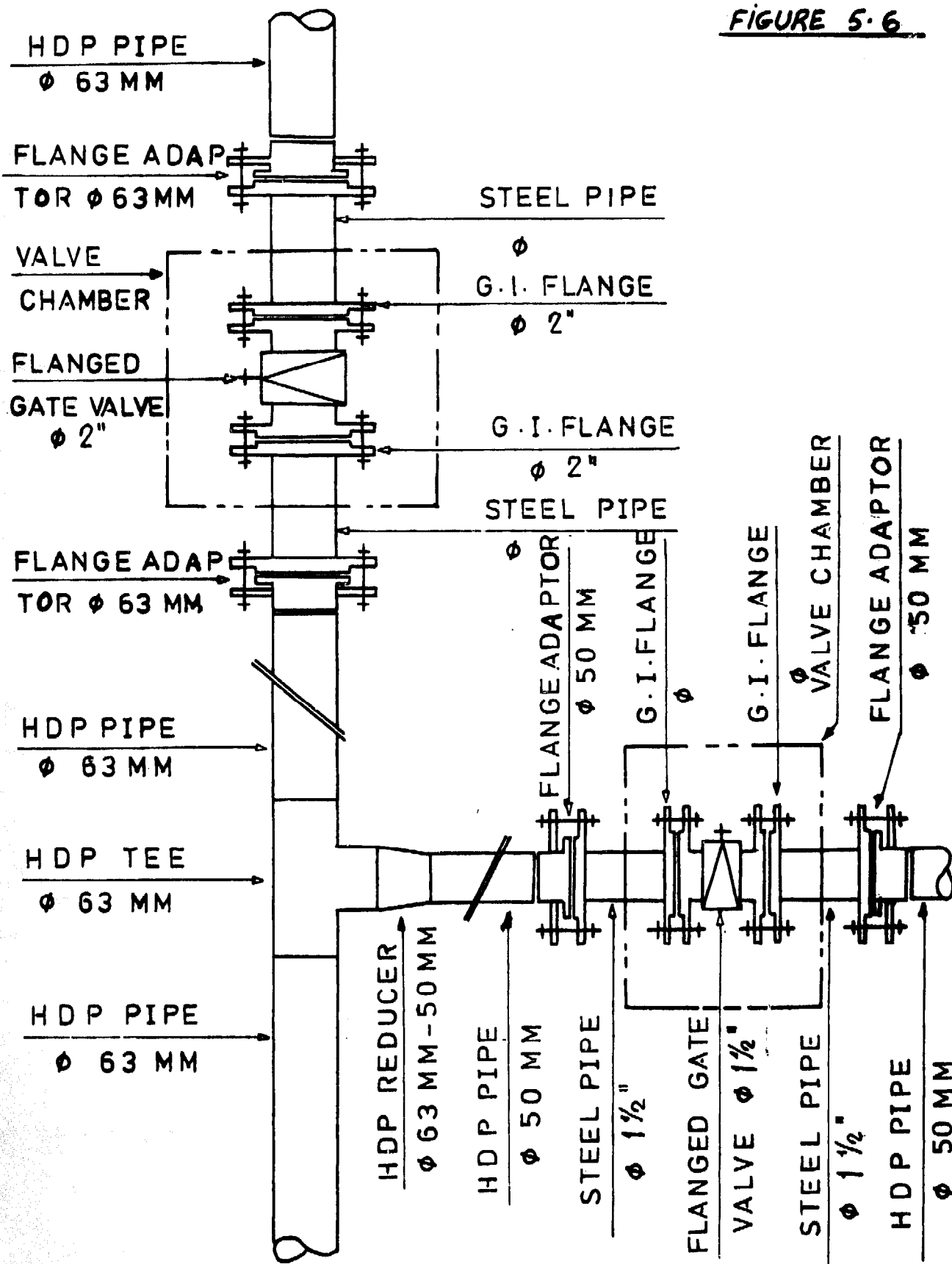


FOR PIPE LINE
 $\phi 50$ AND 63 mm



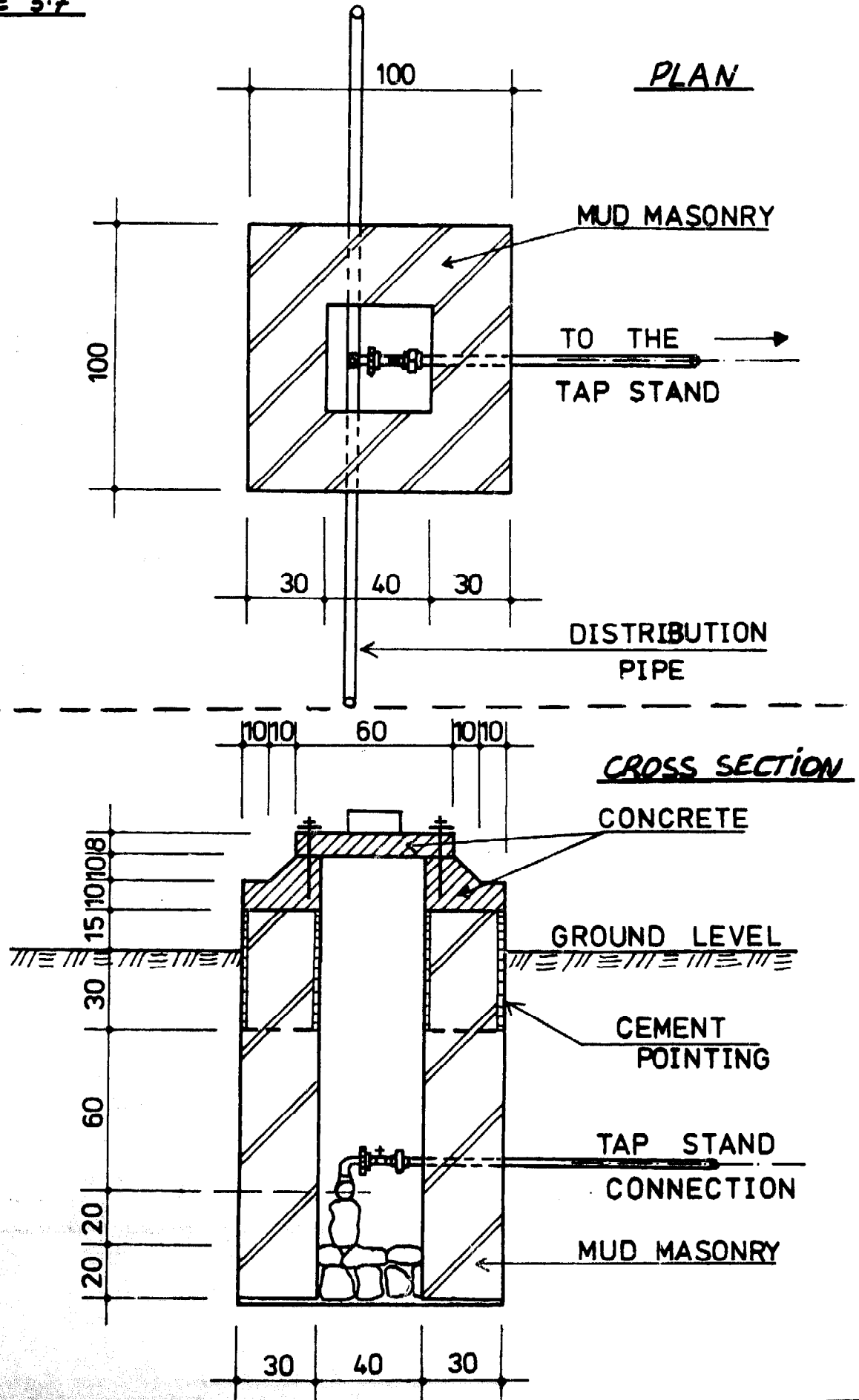
PIPE LINE MAIN CONNECTION INSTALLATION DETAIL

FIGURE 5.6



TAP CONNECTION CHAMBER

FIGURE 5.7



5.4 Pipeline Passing Through Walls

When pipe passes through a wall, as in the installations shown, stress may affect and damage the pipe. The construction details given below show how to fix the pipe, so that the chances of this happening are minimized.

HDP pipes can only be used through the walls if there is no water behind the walls. For example:

- Valve chamber walls
- Tap connection chamber walls
- Operation room outside walls.

Special attention should be paid to avoiding leakages where pipes are inside a wall and are connected under the water level.

Cleaning Pipe and Overflow Pipe - The pipe used is steel. It is fixed rigidly in the wall. The part of pipe in the wall should be scraped before insertion. Diagram A.

Outlet and Inlet Pipes - The pipe used in the wall is steel. It is fixed rigidly in the wall as above. The HDP pipe after the joint will take all the stress because of its flexibility. Diagram B.

