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A catalog of water supply and waste disposal methods for individual units

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9. ABSTRACT

(ENGINEERING--HYDRAULICS R&D)

Urban and industrial growth in developing countries has increased the demand for water and the related need for more information on water and sewage treatment. This project, conducted by the University of Oklahoma, focuses on that need by developing a global network of adaptive and innovative technologies based on economic, social, political and cultural factors. A series of detailed reports have been produced that are designed to assist planners in their selection of suitable water and wastewater treatment processes appropriate to the material and manpower resource capabilities of particular countries at particular times.

"Prediction Methodology for Suitable Water and Wastewater Processes," George W. Reid and Richard Discenza.
PN-AAB-491 English
PN-AAD-291 Spanish

"Prediction Methodology for Suitable Water and Wastewater Processes. Supplement I: Manual Computation Methods," George W. Reid and Richard Discenza.
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"Prediction Methodology for Suitable Water and Wastewater Processes. Supplement II: Computer Program," George W. Reid and Richard Discenza.
PN-AAD-293

"Data Requirement," University of Oklahoma Bureau of Water and Environmental Resources Research.
PN-AAD-295

"A Mathematical Model for Predicting Water Demand, Wastewater Disposal and Cost of Water and Wastewater Treatment Systems in Developing Countries," George W. Reid and Michael I. Muiga.
PN-AAD-294

"Treatment Methods for Water Supplies in Rural Areas of Developing Countries," Ir. L. Huisman.
PN-AAD-284
PN-AAD-285

"Sewage Treatment in Developing Countries," L.W. Canter and J.F. Malina.
PN-AAD-286

"Contributions to a Mail Survey on Practical Solutions in Drinking Water Supply and Wastes Disposal for Developing Countries," International Reference Centre for Community Water Supplies, The Hague.
PN-AAD-287

"A Catalog of Water Supply and Waste Disposal Methods for Individual Units," George W. Reid.
PN-AAD-283

"Historic Implication for Developing Countries of Developed Countries' Water and Wastewater Technology," George W. Reid and Kay Coffey.
PN-AAD-288

"Evaluation of Lower Cost Methods of Water Treatment in Latin America," Odyer A. Sperandio and Jose Perez C.
PN-AAD-289

"Socio-Economic Conditions which Pertain to Cost of Construction and Operation of Water and Sewage Treatment Facilities and Quality of Water Consumption in Kenya," Erasto Muga.
PN-AAD-290

"A Water Sterilization Study in the Philippines," Reynaldo M. Lesaca.
PN-AAD-282

"The Study of Microbial Treatment of Nightsoil," Taiwan Institute of Environmental Sanitation.
PN-AAD-281

"Study of an Existing Water Treatment Plant on Simple Design and Operating System for Supplying Drinking Water to Rural Communities in the Lower Mekong Basin Countries," Thailand Ministry of Public Health, Department of Health, Rural Water Supply Division.
PN-AAD-280

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PN-AAD-283

A CATALOG OF WATER SUPPLY AND WASTE DISPOSAL METHODS FOR INDIVIDUAL UNITS

Prepared by

George W. Reid
Regents Professor and Director
Bureau of Water & Environmental Resources Research
The University of Oklahoma
Norman, Oklahoma 73069

October 1975

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October 1975

A Catalog of Water Supply and Waste Disposal Methods for Individual Units

I. Purpose. The purpose of this manual is to provide a collection of methods of water supply and waste disposal for individual units. However some practices compiled herein are also applicable to groups of housing units.

The users of this manual are assumed to be familiar with sanitary practices and this work merely assists them as a suggestive list of various possible methods. Thus, no explanation nor discussion will be given. Further documentation can be made by consulting the references list.

It is believed that the various methods presented in this manual are appropriate for less developed and developing countries. It is noted however that many of these methods are currently used in small communities of developed countries.

II. Approach. This manual consists of 183 figures taken from published literature listed in the references table. Each figure is equiped with a 3 number index which indentifies the figure. For example, the figure equiped with the index 6/9/230 would mean: "This is figure no. 6 of this manual. It is taken from page 230 of the document no. 9 in the

references list (i.e., Small Well manual)".

However, for the sake of conveniences, each figure will be called by its first number in the index only, rather than by its 3-number index itself. Thus the Figure 6/9/230 will be referenced as Figure 6. Similiarly by Figure 83, we would like to refer to Figure 83/4/52.

The user should take a look at the list of subjects in Part III below and locate the topics he is interested in. He then looks carefully at each figure relative to the topics and picks up the methods he needs. In case further documentation is desired, the 3-number index of the figure will enable him to find the book and the page from which the figure was reproduced.

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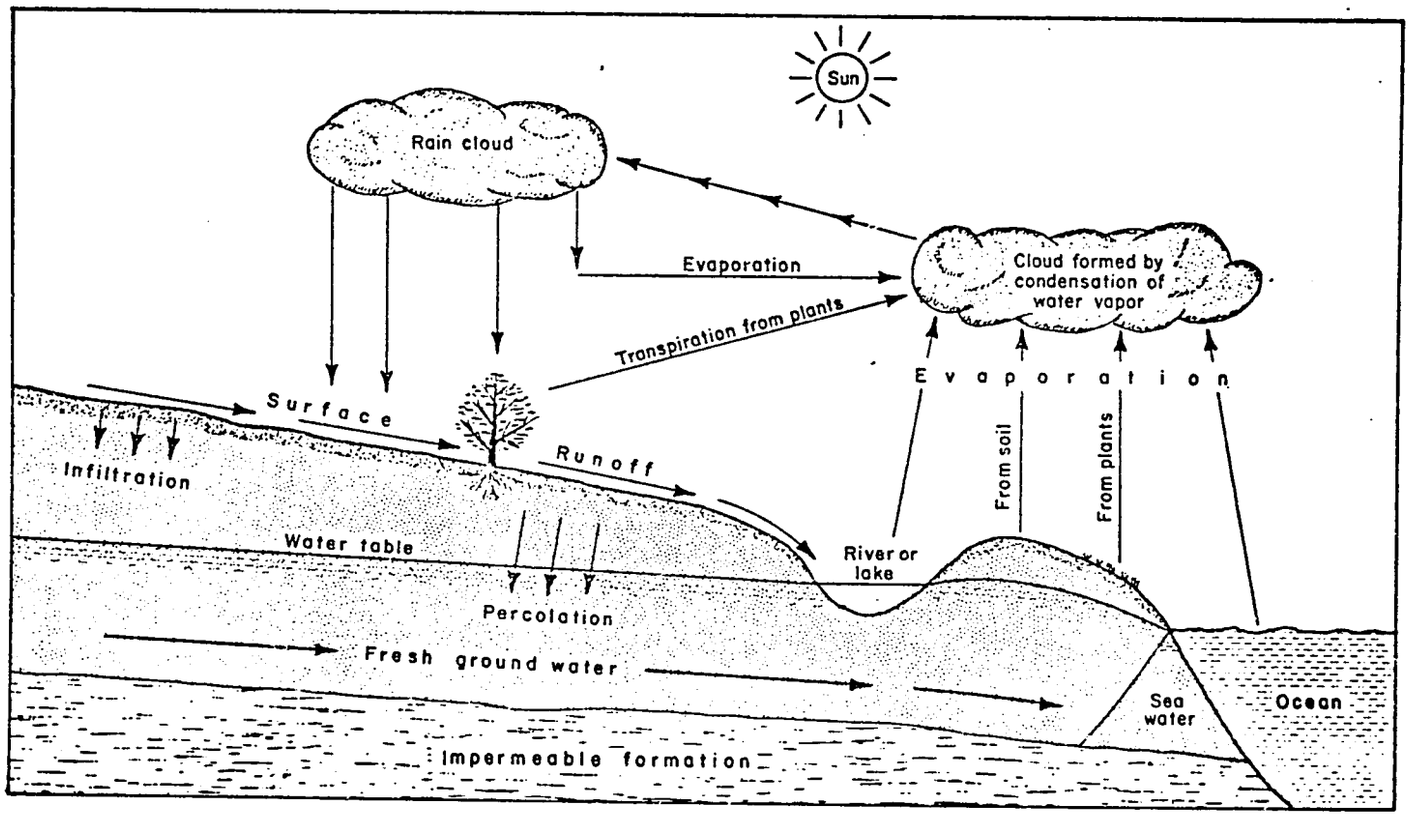

Fig. 2.1 THE HYDROLOGIC CYCLE.

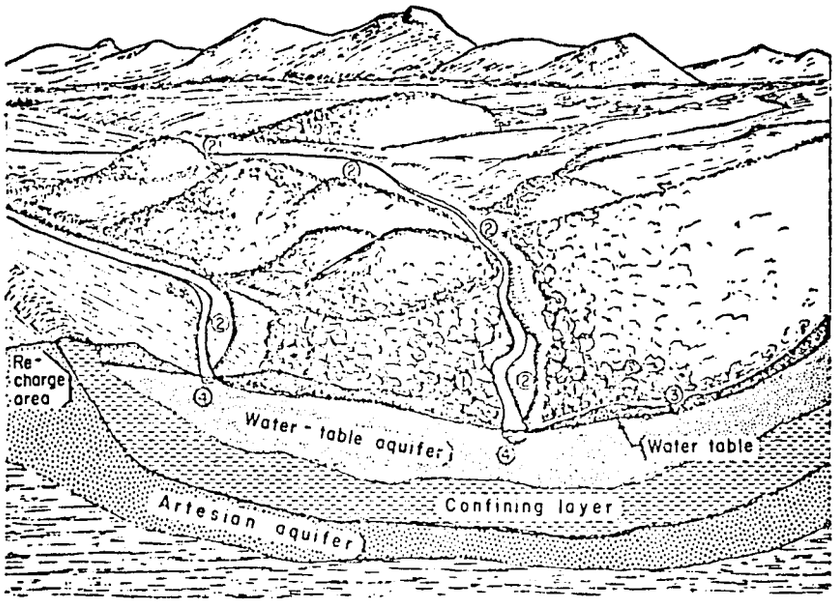

Fig. 3.3 SURFACE EVIDENCE OF GROUND-WATER OCCURRENCE. (Adapted from Fig. 4, *Water Supply For Rural Areas And Small Communities*, WHO Monograph Series No. 42, 1959.)

1 – Dense vegetation indicating possible shallow water table and proximity to surface stream.

2 – River plains: possible sites for wells in water-table aquifer.

3 – Flowing spring where ground water outcrops. Springs may also be found at the foot of hills and river banks.

4 – River beds cut into water-bearing sand formation. Indicate possibility of river banks as good well sites.

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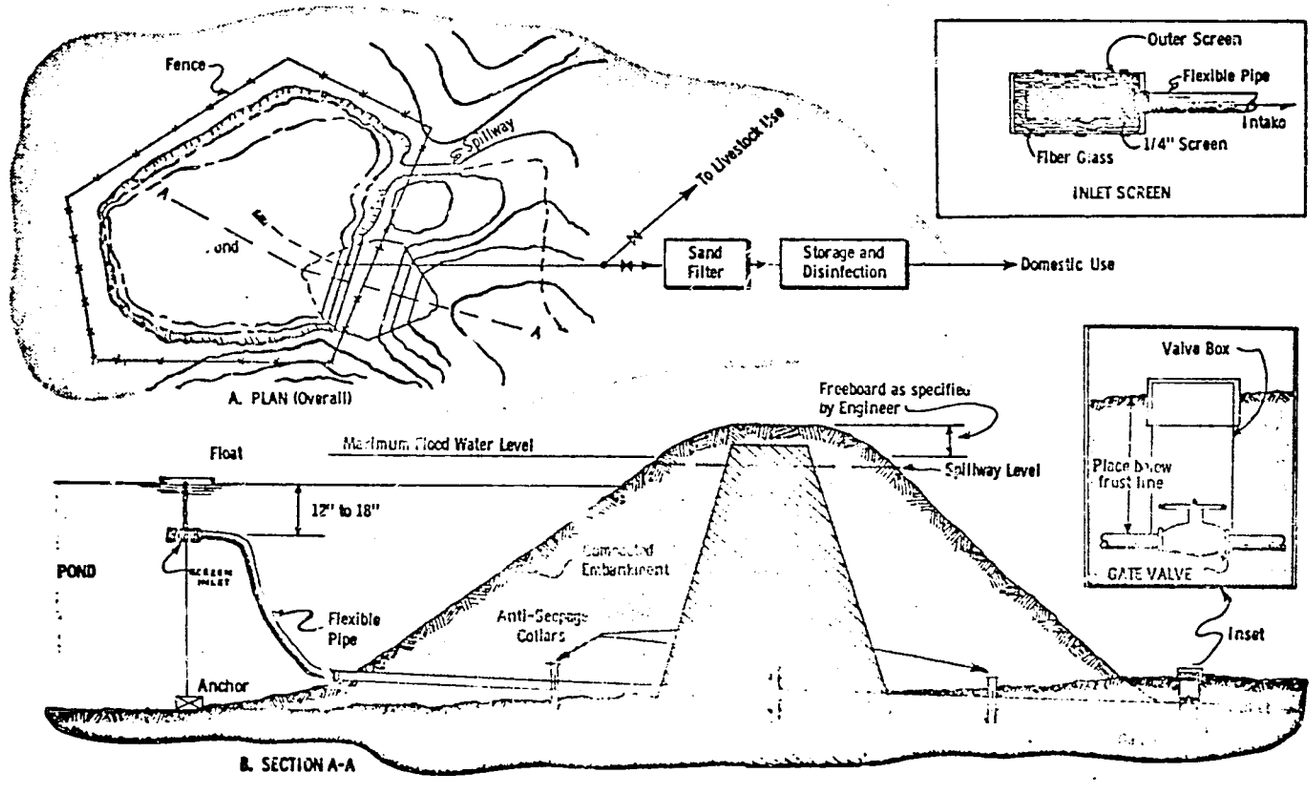


FIGURE 13. Pond.

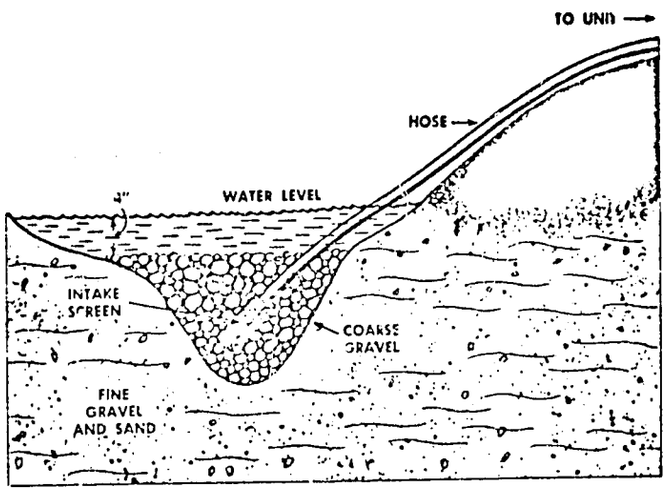


Figure 119. Surface intake buried in gravel-filled pit. Gravel acts as coarse strainer.

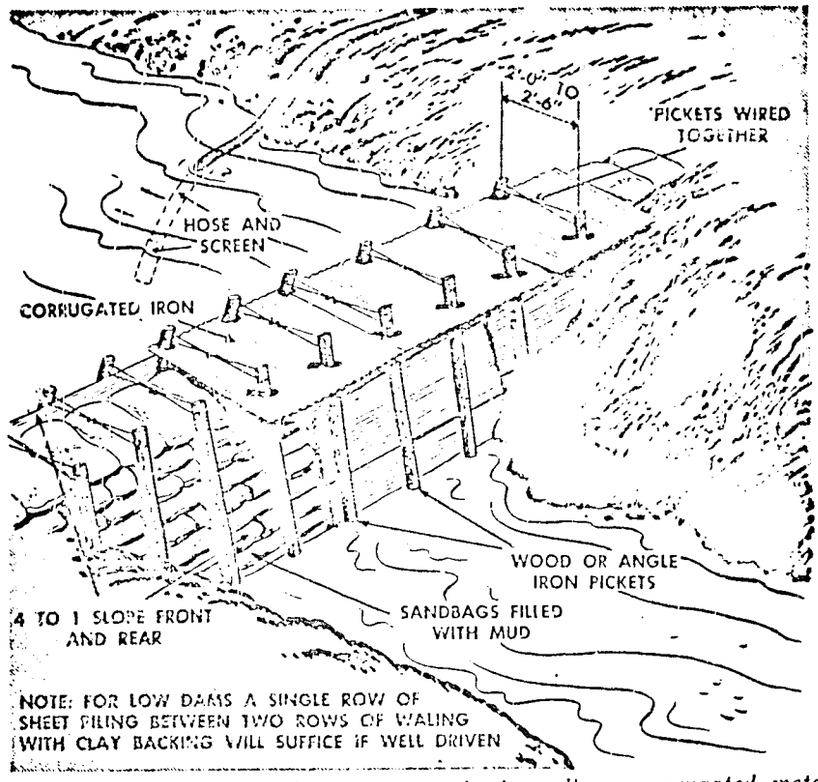


Figure 120. Improvised dam constructed of sandbags, corrugated metal, pickets, and wire for impounding small streams.

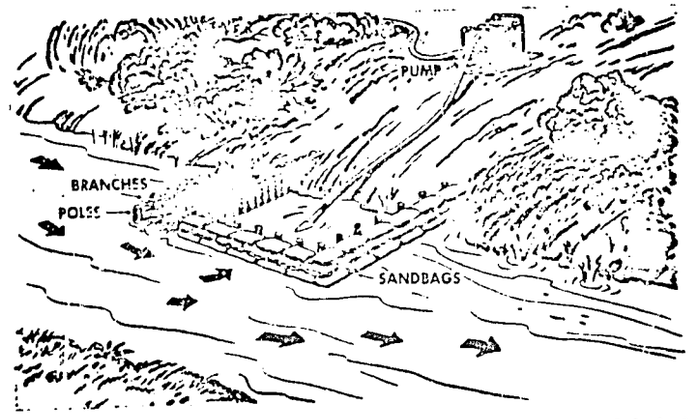


Figure 121. Baffle dam for protecting the intake strainer from debris in swift streams.

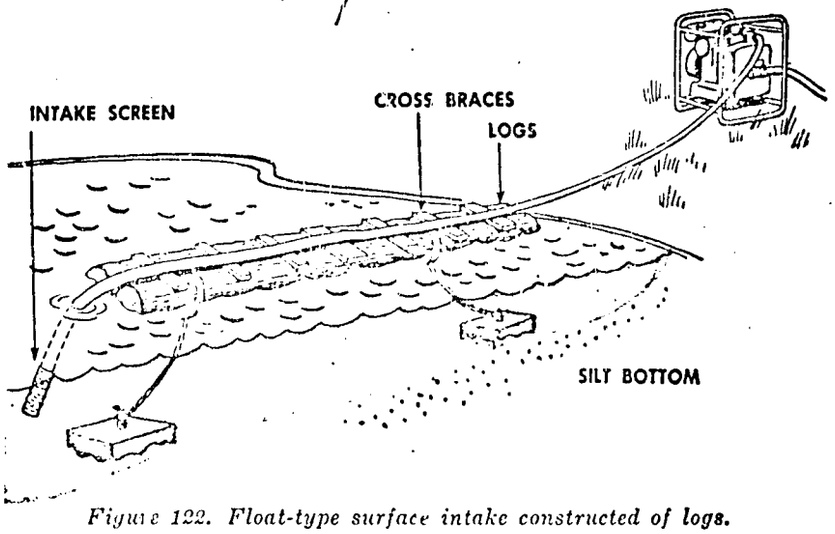


Figure 122. Float-type surface intake constructed of logs.

struction by reducing the amount of coagulating chemicals needed and by eliminating frequent backwashing of the filter.

e. WELLS ALONG STREAM BANKS. Wells along stream banks sometimes yield water so much higher in quality than the stream water that the extra work of installing them is justified. Directions for installing a driven well (fig. 124) are found in TM 5-297.

f. STREAM-BED DAMS. Dry stream beds can be developed into water sources by constructing subsurface dams which stop the flow of ground water. Conditions required for successful use of such dams are a stream bed of sand or gravel lying on a subsurface layer of impervious material which extends upward into the banks. A dam sunk to the impervious subsurface layer of such a stream impounds the ground water as shown in figure 125. Dams can be constructed of wood, concrete, or sheet piling. Recovery of

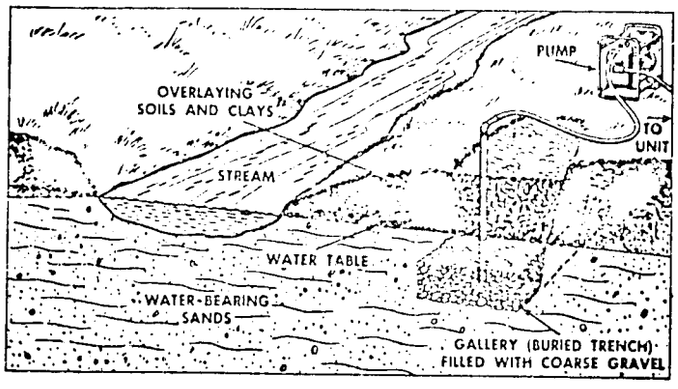


Figure 123. Gravel-filled gallery intake installed on bank of muddy stream.

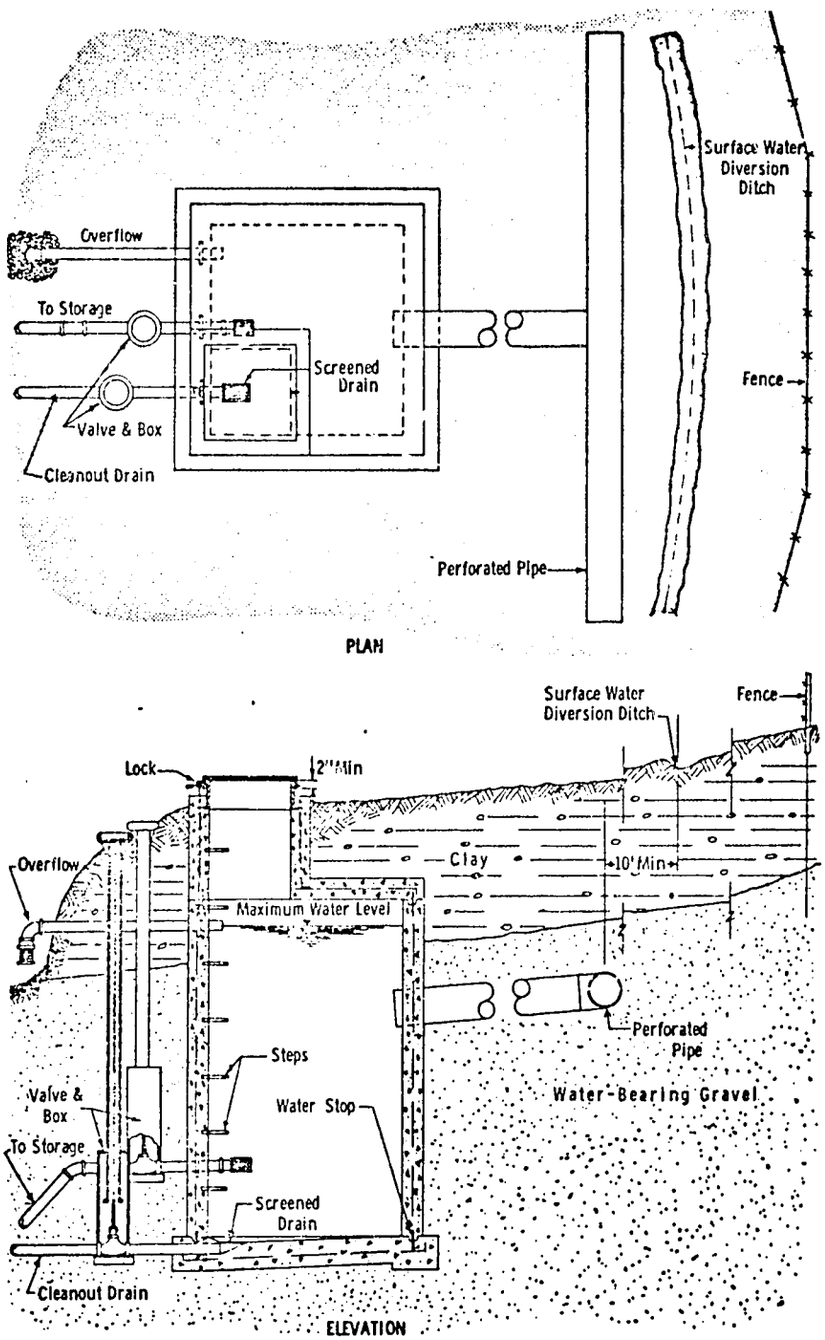


FIGURE 10. Spring protection.

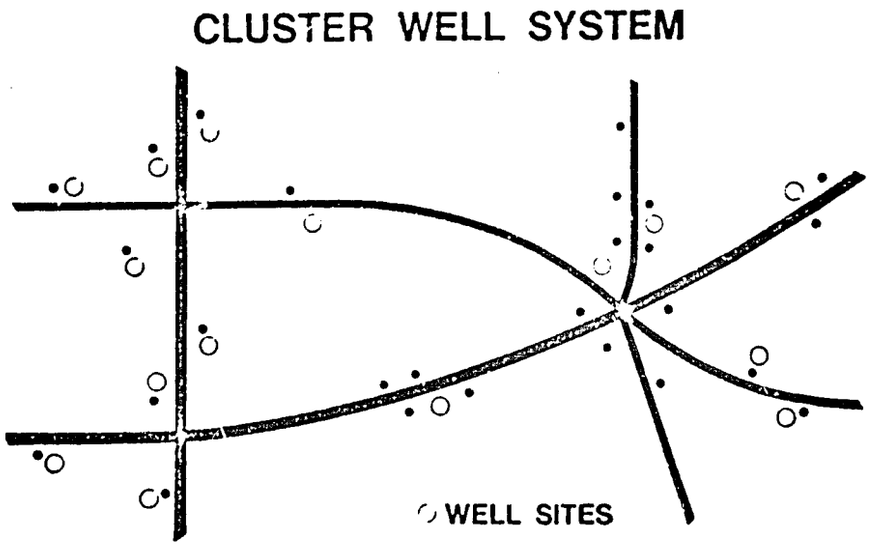


Figure 3.

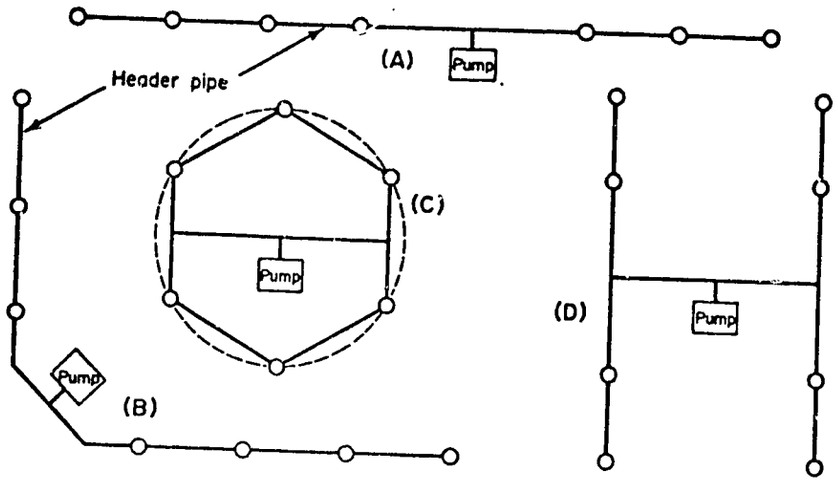


Fig. 2.17 LAYOUT PATTERNS FOR MULTIPLE WELL SYSTEMS USED AS WATER SUPPLY SOURCES. CENTRALLY LOCATED PUMP EQUALIZES SUCTION LIFT.