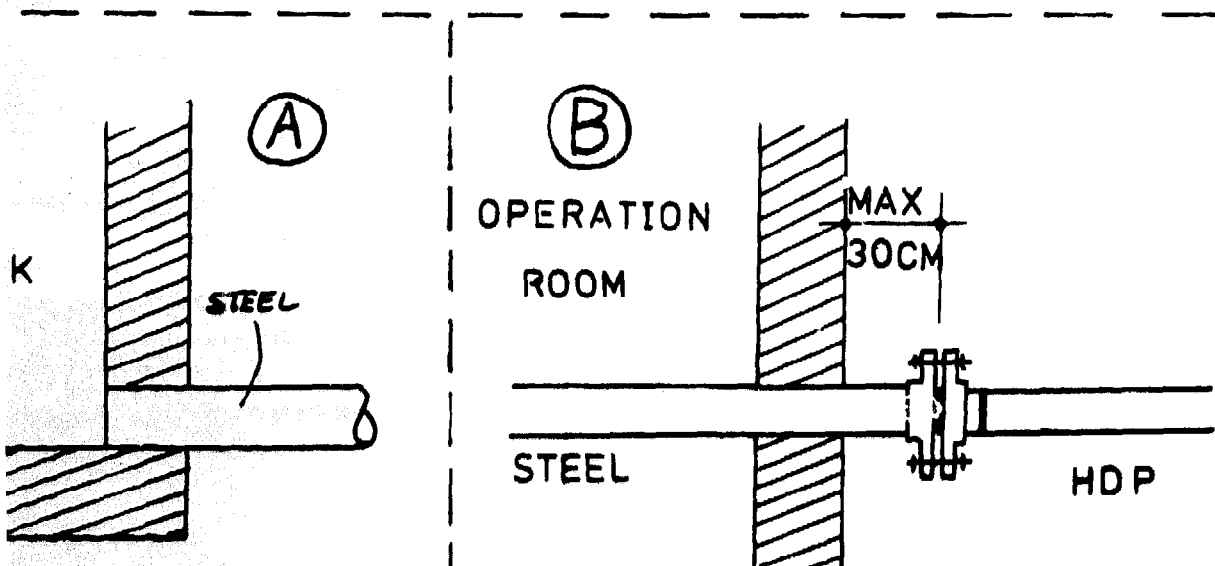
Sedimentation tank - As in Diagram A and B.

Pressure reducing pipe - Identical to the inlet and outlet shown in Diagram B.

Break pressure tank - As in diagram A and B.

Valve Chamber - HDP pipe will be fixed directly inside the chamber walls for all diameters of pipe. (See page 63).

FIGURE 5-B — PIPELINE PASSING THROUGH WALLS



5.5 Velocity of Water and Pressure Loss

The velocity of water in a supply main should not be more than 2.5m. per second. The velocity in a distribution main should not be more than 1.5m. per second. If the velocity is too high it will damage pipes, taps and valves.

Whenever water flows in a pipe there is continuous loss of pressure along the pipe in the direction of the flow. This loss is due to friction between the water and the inside surface of the pipe. A pipeline should therefore always be laid on a downward slope to carry water to its destination. This "head loss", as it is called, is a function of the diameter of the pipe, its quality and the quantity of the water flowing in it.

5.6 Laying HDP Pipe, Trenching and Embankment

Laying pipe - Before laying HDP pipe it is important to remove from the trench all rocks and stones. The pipe should be layed on a bed of good inorganic soil. Here are some important points to watch for.

- The coil of HDP pipe should be put into the trench and unrolled in the direction of the water flow. Care should be taken that the pipe does not become buck-bended as it unrolls, because this will make weak points in it and later it will break under pressure.
- When the pipe bends or turns make sure a good long line is allowed with a radius big enough to prevent the pipe being bent and weakened.
- If the trench is on a slope the coil should be unrolled very slowly. There should be enough people to hold the coil as this is being done, so that it does not get damaged in the process.

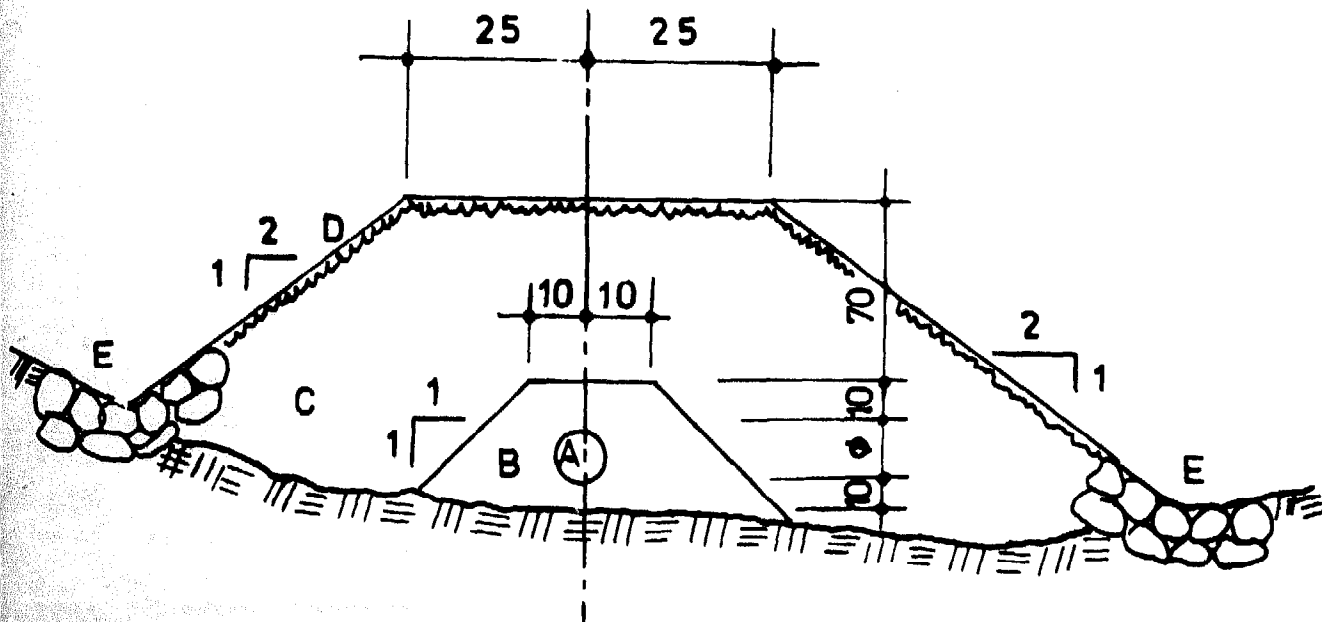
Trenching - The minimum width of the trench should be 50cm. for HDP pipeline with a diameter under 100m. A trench which is too wide will increase the earthload on the pipe. Pipe should be buried in the ground at a suitable depth (approx. 90cm.) in order to protect it from erosion, action damage from traffic above it, chemical action, weathering by the sun, rain or frost, and to prevent vandalism. The depth for a pipeline under a road should be 150cm. The pipeline should be laid along the straightest possible course. Road crossing should be done at right angles to the road and avoided wherever possible. Lengths of pipeline should be laid with a gradual rise to high points of about 2% to 5% so that air can be released through air valves (pages 56 and 57), and with a gradual fall to low points. Cleaning-valve outlets should be fixed at these low points for emptying that portion of the line. Flat lengths of pipeline - those laid parallel to the hydraulic gradient - should be avoided since they will give air lock problems. The bottom of the trench should be straight and rocks and stones should be cleared away.

Embankment - Where soil cannot be excavated, or only excavated to a small depth, pipe should be protected by an embankment of earth instead of by burying it. The outside base of the embankment should be fixed into the original ground stone. These stones have the effect of lining up the new edge with the ordinary ground and preventing erosion. The earth around the pipe should be well compacted. The top and sides of the embankment should be planted with grass to stabilise the soil or other ground cover. (See below)

- A - Pipe
- B - Soil free of sharp pebbles, stones and organic matter. Well compacted
- C - Soil free of stones and organic matter, compacted in layers of 10cm.
- D - New grass cover or other stabilization.
- E - Stones fixed into the original ground - to provide continuity with it.