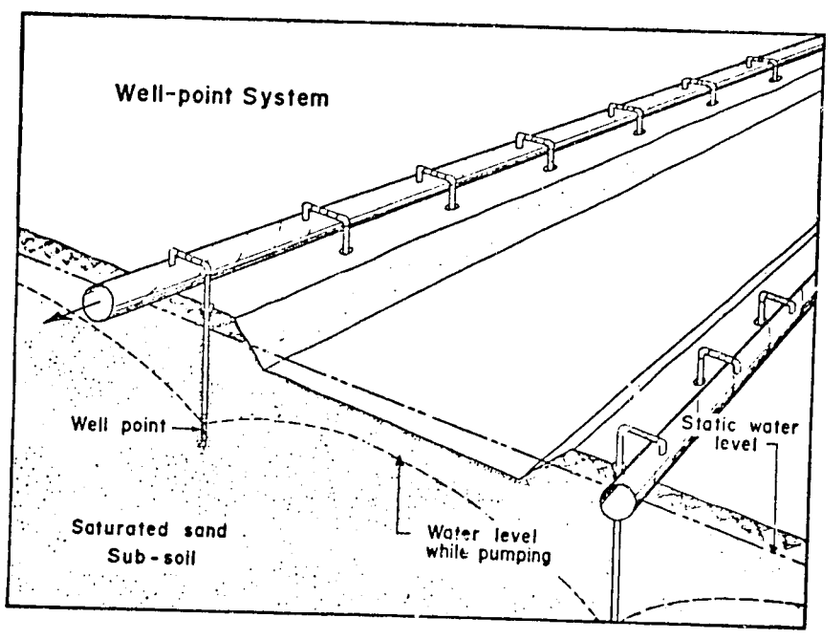


Fig. 2.18 WELL-POINT DEWATERING SYSTEM.

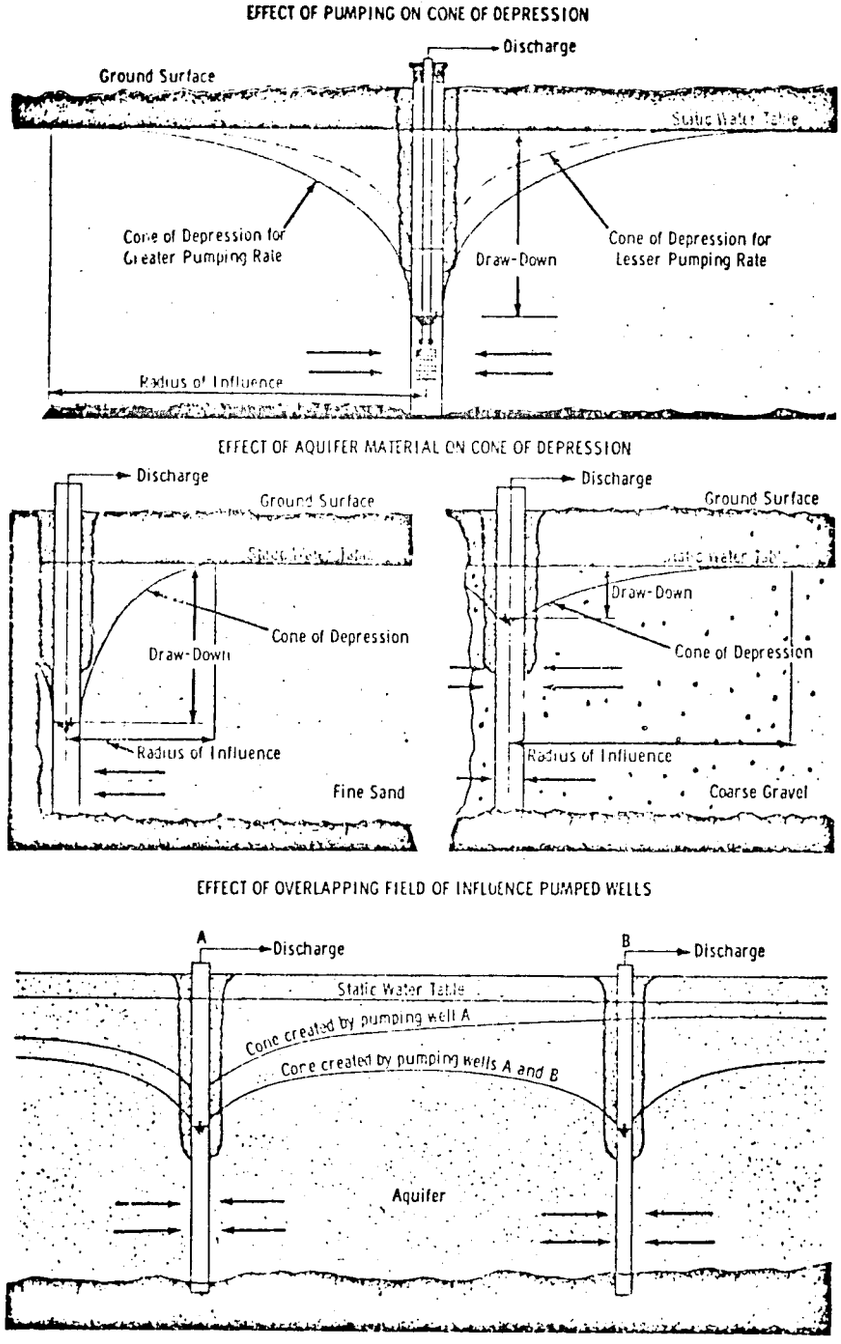
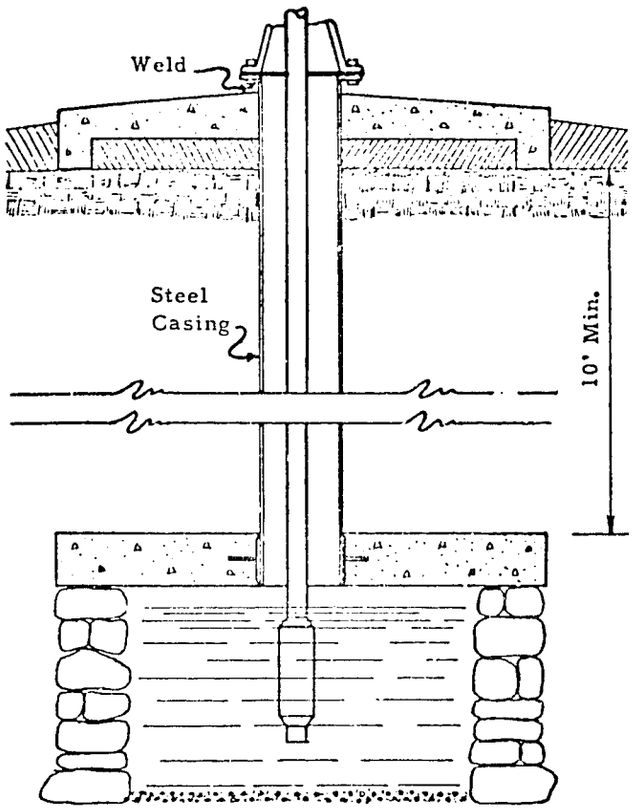
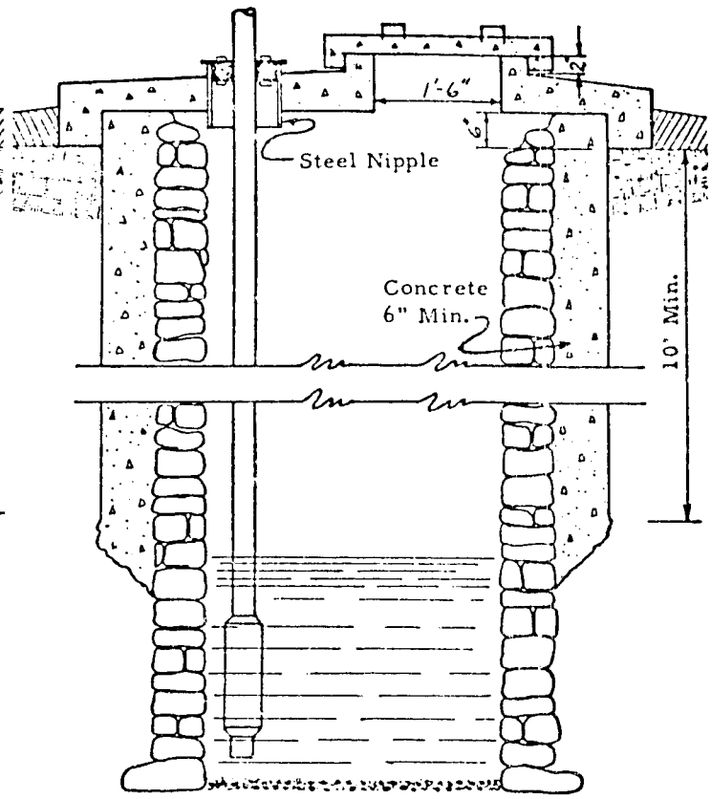


FIGURE 2. Pumping effects on aquifers.

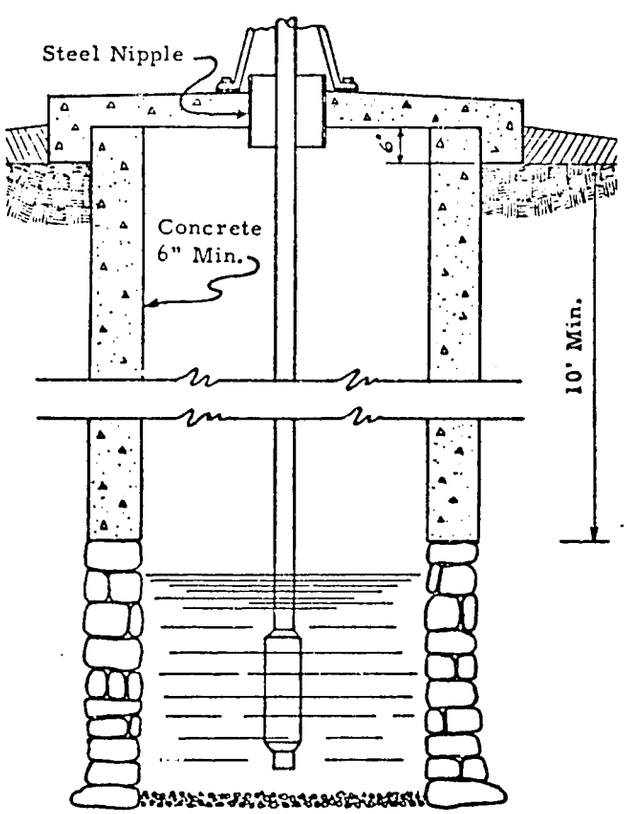
DUG WELLS



A



B



C

Figure A shows a buried slab type of construction for a dug well. The concrete slab is poured on the surface with center opening to fit the casing. The slab is lowered to a point at least 10' below surface supported by the existing wall. The steel casing is placed and the excavation void is backfilled with surface soil.

Figure B shows a method of protecting an existing rock walled dug well. An excavation at least 6" in width is made to a depth of 10 feet and filled with good quality concrete well tamped. The well cover shows the required type manhole opening and manhole cover. A short length of steel pipe 6" in diameter is placed in the cover when poured to accept a sanitary well seal.

Figure C shows a properly constructed new dug well with 6" concrete casing to a depth of 10 feet using rock or other masonry for support below that level.

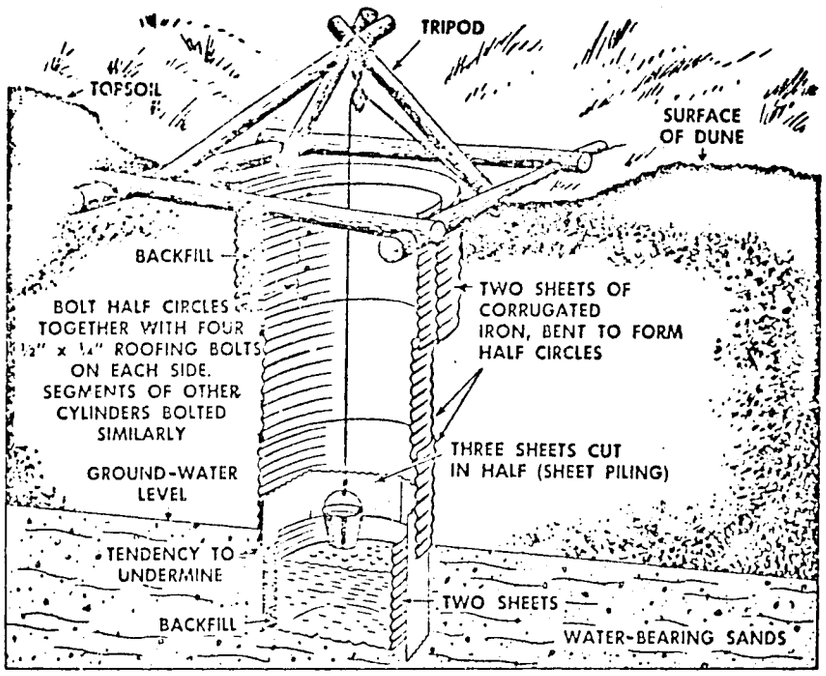
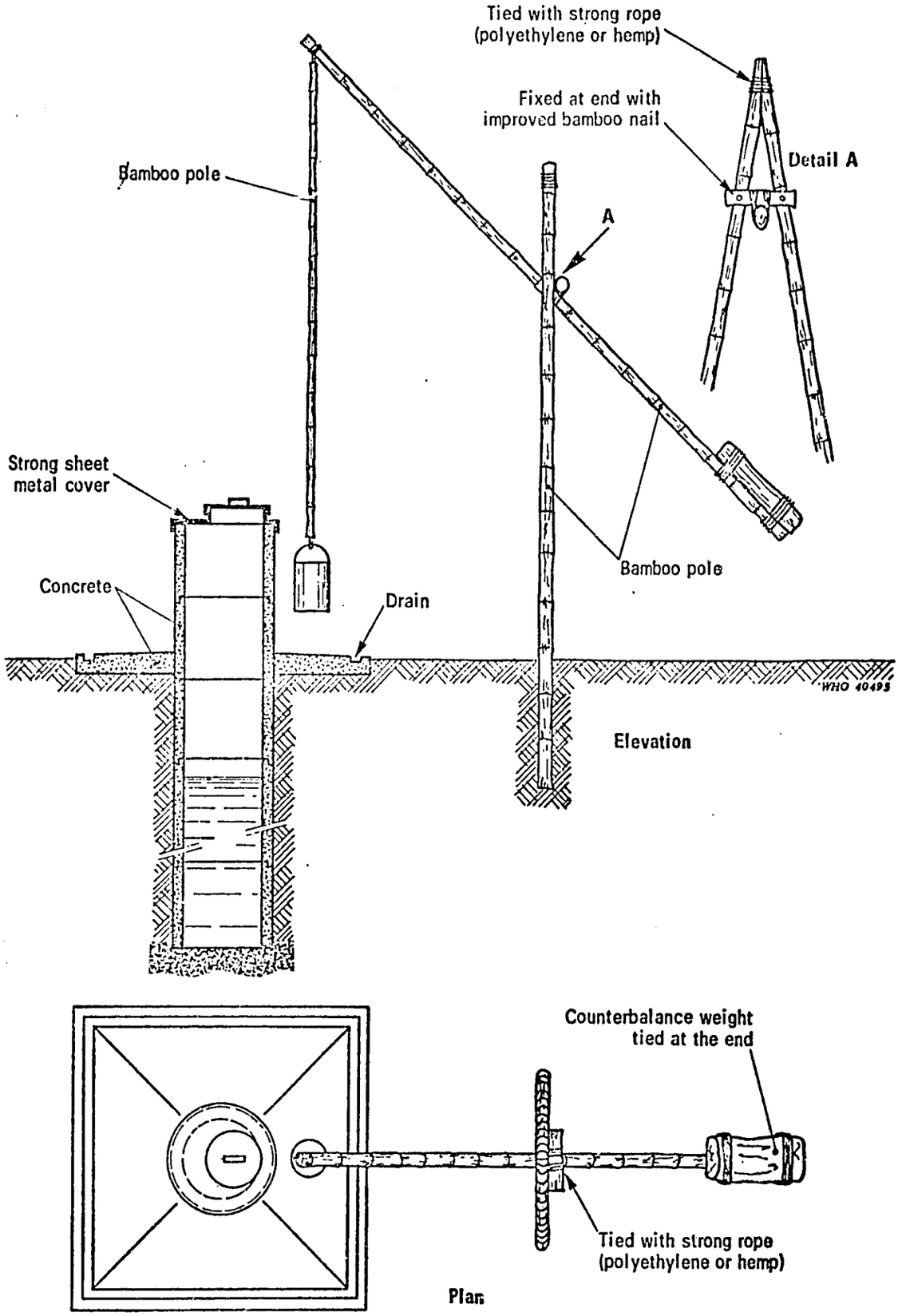


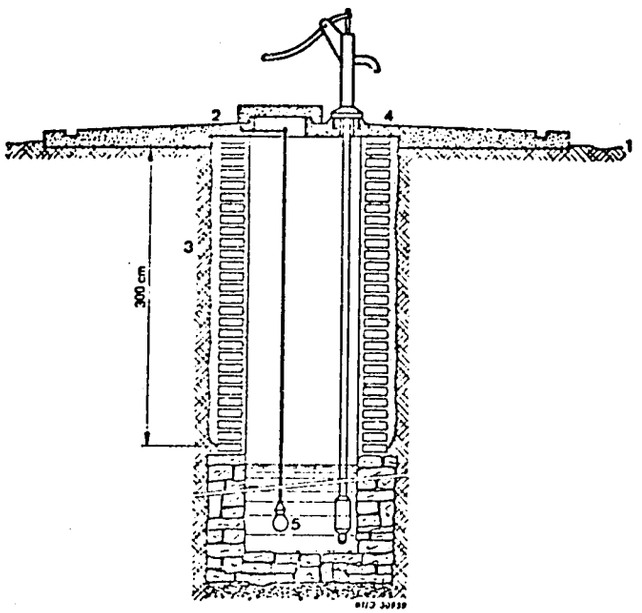
Figure 131. Well dug in beach sand to tap lens of fresh ground water lying on salty ground water. Well is cased with metal culvert piping.

FIG. 10. IMPROVEMENTS TO A DUG WELL USED IN A FIELD PROJECT IN THE PHILIPPINES •



• Modified from a design prepared by C. J. Hilado, Philippines-Japan-WHO Cholera El Tor Research Project.

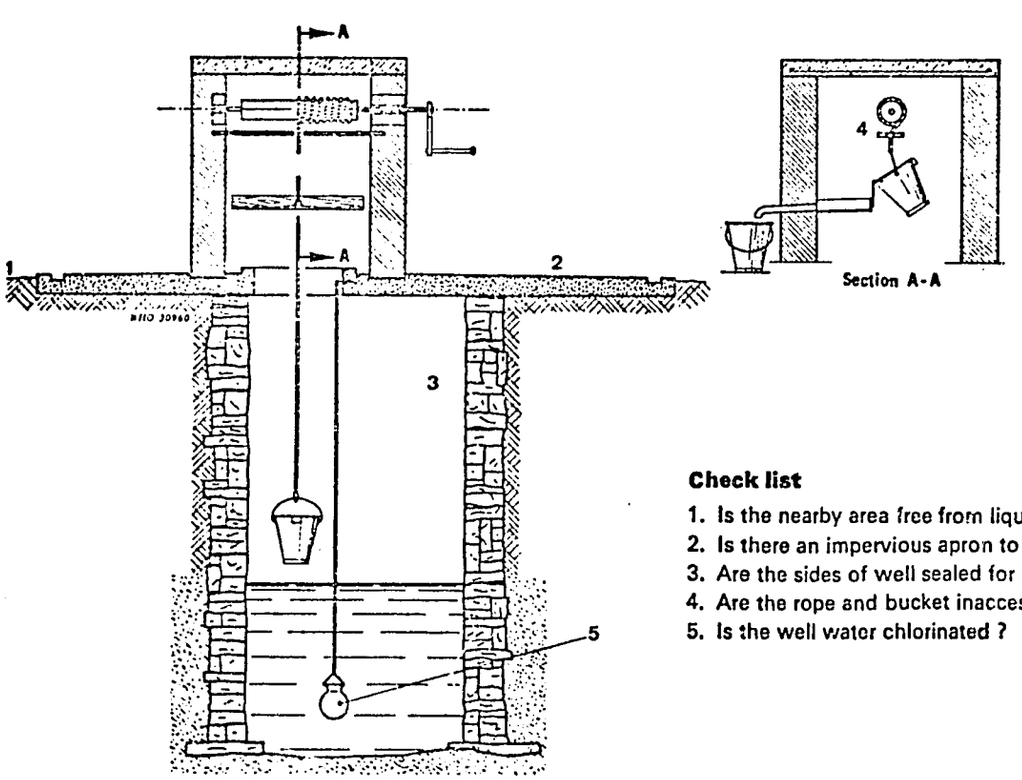
FIG. 8. DUG WELL WITH PUMP



Check list

1. Is the nearby area free from liquid wastes and privies ?
2. Is there an impervious apron to exclude surface water ?
3. Are the sides of well sealed watertight for 3 m below ground level?
4. Is the eduction pipe to pump sealed in apron at exit ?
5. Is the well water chlorinated ?

FIG. 9. DUG WELL WITH WINDLASS *



Check list

1. Is the nearby area free from liquid wastes and privies ?
2. Is there an impervious apron to exclude surface water ?
3. Are the sides of well sealed for 3 m below ground level ?
4. Are the rope and bucket inaccessible to the users ?
5. Is the well water chlorinated ?

* Reproduced from Wagner & Lanoix (1959).

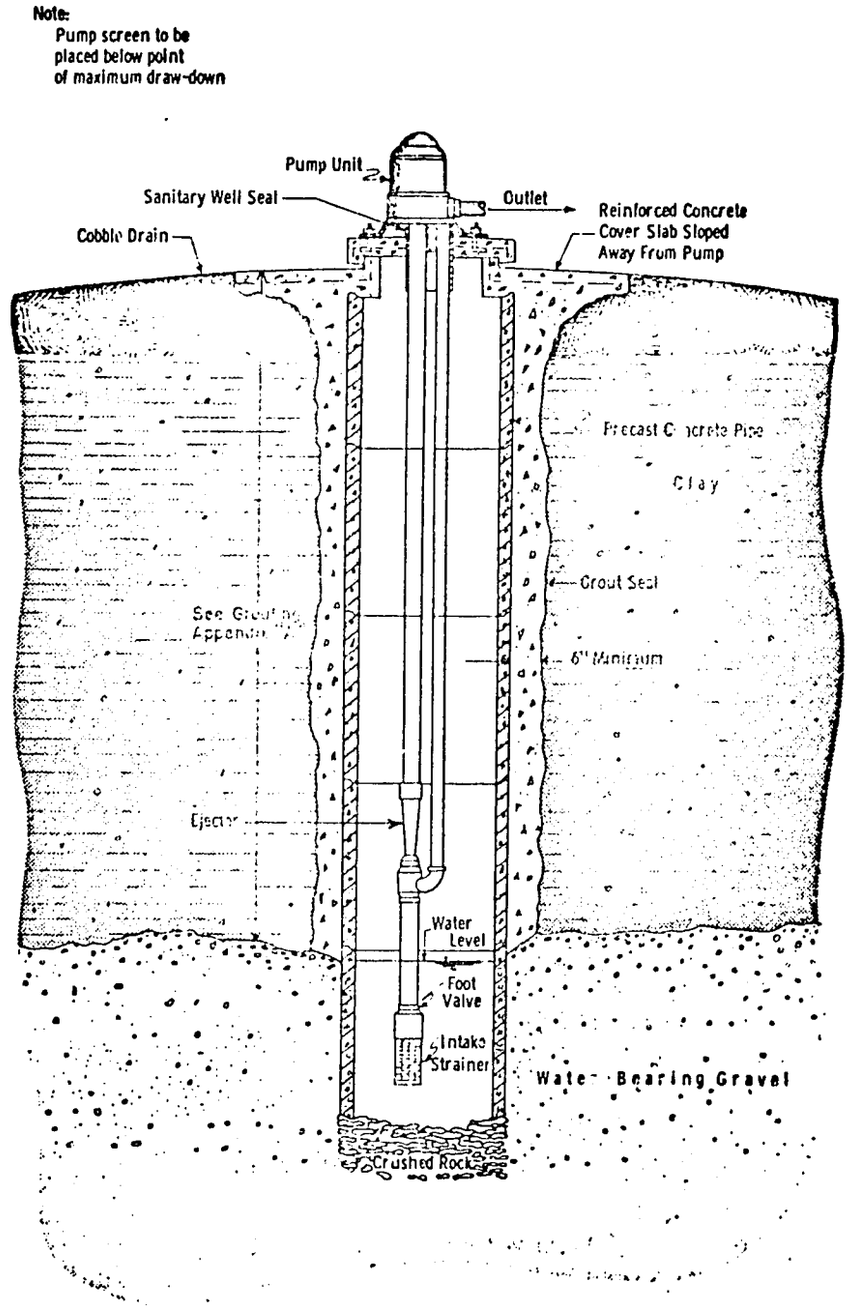


FIGURE 3. Dug well with two-pipe jet pump installation.

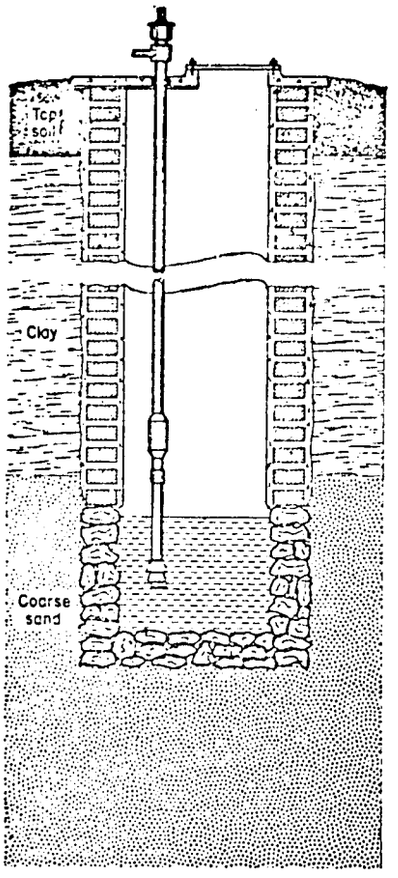


Fig. 7.3 DUG WELL.