FIGURE 5.9 — EMBANKMENT

CROSS SECTION



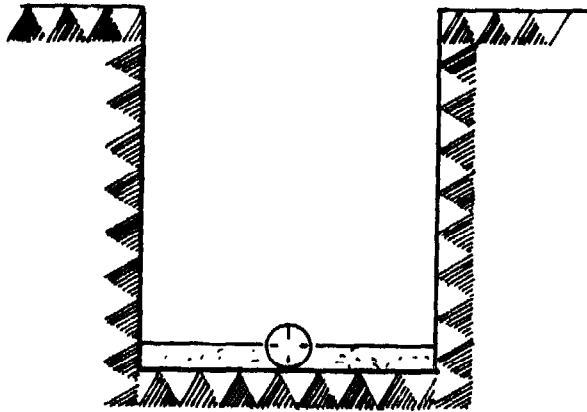
5.7 Backfilling and Tamping

Backfilling and tamping have a big influence on the life of the pipeline, so this should be done very carefully. The first backfilling materials must be soft, inorganic and free of stones, lumps or rocks. Backfill should be laid in layers of 10cm. each. Layers should be laid until a level 30cm. above the top of the pipe has been reached. After this bulk backfilling of the remaining part of the trench may take place, using excavated materials which are free of rocks and stones. Since some settling will occur, the trench when filled should be made into a mound large enough to avoid it becoming a conduit for rain water or surface run off. Look at the diagrams on pages 68 and 69 for step by step illustrations of backfilling.

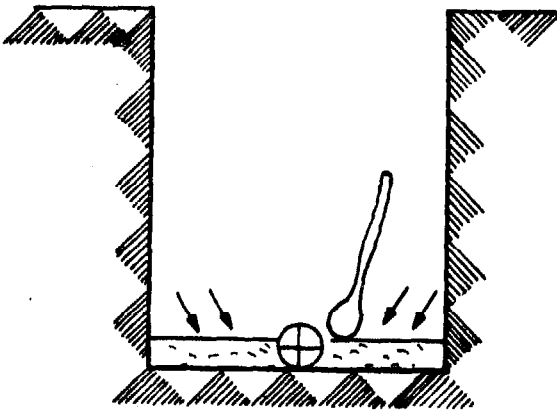
The diagram on page 70 shows how to proceed when the pipe is laid beneath a road.

- a. Where pipe is laid at a depth of 1.20 metres or more, proceed as with normal backfilling shown on pages 68 and 69.
- b. Where pipe is laid at depths of 1 metre to 1.20 metres, the pipe should be laid on a sand bed and be covered with at least 30cm. of sand. The remaining backfilling is done as normal.
- c. Where pipe is laid at a depth of less than 1 metre, the pipe should be laid on a sand bed and covered by 20cm. of sand. In addition a concrete slab should be laid, as in the diagram, to disperse the load above the pipe caused by traffic. The backfilling above the slab should be done as normal.

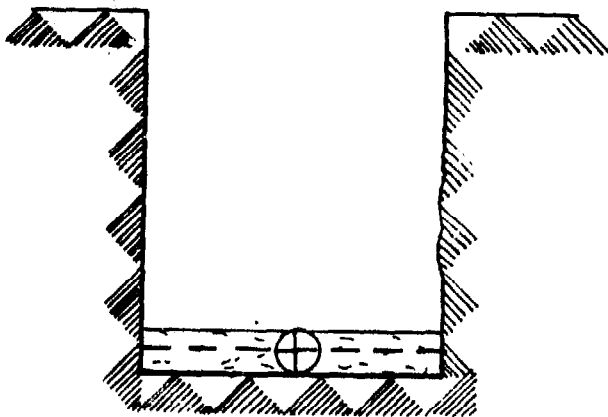
FIGURE 5.10.1 — LAYING A PIPELINE : TAMPING & BACKFILLING



A

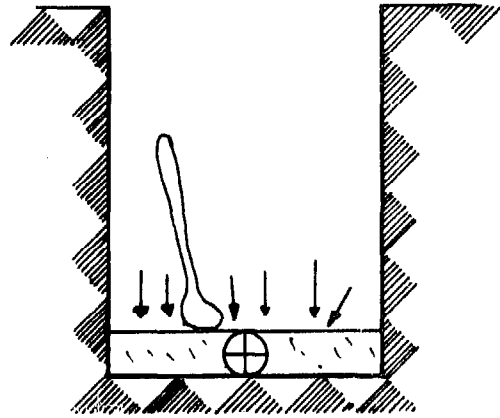


B

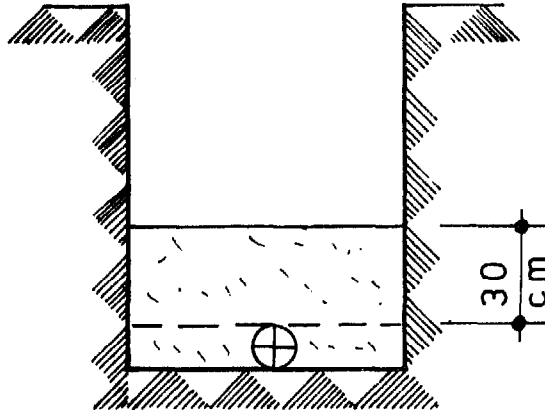


C

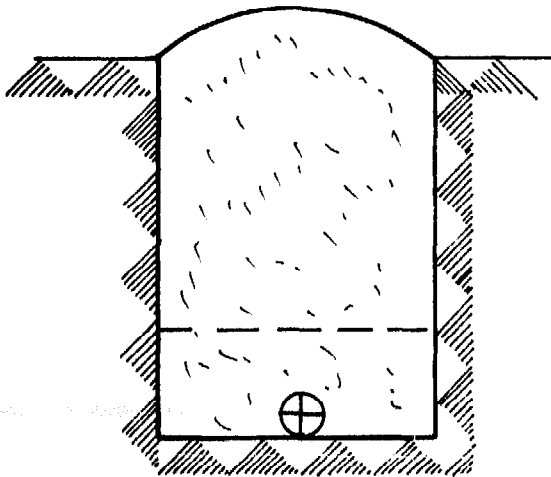
FIGURE 5.10.2 — TAMPING & BACKFILLING



D

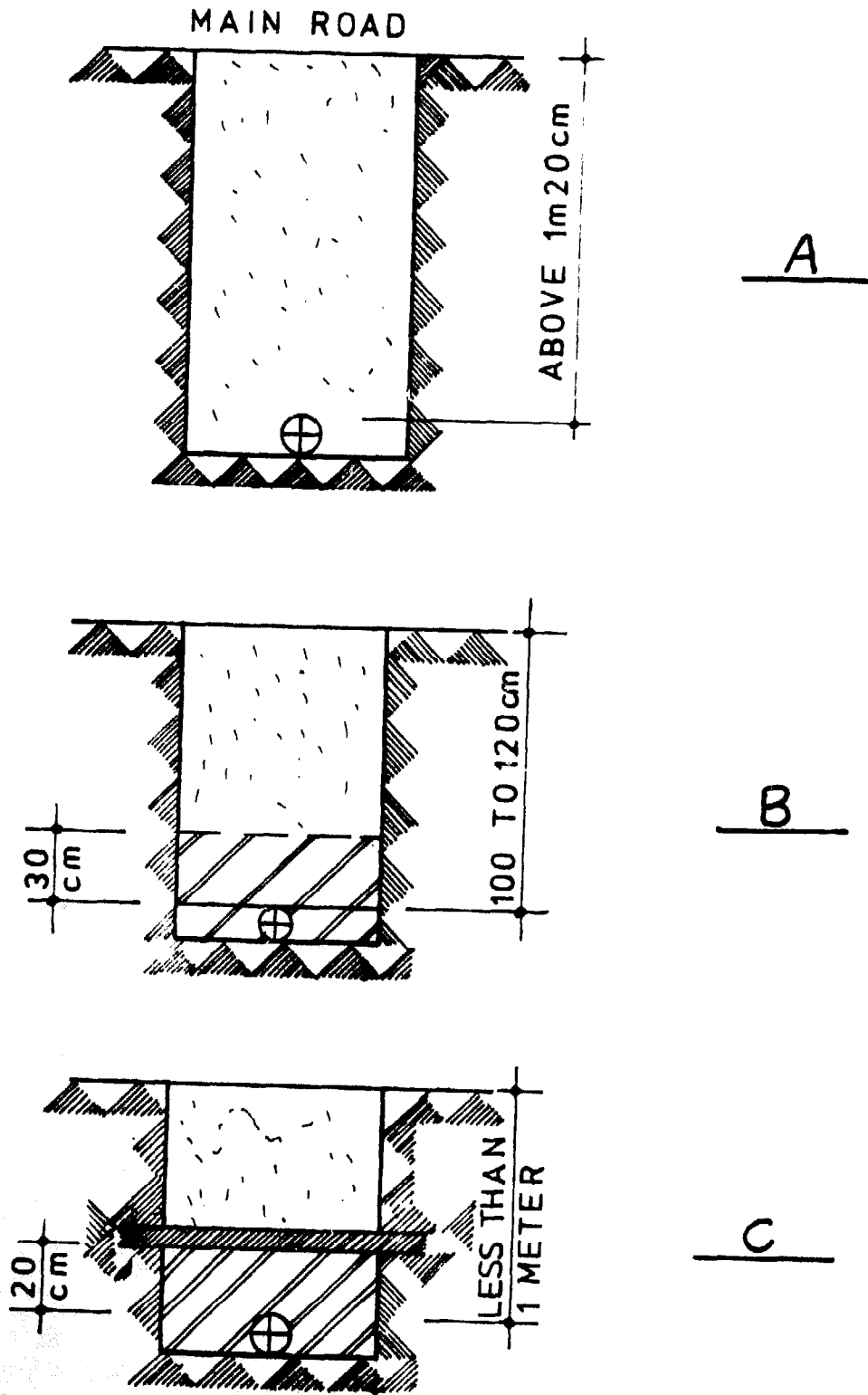


E



F

FIGURE 5.11 — LAYING A PIPELINE UNDER A MAIN ROAD



5.8 Pipeline Testing

After laying pipe, but before backfilling, the pipeline should be tested. Here are some points to remember about this.

- All HDP pipe joints should be checked when cool, after butt-welding, by hand testing i.e. bending gently and looking at them closely.
- All service pipes and fixed fittings should be checked with a hand-pump pressure test, before beginning construction of masonry standpipes.
- After completing storage tank pipelines and stand pipes the system should be put under water pressure. Each welded joint, fitting and pipeline connection through a wall should be carefully checked by hand as above.
- Repairs should be done as necessary. After the first test there should be a second test, carried out with the same attention as for the first, to check that all repairs are satisfactory. Trenches should not be filled until both tests have been successfully completed. They should be filled only if the whole system has been shown to contain no leakages.

5.9 Marking The Pipeline

Immediately after backfilling, the pipeline should be marked with permanent signs otherwise, it might be difficult to find the pipeline later by relying on memory alone. It may be necessary to know the route in order to do maintenance or repair work.

Marks should be placed at the following points:

- a. At branches
- b. At changes in direction
- c. At changes of size
- d. At valve boxes,
- e. At every 200 meters in straight runs in good terrain, and
- f. At every 50 meters in straight runs in bad terrain.

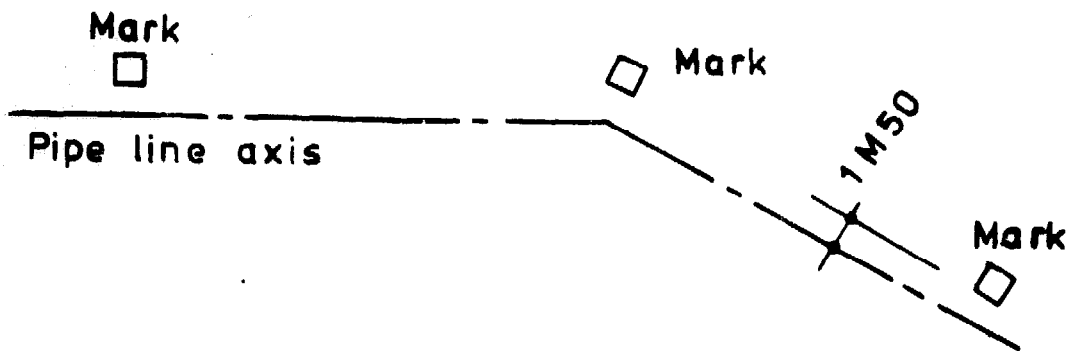
Note that diagram B (page 72) shows a small piece of pipe buried in the mark. This is used to indicate the diameter of the pipeline at that point. Notches should be cut into this piece of pipe to indicate the direction of the pipeline. Marks are usually buried on one side of the pipe axis (diagram A, page 72). If the marks were directly over the pipe two things could occur: they might be removed, lost or not correctly replaced when repair work was done; the backfill might sink, taking the mark with it and covering it up.

All marks from source to storage tank to village should be numbered in sequence. This is very important. A small stone masonry construction with a concrete top is recommended. This should rise at least 15cm. above the ground and be well fixed in place. These points are illustrated in diagrams A and B below.

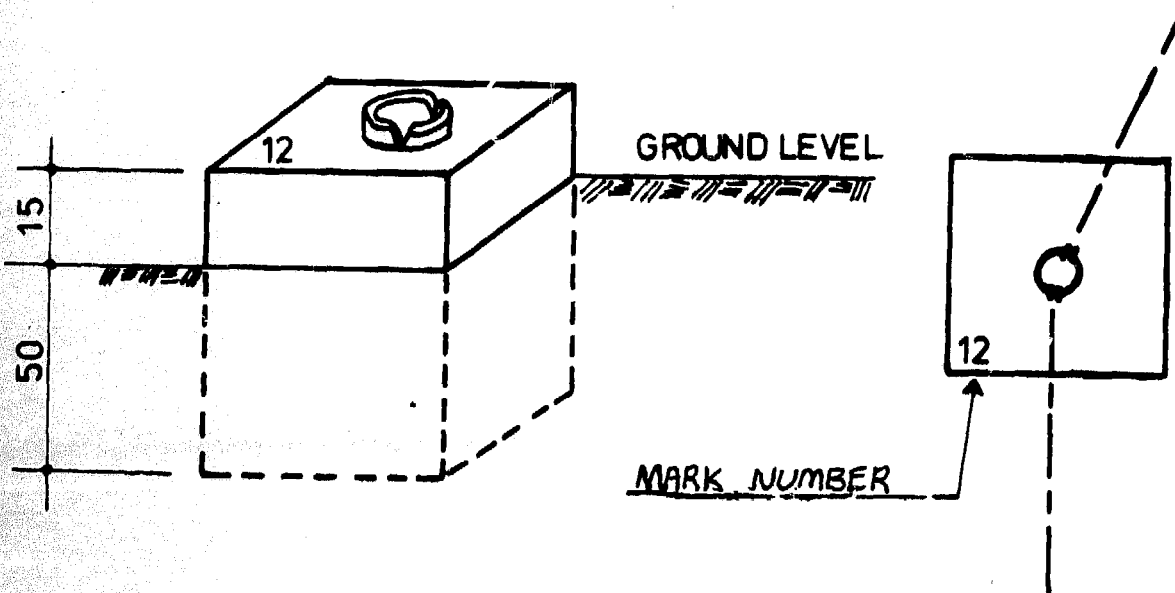
FIGURE 5.12 - MARKING THE PIPELINE

A. WHERE MARKS SHOULD BE PLACED

EXAMPLE



B. WHAT MARKS SHOULD LOOK LIKE



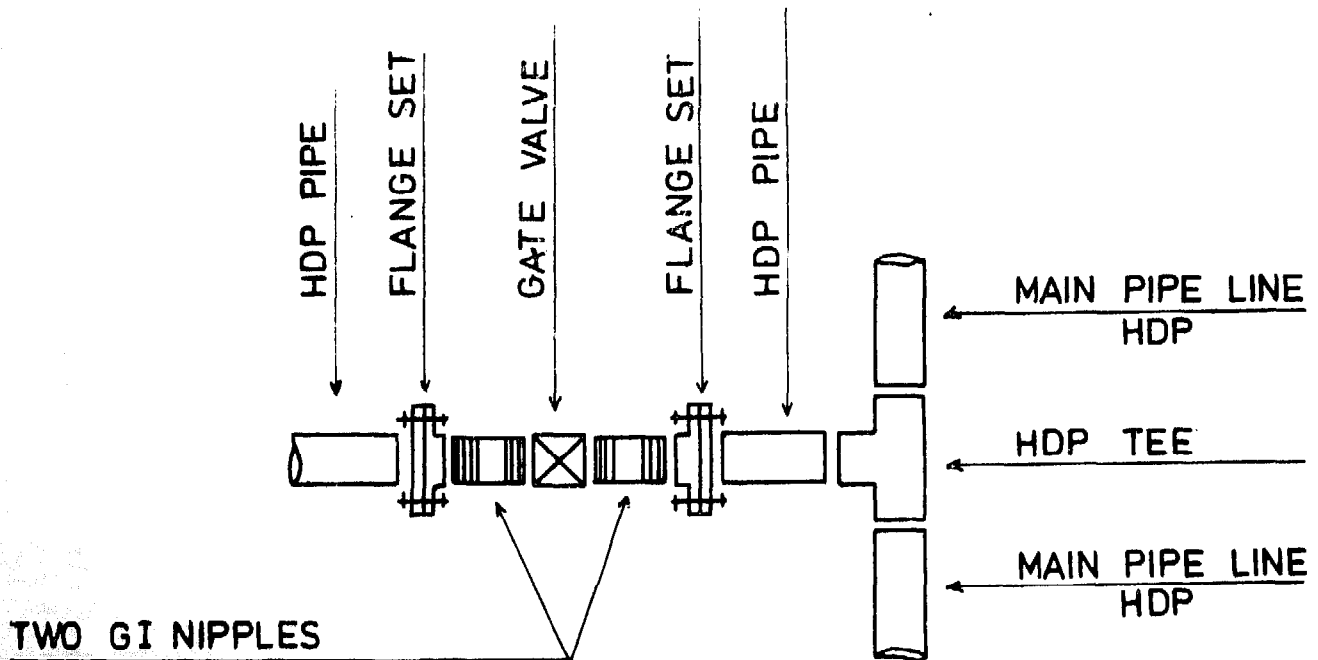
5.10 Finishing and First Chlorination

It is as important to finish the trench properly as it is to correctly lay the pipe. Ground surface over a new trench should be restored to its original condition or improved if possible. This will minimise erosion of the fresh soil and it is especially important for steep slopes which will present greater problems of erosion. Alternatively, one can pave the disturbed area with stones. To do this place long flat stones across the path of the pipe. This will break the flow of the surface water.