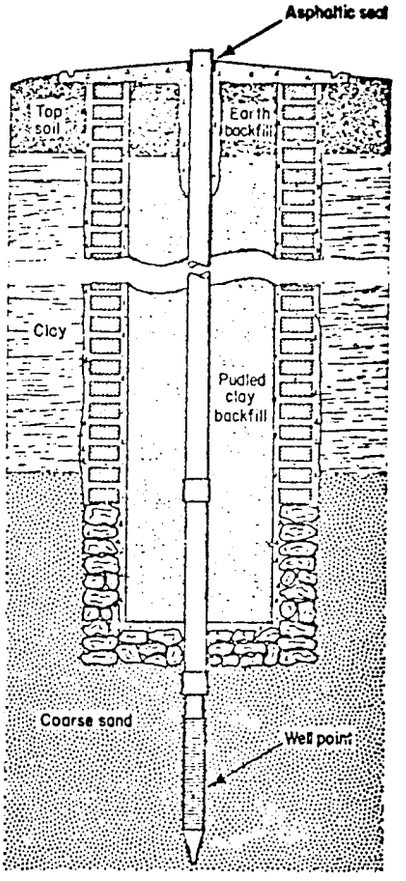
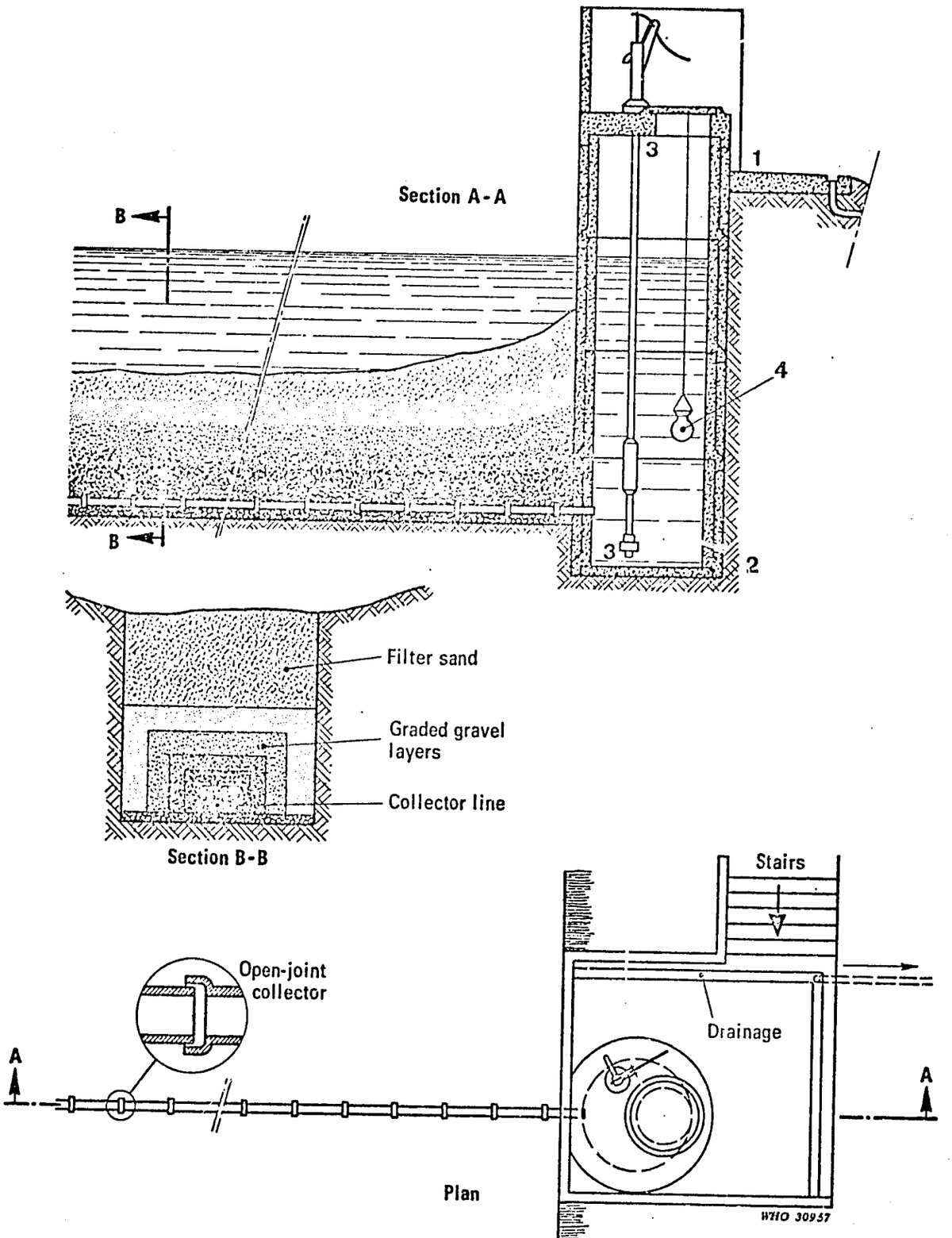


Fig. 7.4 DUG WELL OF FIG. 7.3 CONVERTED TO SAFER AND MORE PRODUCTIVE TUBULAR WELL WITH DRIVEN WELL POINT AS SCREEN.

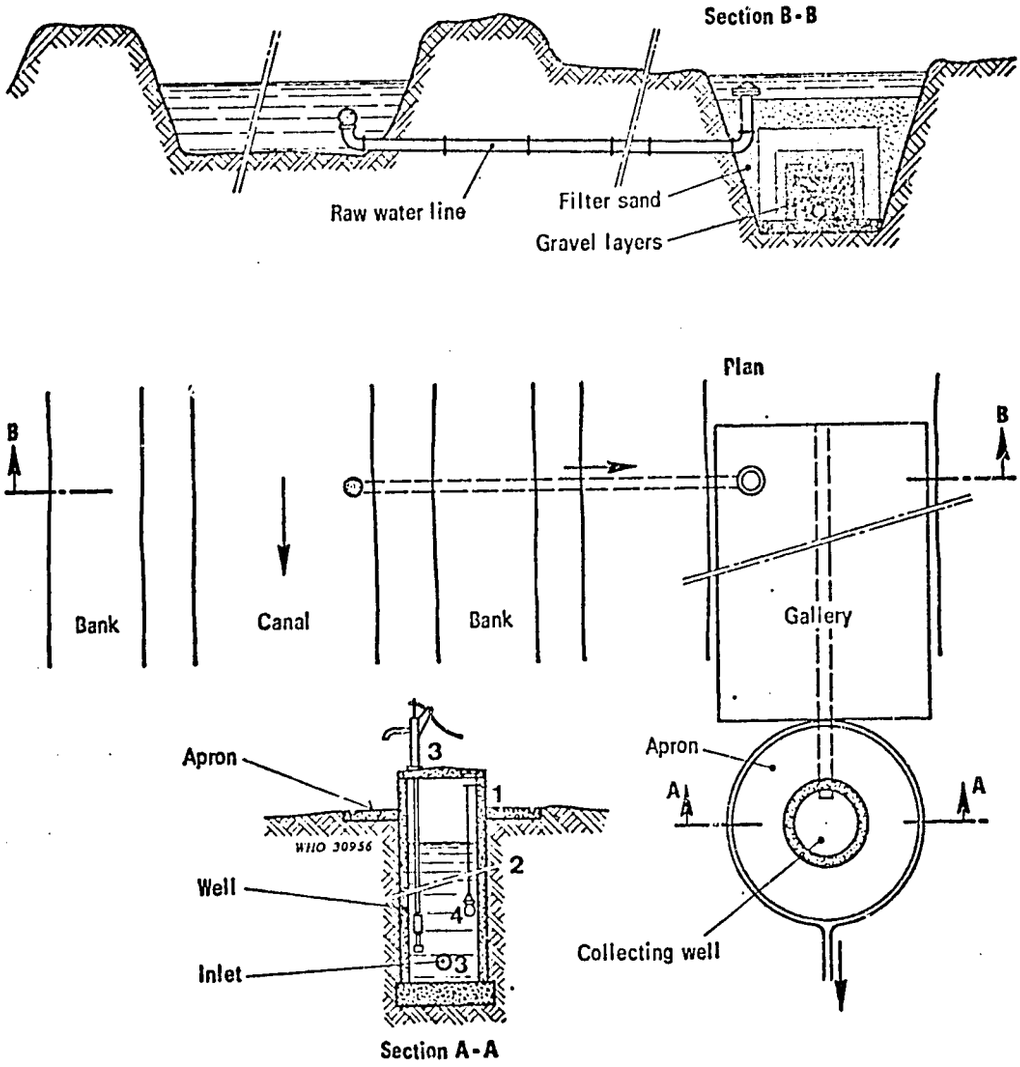
FIG. 13. GALLERY IN VILLAGE POND



Check list

1. Does the collecting well extend 1 m above ground ?
2. Is the collecting well sealed watertight throughout ?
3. Are the inlet and outlet pipes well sealed in ?
4. Is the water chlorinated ?

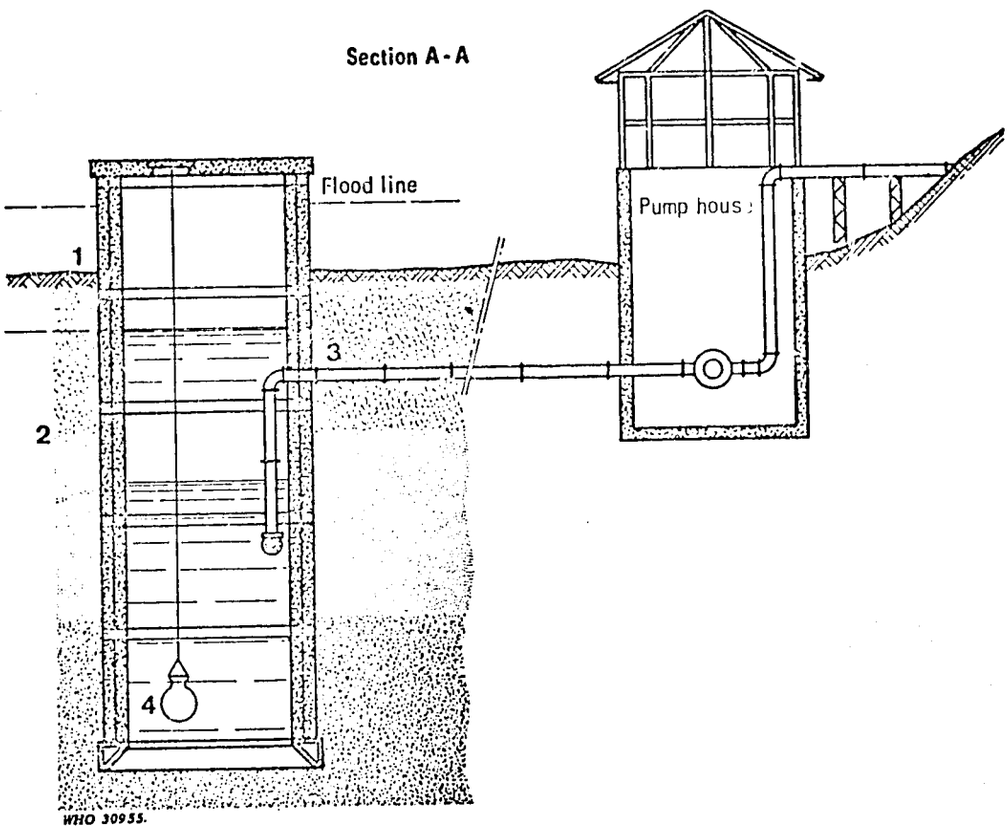
FIG. 14. GALLERY FOR CANAL

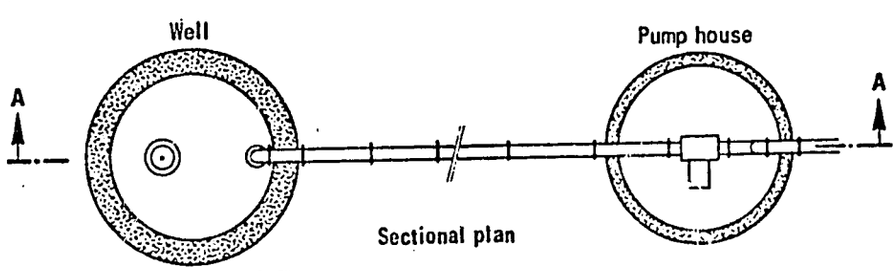


Check list

1. Does the collecting well extend 1 m above ground ?
2. Is the collecting well sealed watertight throughout ?
3. Are the inlet and outlet pipes well sealed in ?
4. Is the water chlorinated ?

FIG. 15. INFILTRATION WELL IN RIVER BED

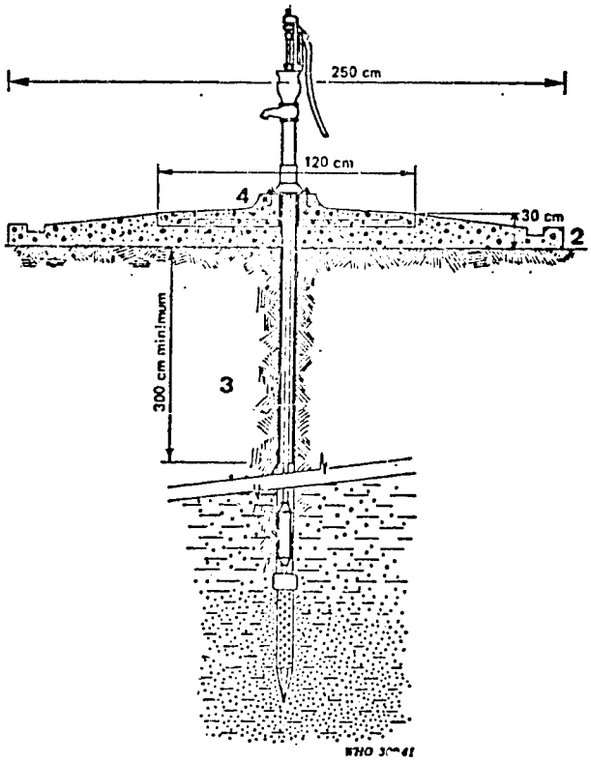




Check list

1. Does the infiltration well extend above mean flood level ?
2. Are the sides of well sealed watertight top to bottom ?
3. Is the outlet pipe of well sealed in ?
4. Is the water chlorinated ?

FIG. 11. TUBE WELL*



* Reproduced from Wagner & Lanoix (1959)

Check list

1. Is the nearby area free from liquid wastes and privies ?
2. Is there a watertight concrete apron and is drainage provided?
3. Is there watertight tubing for 3 m below ground level ?
4. Is the eduction pipe to pump sealed in apron at exit ?

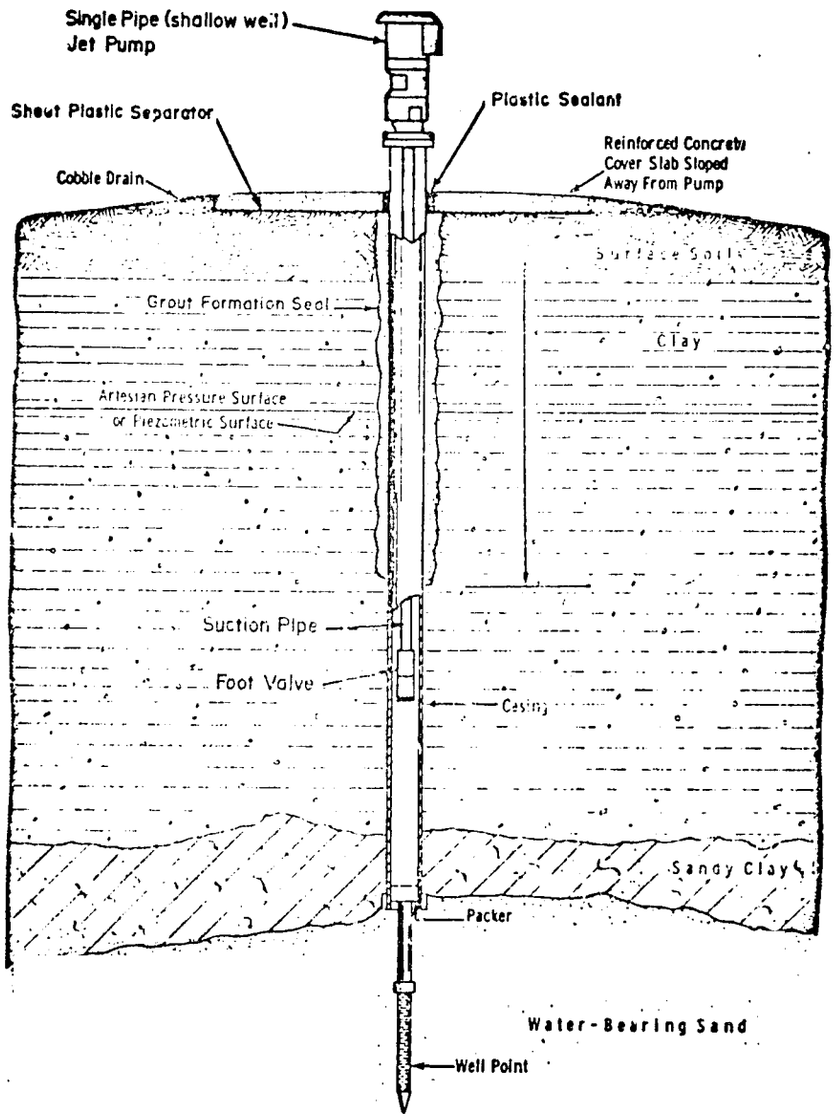


FIGURE 6. Hand-bored well with driven well point and "shallow well" jet pump.