After completing the project, the tank and the pipeline must be cleaned and disinfected with a chlorine solution in order to prevent pollution of the drinking water.

Chlorine should be mixed with water from the storage tank and should stay in the pipeline for at least three hours. The strength of the chlorine solution, that is, the quantity of chlorine put into the water, will be worked out by the engineer in charge of the project.

FIGURE 5.13 — CLEANING OUT INSTALLATION DETAIL



REMARK: ALL FITTINGS ARE ACCORDING TO THE PIPE LINE DIAMETER

6. STAND PIPES, TAPSTANDS AND PUBLIC FOUNTAINS

6.1 General Points

Stand pipes should be built wherever it is most convenient for the villagers to collect water. Two considerations should be remembered when building them.

The first are technical considerations such as the need for cleaning valves in the pipeline, or air valves. The second is the concentration of population in the village. One tapstand should be built for every 150-250 persons.

The design should also take account of the following points all of which apply to the local situation in Nepal.

- a. There should be a hole under the tap through which water can drain.
- b. Waste water should be used for cattle or small gardens. There should be a waste pipe to bring the water to a pond. This pond should be at least 50m. from the stand pipe to prevent pollution. It should be constructed at the same time as the stand pipe itself.
- c. There should be enough space around the drainage hole to allow people to wash clothes on the tap stand floor.
- d. The tap stand floor should be built with big, flat stones pointed at the joints.
- e. The sides of the stand pipe pillar should be built in such a way that there will be a flat surface on which baskets, loads or gagros can be placed. These surfaces should be done in dry masonry.
- f. The tap should be at a height of about 1.20 meters.
- g. The faucet (tap) should be at 25mm. from the pillar, to allow a wide-rimmed gagro to be filled with water.

6.2 Construction

Designs for stand pipes and details of fittings are shown on the following pages. These conform to the general points mentioned earlier.

There are three designs shown:

- Public tapstand (pages 76, 77 and 78)
- Bazar tap stand (pages 79, 80 and 81). These are built in areas where there is not enough space to build a public tapstand.
- Public fountains. (Pages 82, 83 and 84). These are erected in areas of high population density. Water distribution is from two taps located one on either side of the post.

Details of required fittings are given on pages 85, 86 and 87.

FIGURE 6.1 - PUBLIC TAPSTAND DETAILS

PLAN 1.20

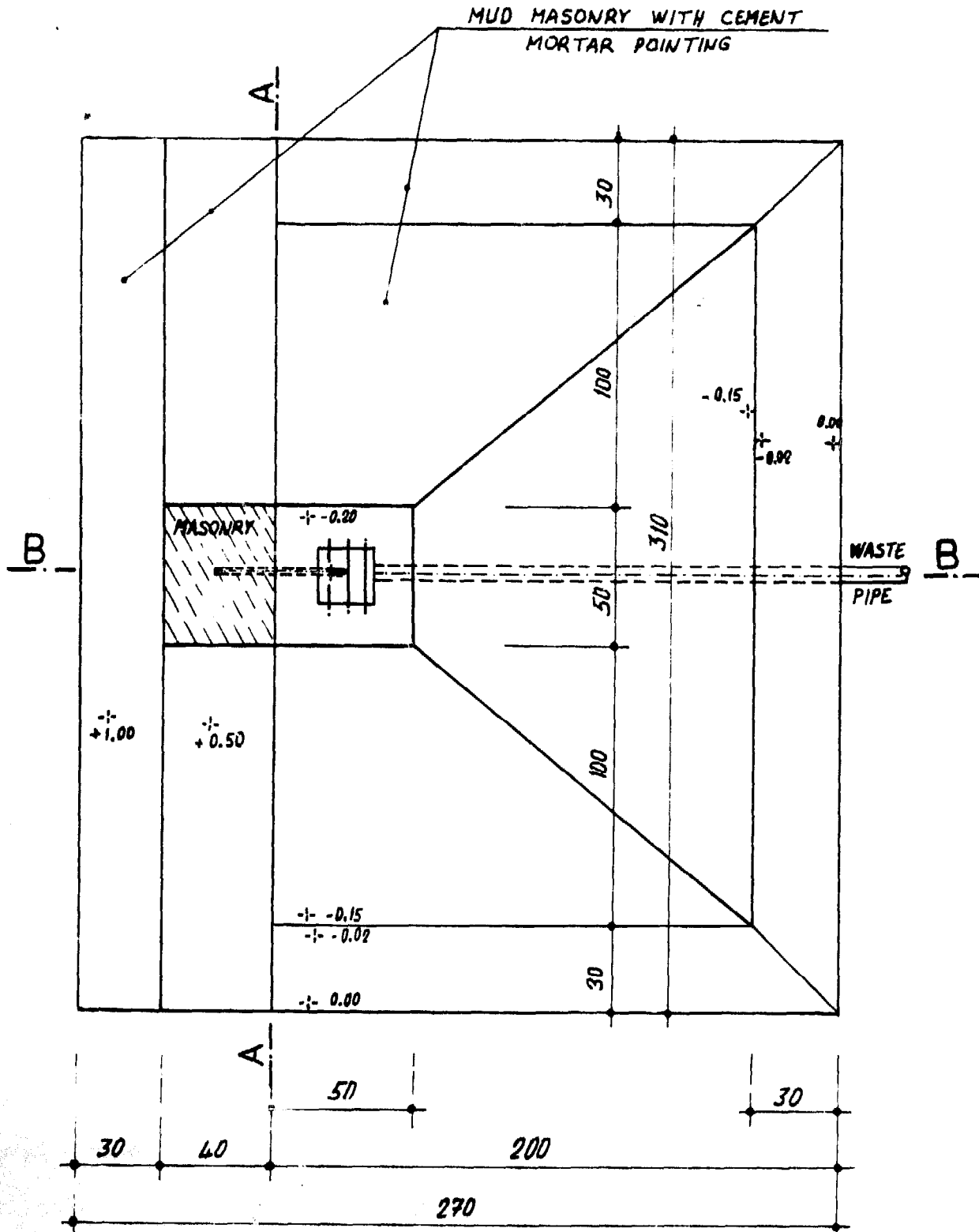
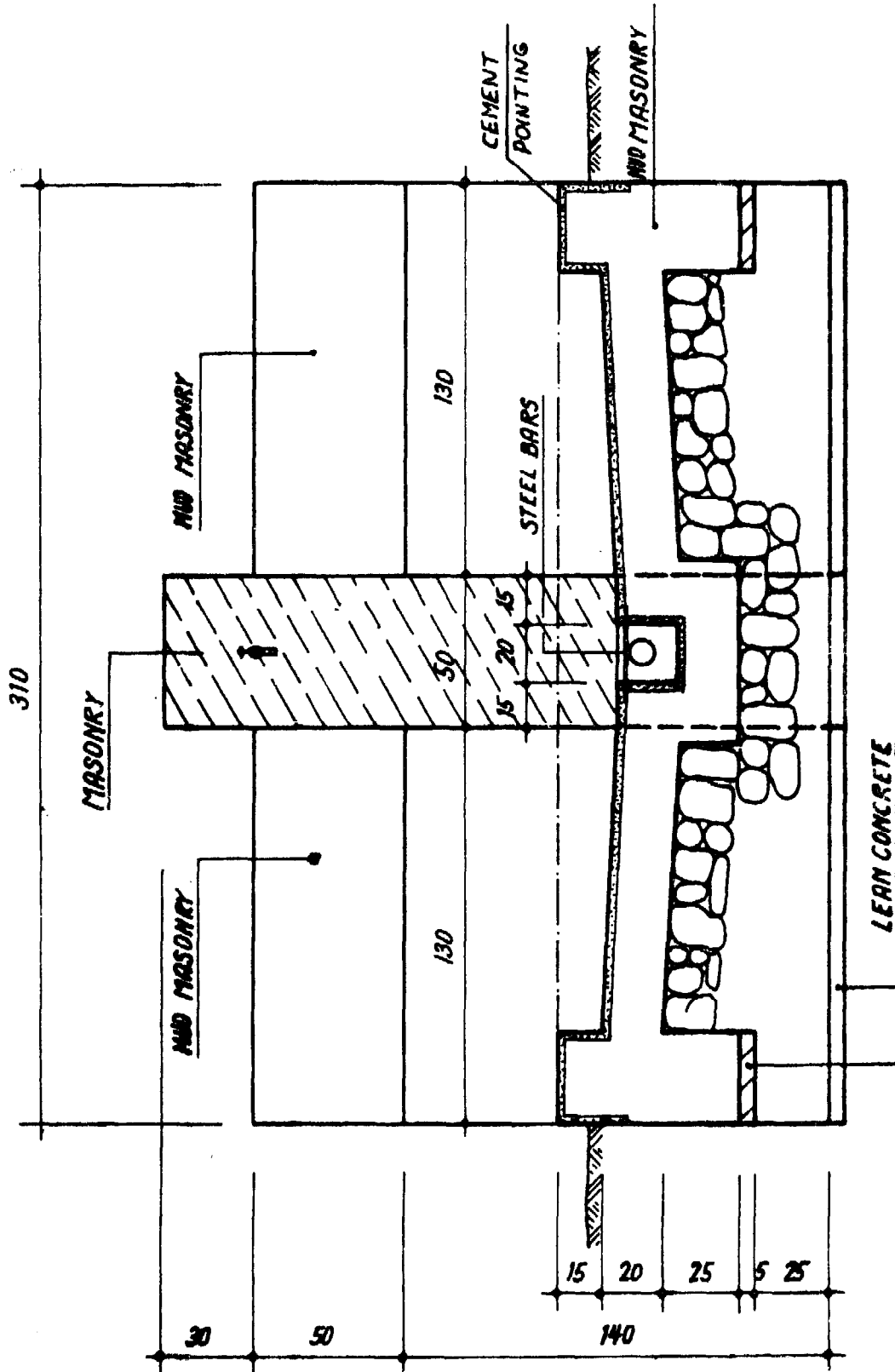