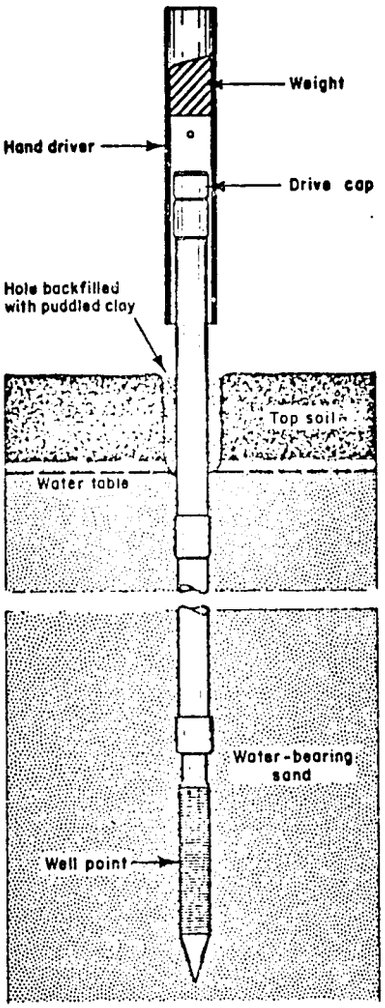
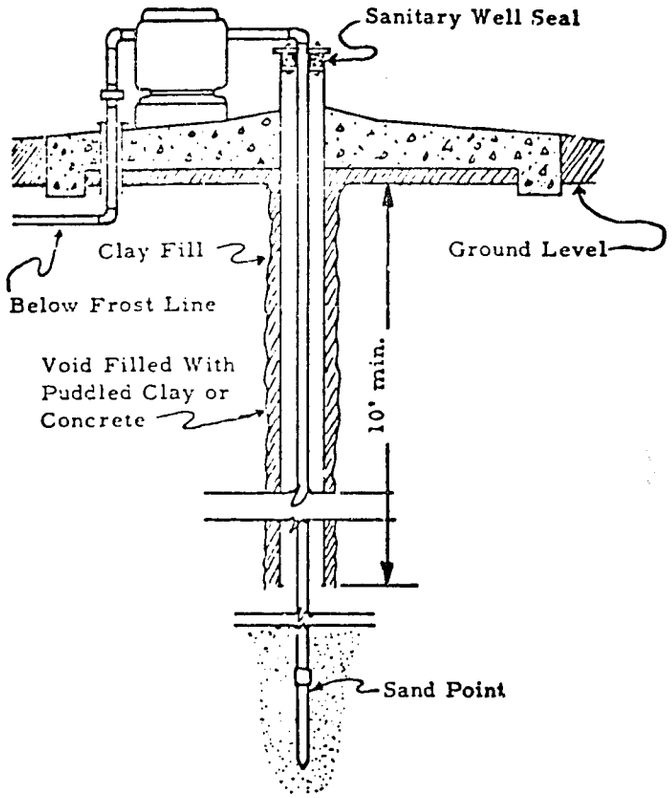
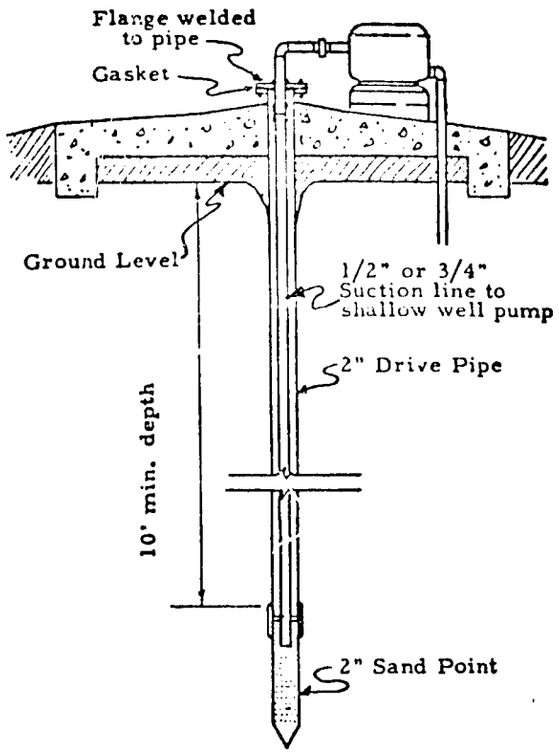


Fig. 5.3 SIMPLE TOOL FOR DRIVING WELL POINTS TO DEPTHS OF 15 TO 30 FT.

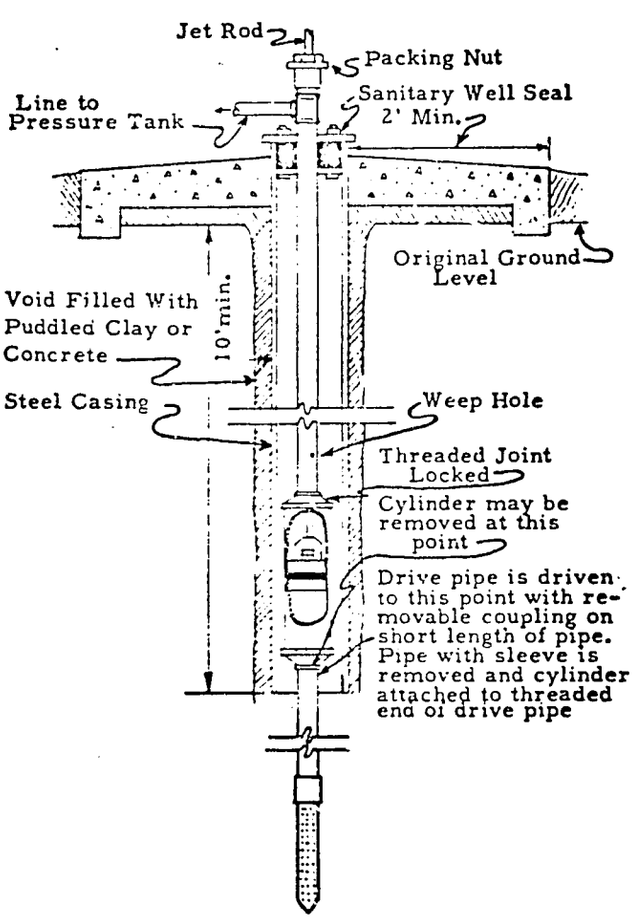
DRIVEN WELLS



A



B



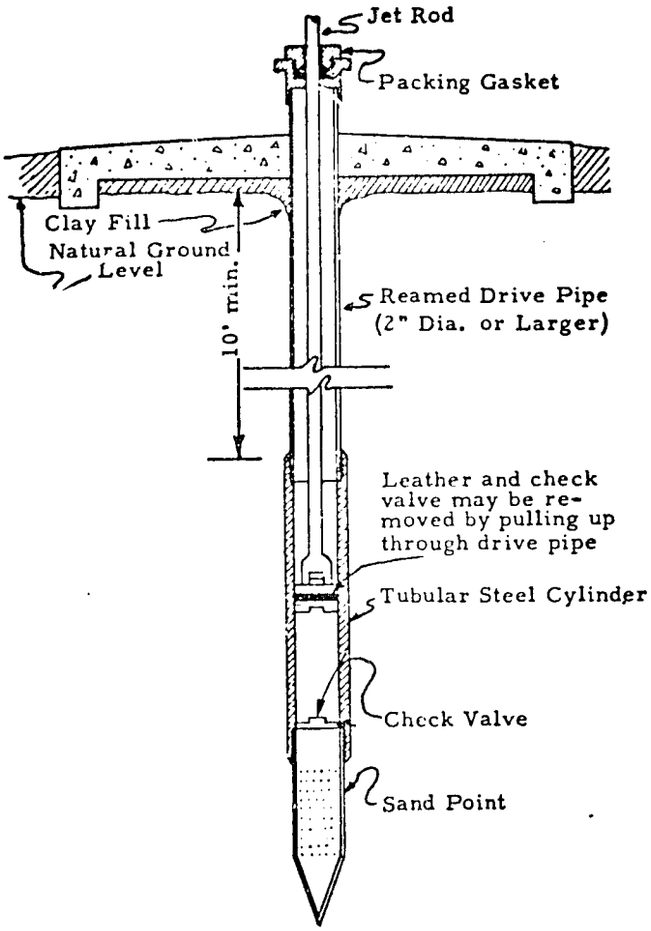
C

Figure A shows proper method of installing a sand point well where drive pipe is used as return line and is under negative pressure. Wrought iron or steel casing 6' in diameter extends to a depth of 10' below surface.

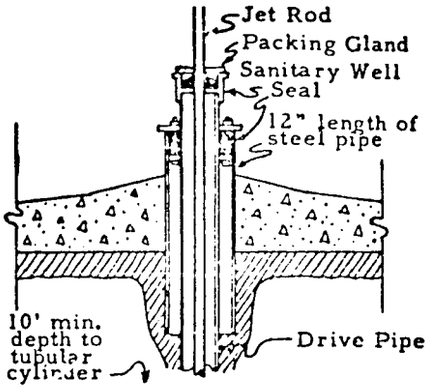
Figure B shows a satisfactory installation of a sand point well with a small suction return line suspended inside the drive pipe.

Figure C shows method of installing sand point well using cast iron cylinder.

DRIVEN WELLS



D

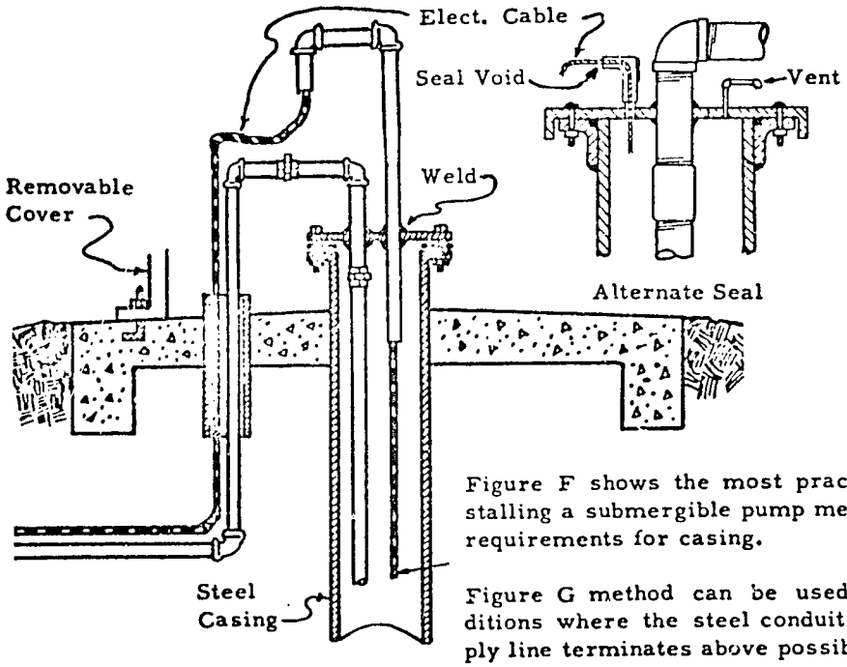


E

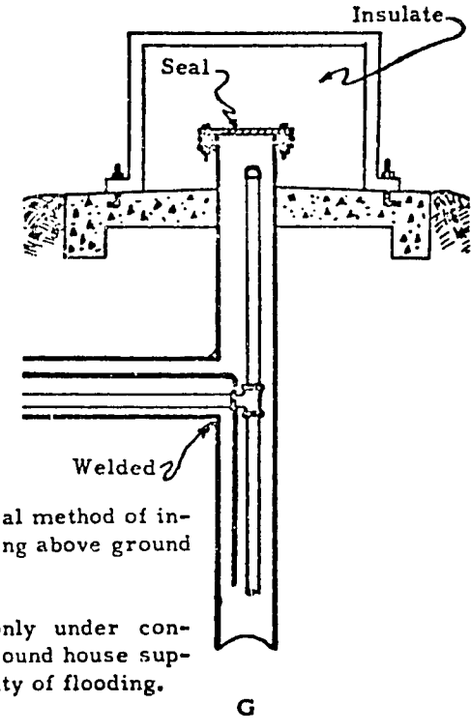
Figure D shows method of installing sand point well using steel tubular cylinder attached to sand point. All inner parts of cylinder may be removed for repair by jet rod through drive pipe.

Figure E shows an alternate method of installing positive pressure drive pipe in Figure D, using a 12" length of 6" diameter steel pipe in slab to permit removal of drive pipe and sand point.