FIGURE 6.2 - PUBLIC TAPSTAND DETAILS

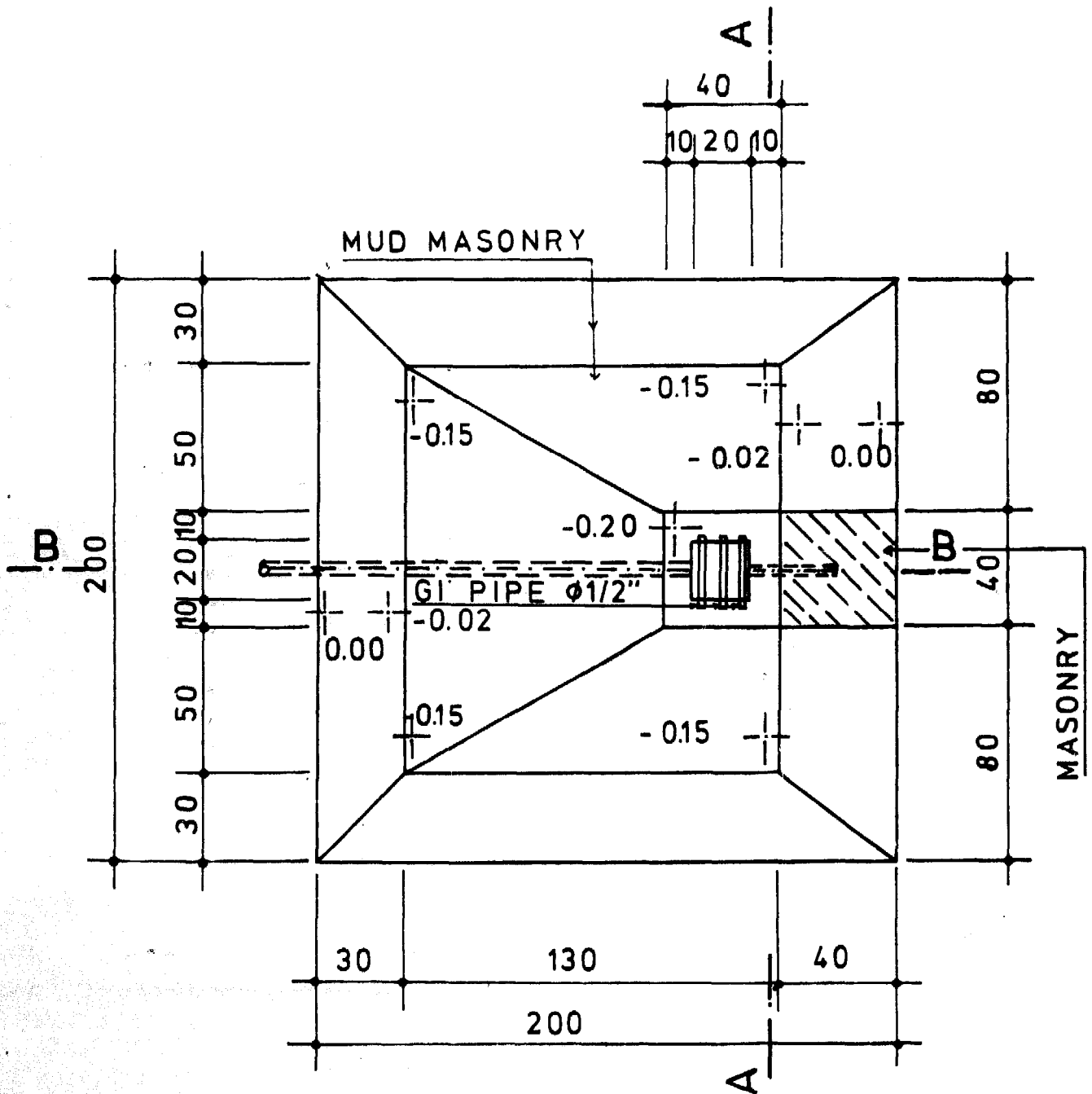
SECTION A-A 1:20



BAZAR TAPSTAND DETAIL

FIGURE 6.4

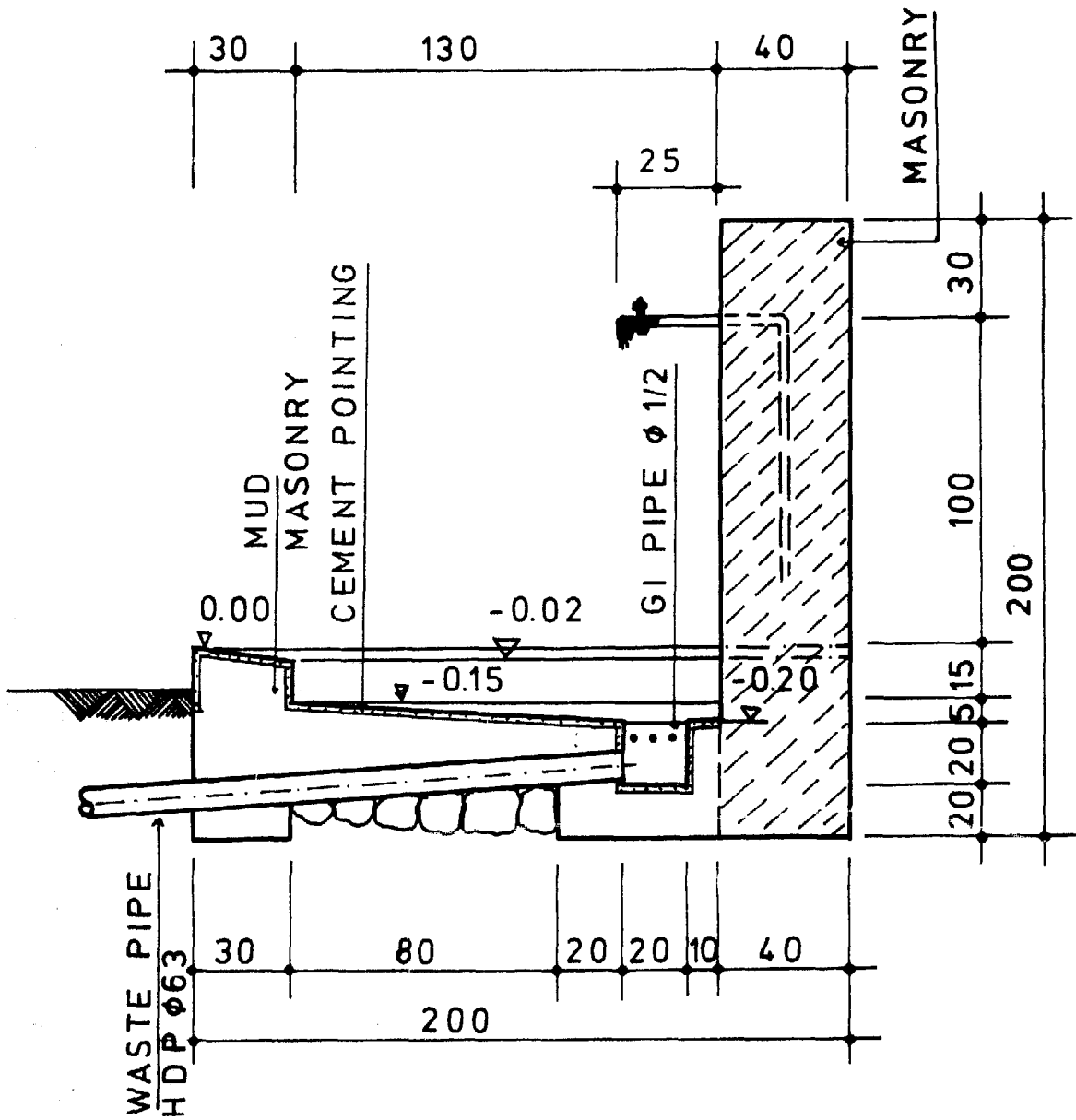
PLAN



BAZAR TAPSTAND DETAIL

FIGURE 6-6

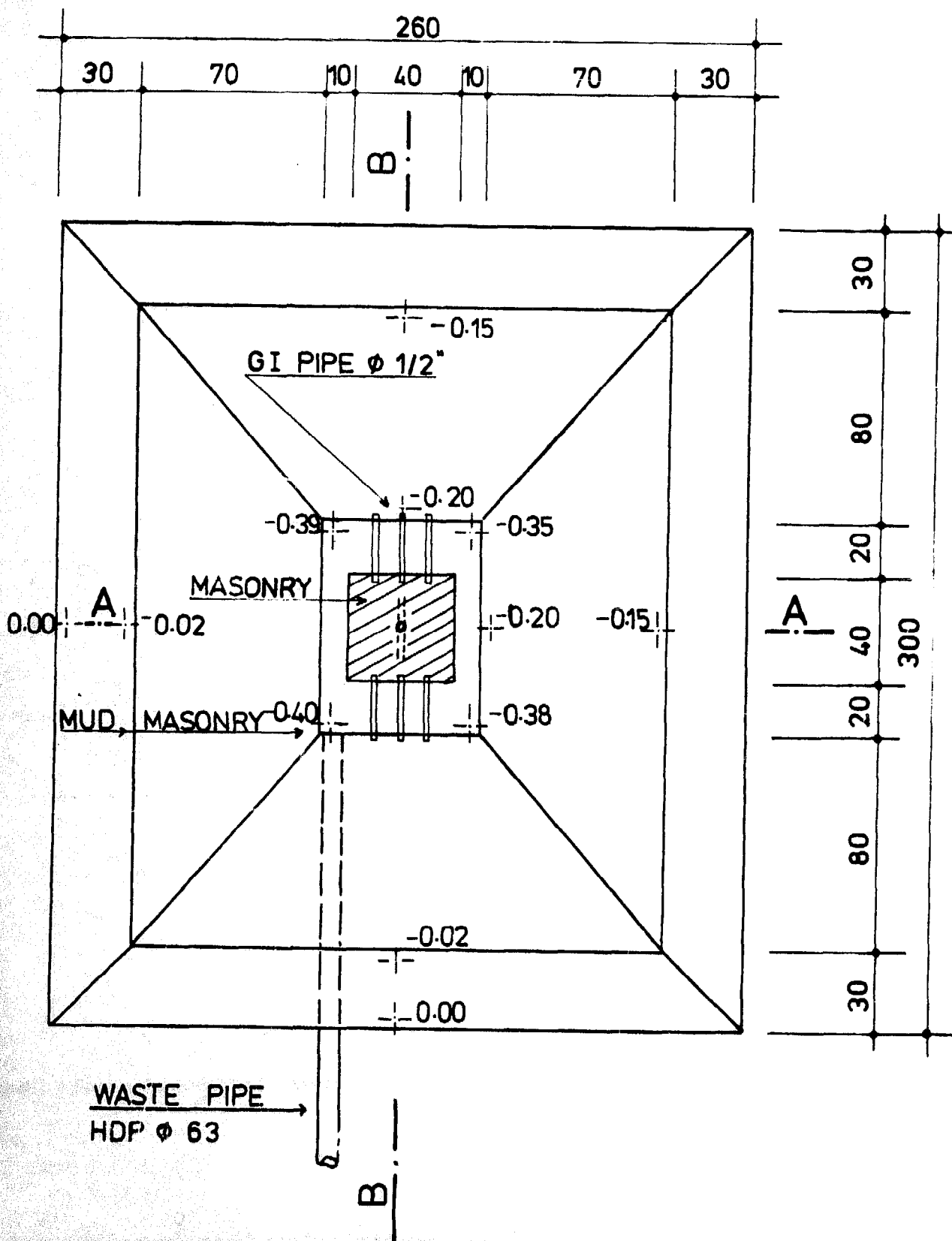
SECTION B—B



PUBLIC FOUNTAIN DETAIL

FIGURE 6.7

PLAN



PUBLIC FOUNTAIN DETAIL

SECTION B-B

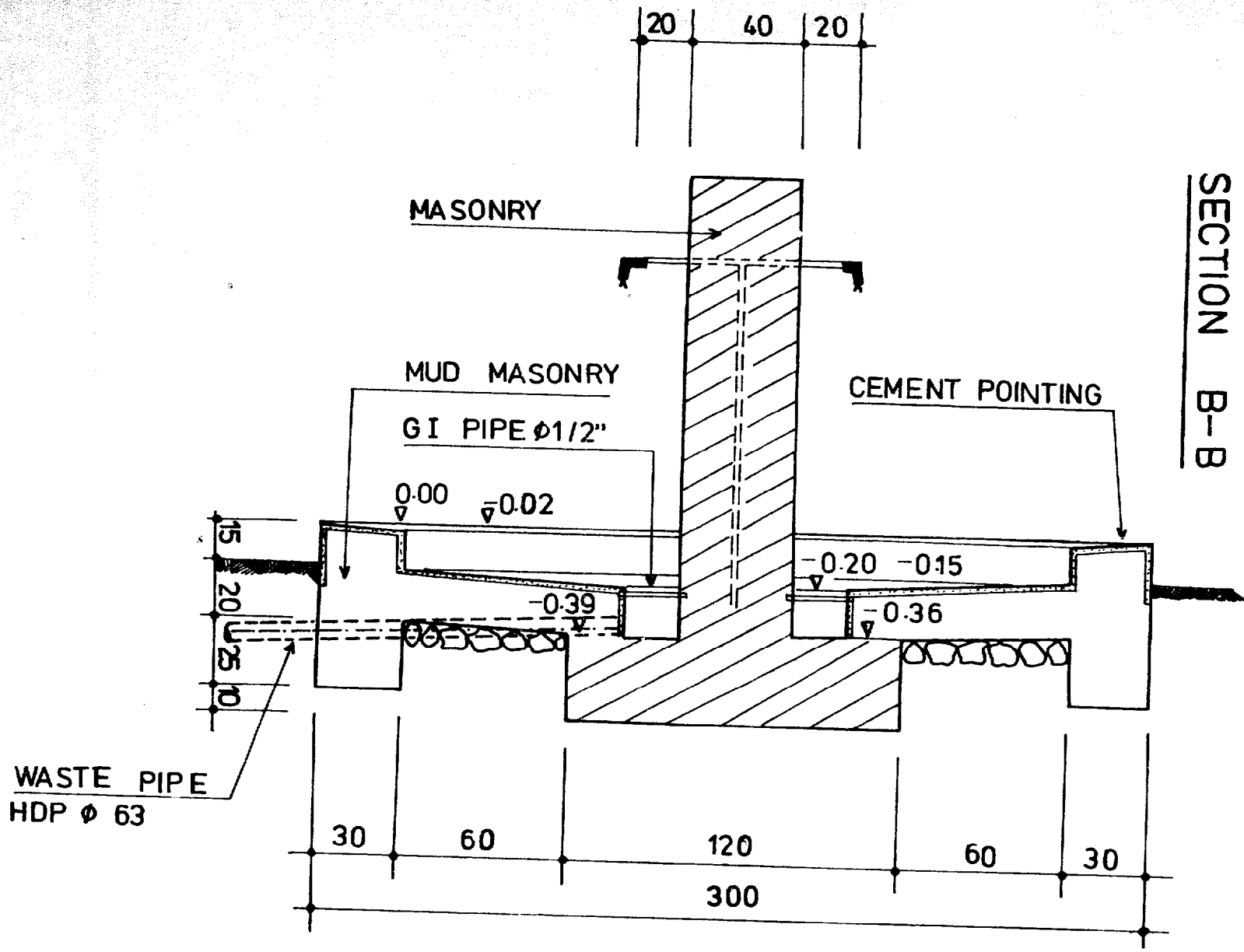
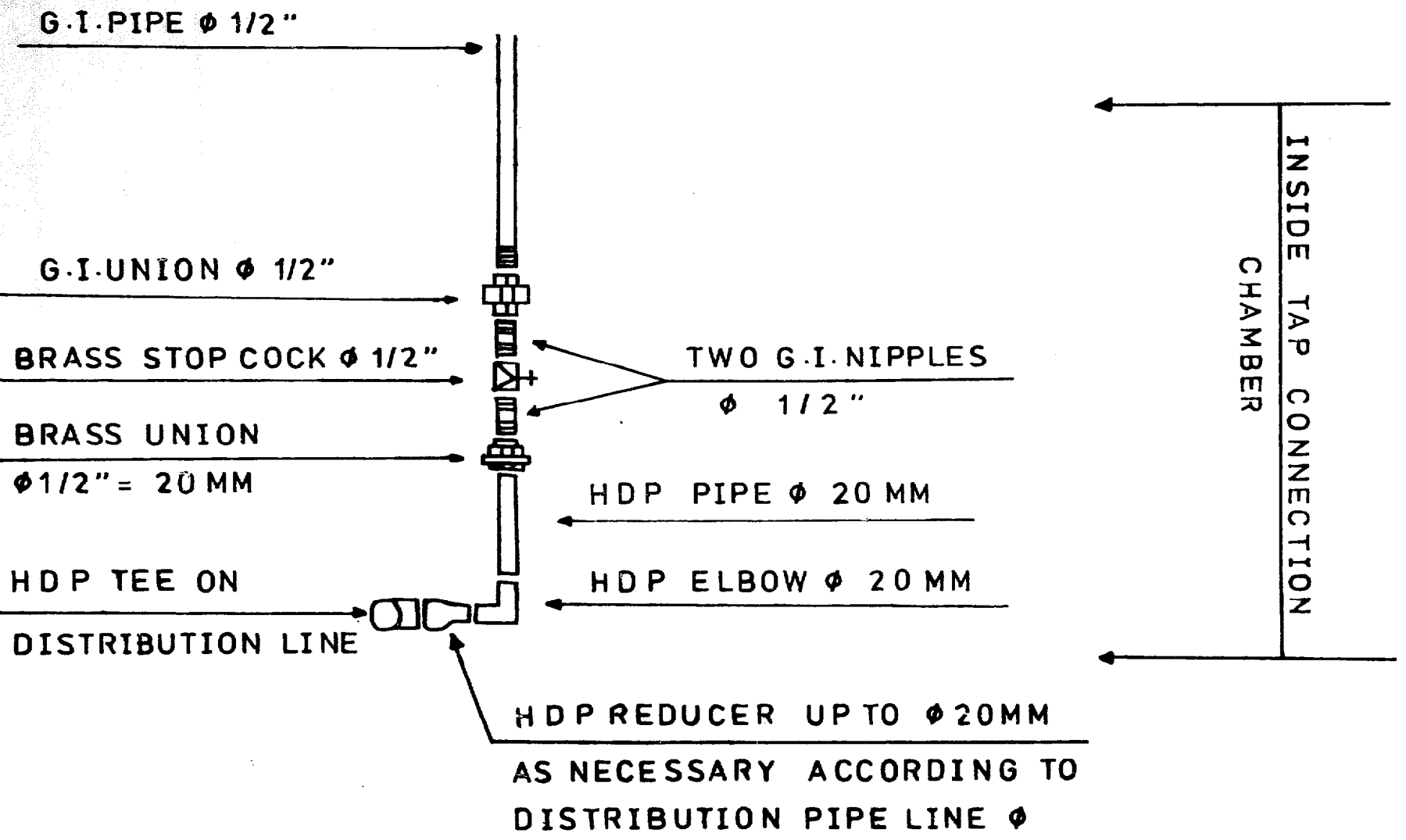