SUBMERGIBLE PUMP INSTALLATION



F



G

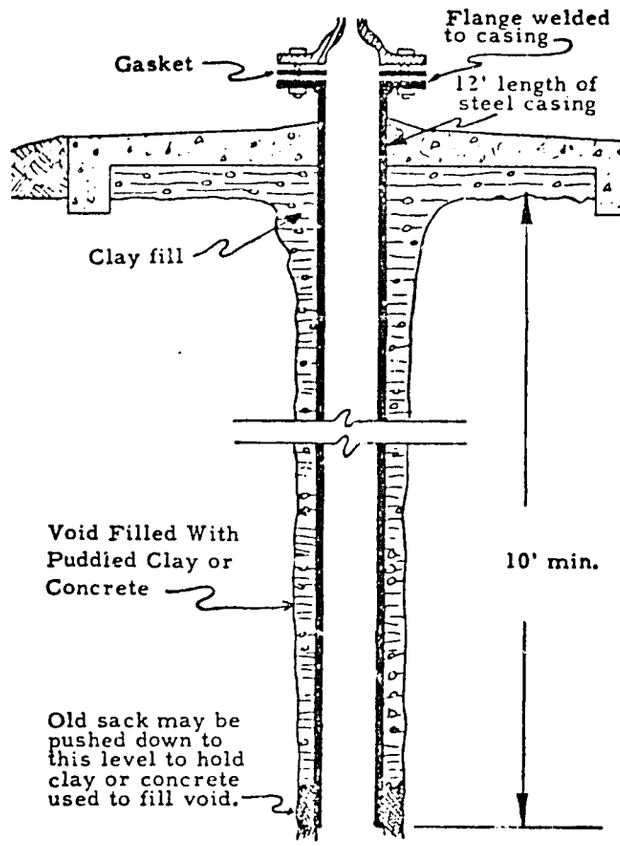
Figure F shows the most practical method of installing a submergible pump meeting above ground requirements for casing.

Figure G method can be used only under conditions where the steel conduit around house supply line terminates above possibility of flooding.

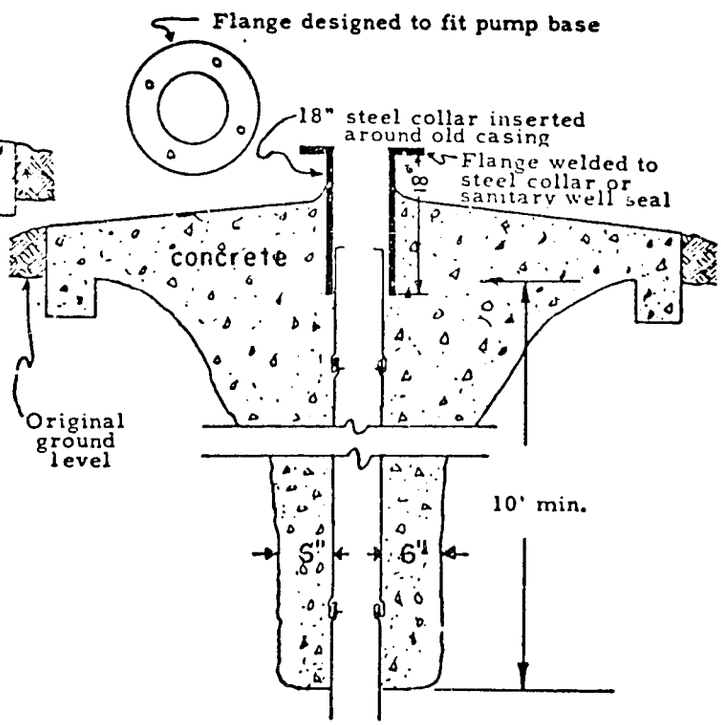
Construction Details for Wells

DRILLED WELLS

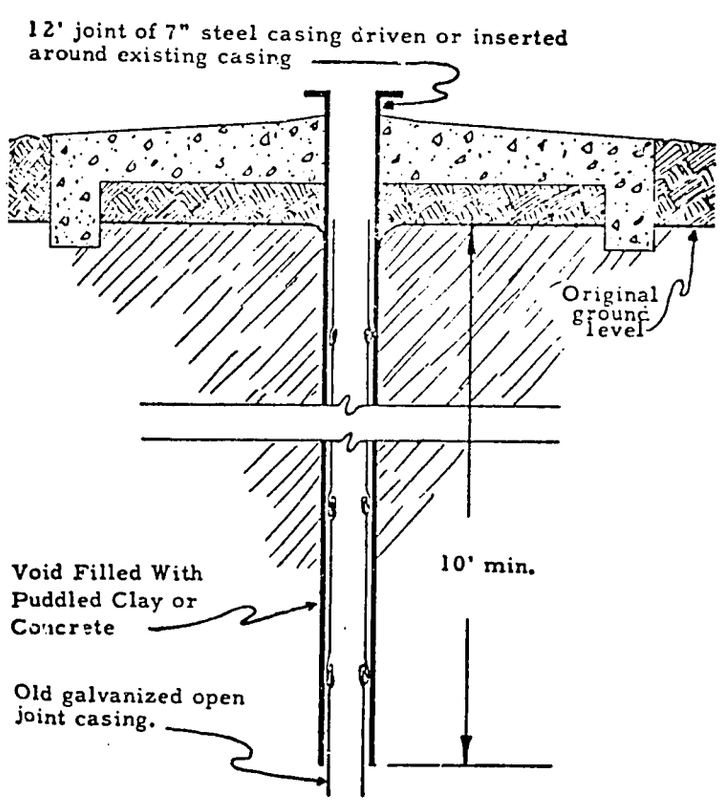
26/13/21



A



B



C

Figure A shows a properly constructed new drilled well with a 12' length of wrought iron or steel casing with the void filled with clay or cement mix. A flange is welded on casing to fit pump base.

Figure B shows another method of reconstructing an existing well by pouring 6" of concrete around the existing casing to a depth of 10'. This method requires a short length of wrought iron or steel extending thru the concrete slab to provide a rigid base for pump or sanitary well seal.

Figure C shows a method of reconstructing an existing well by inserting a new 12' joint of surface casing around the existing open joint galvanized casing.

25/6/59

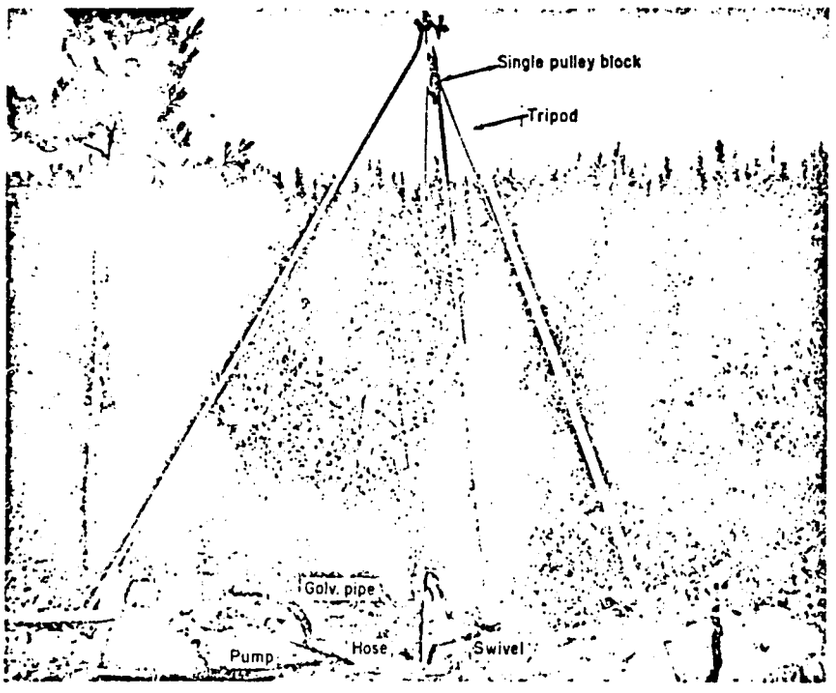


Fig. 5.6 SIMPLE EQUIPMENT FOR JET OR ROTARY DRILLING.

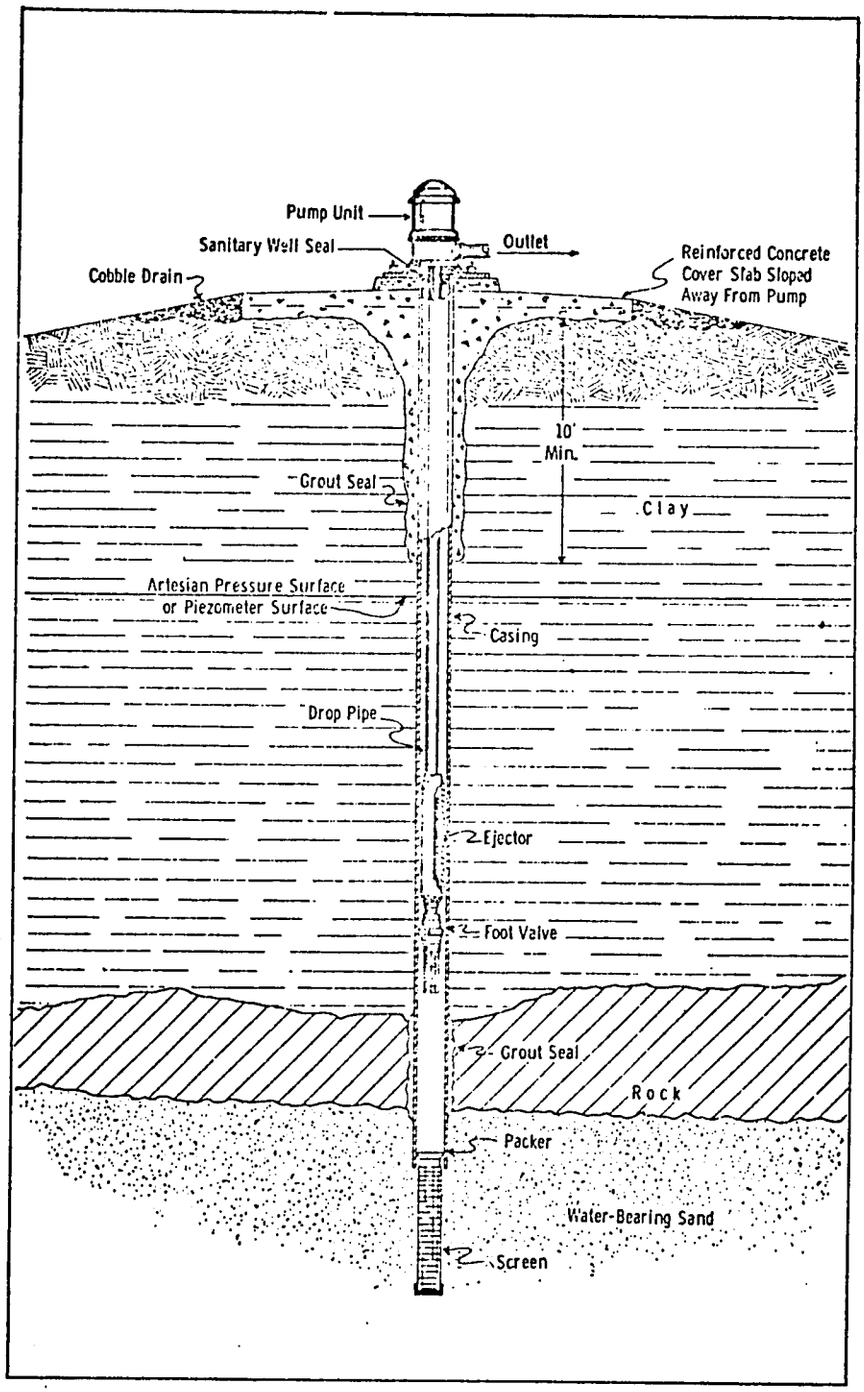


Figure 4.—Drilled well.

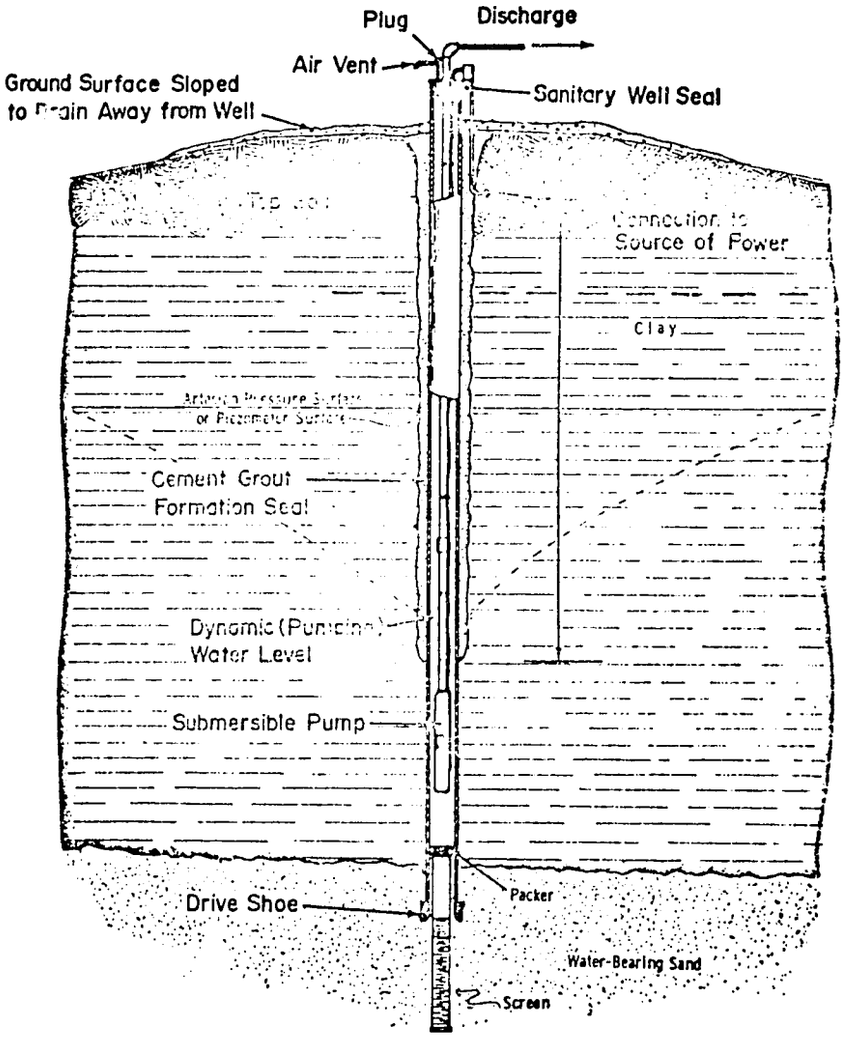


FIGURE 7. Drilled well with submersible pump.