FIGURE 6.9

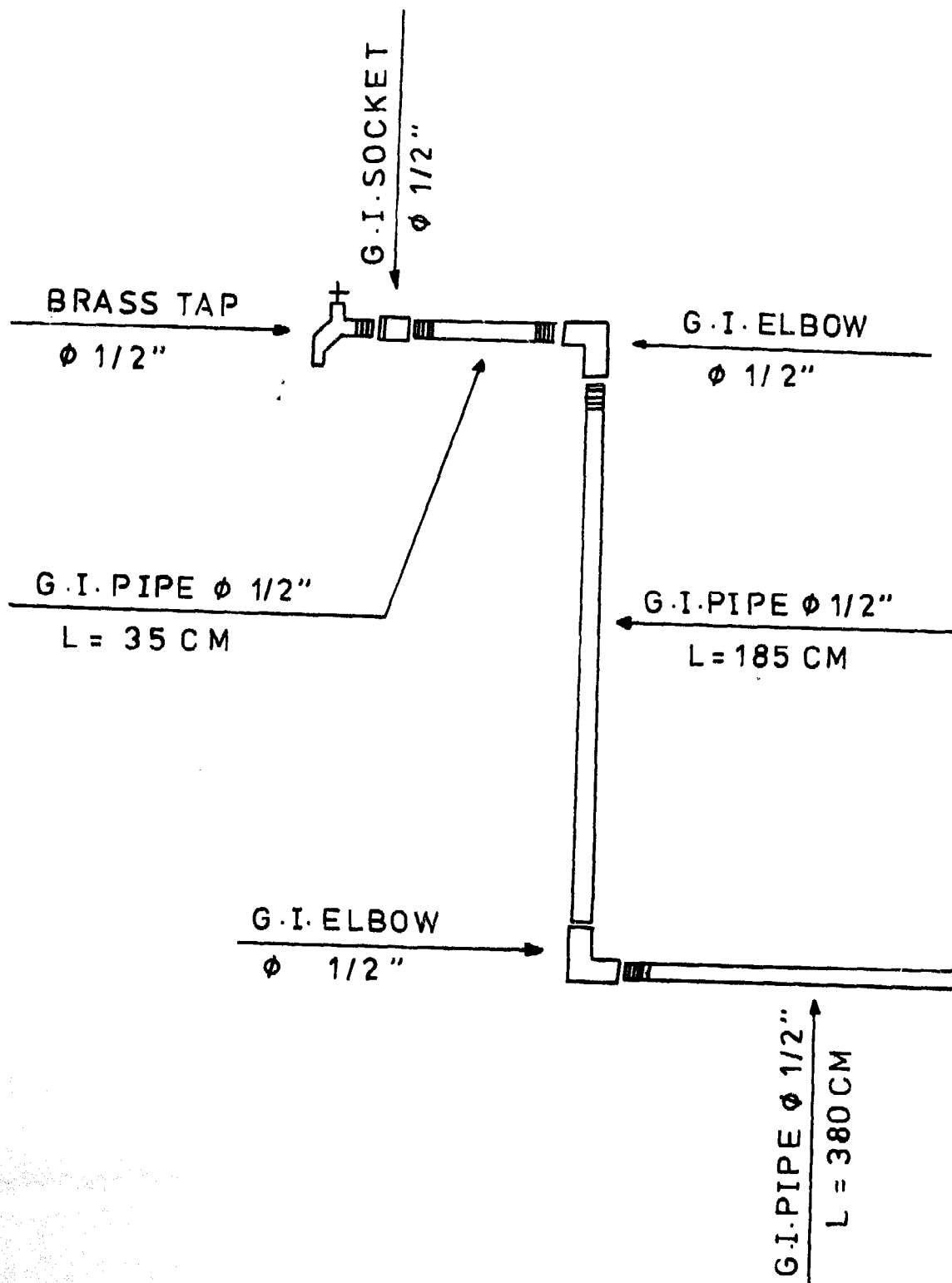
TAP STAND INSTALLATION DETAIL

FIGURE 6.10



TAP STAND INSTALLATION DETAIL

FIGURE 6.11



PUBLIC FOUNTAIN INSTALLATION DETAIL

FIGURE 6.12