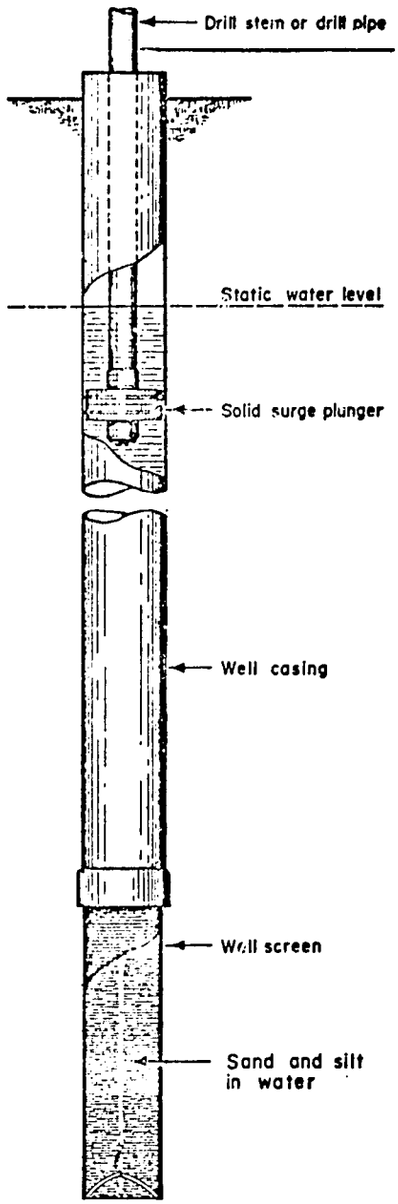


Fig. 6.5 SOLID-TYPE SURGE PLUNGER READY FOR USE IN DEVELOPING A WELL. DOWNSTROKE FORCES WATER OUTWARD INTO SAND FORMATION. UPSTROKE PULLS IN WATER, SILT AND FINE SAND THROUGH SCREEN.

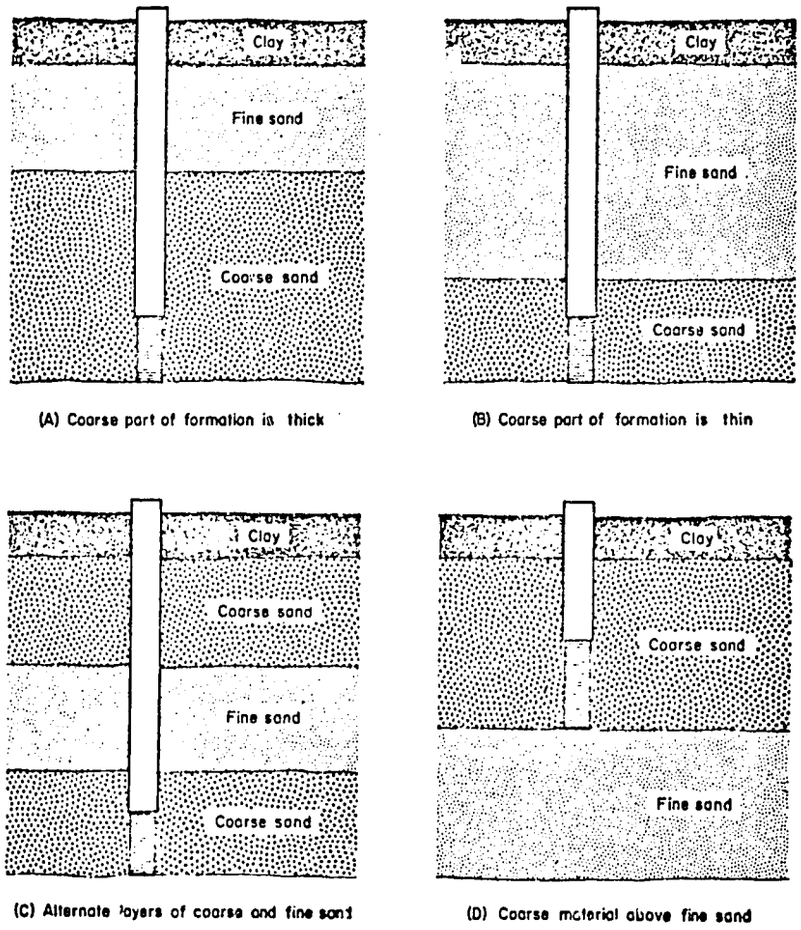


Fig. 4.7 RECOMMENDED POSITIONING OF WELL SCREENS IN VARIOUS STRATIFIED, WATER-BEARING SAND FORMATIONS.

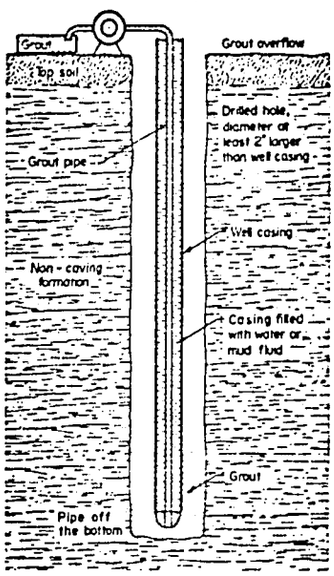


Fig. 5.23 INSIDE-TUBING METHOD OF CEMENT GROUTING WELL CASING.

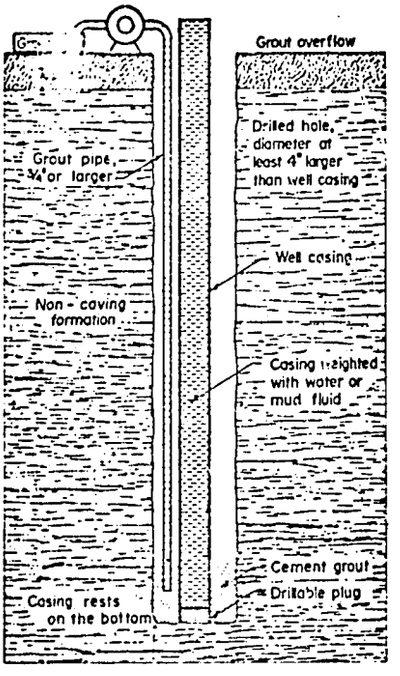


Fig. 5.24 OUTSIDE-TUBING METHOD OF CEMENT GROUTING WELL CASING.

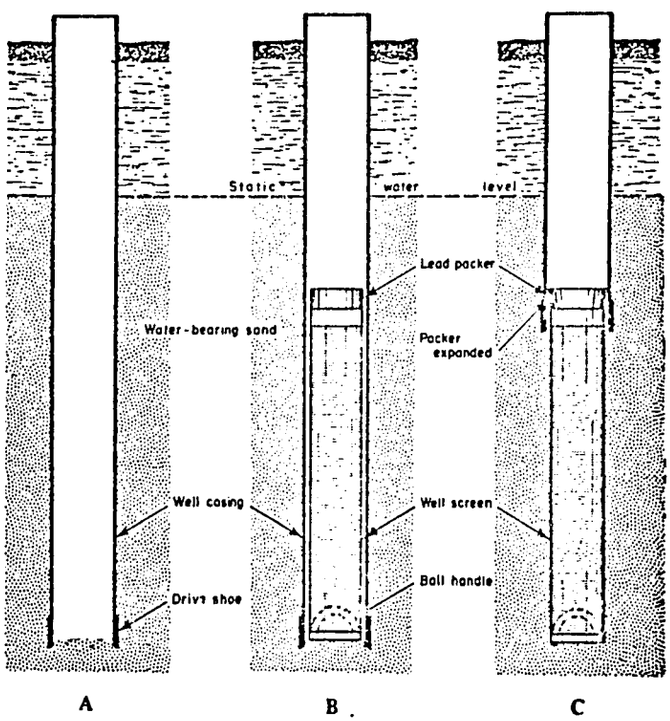


Fig. 5.25 PULL-BACK METHOD OF SETTING WELL SCREENS.
A. Casing is sunk to full depth of well.
B. Well screen is lowered inside casing.
C. Casing is pulled back to expose screen in water-bearing formation.

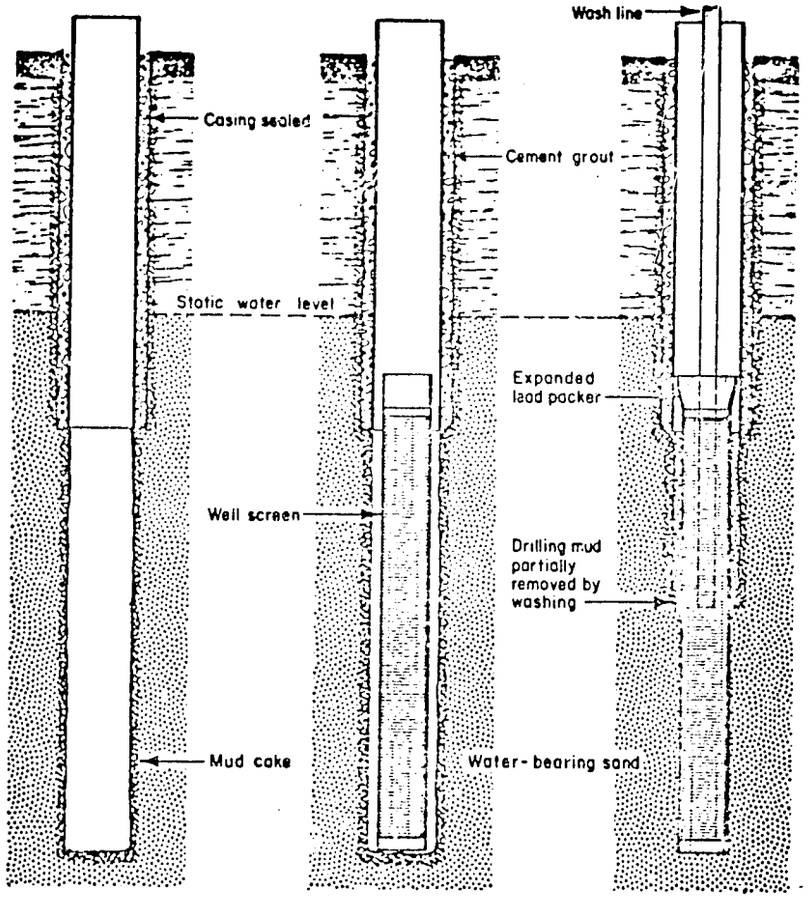


Fig. 5.30 SETTING WELL SCREEN IN OPEN HOLE DRILLED BELOW THE WELL CASING.

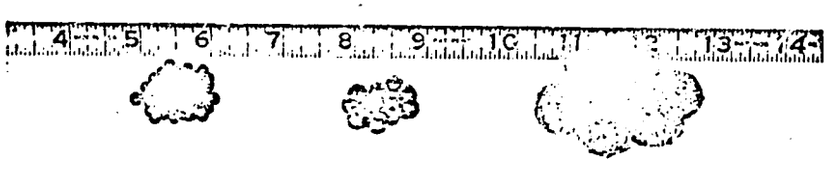


Fig. 5.31 LEAD SHOT AND LEAD WOOL FOR PLUGGING OPEN BOTTOM END OF WELL SCREEN.

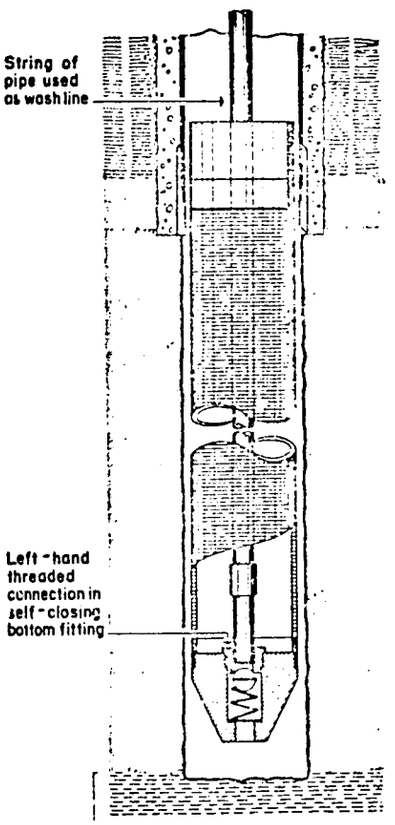


Fig. 5.32 WASH-DOWN METHOD OF SETTING WELL SCREEN.

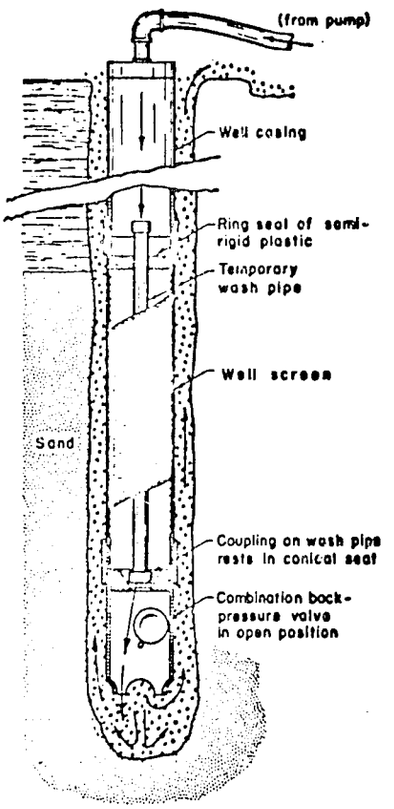


Fig. 5.33 JETTING WELL SCREEN INTO POSITION.

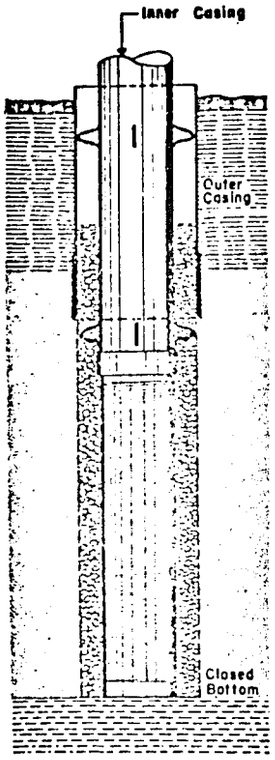


Fig. 5.36 DOUBLE-CASING METHOD OF ARTIFICIALLY GRAVEL PACKING A WELL. GRAVEL IS ADDED AS THE OUTER CASING IS PULLED BACK FROM THE FULL DEPTH OF THE WELL.

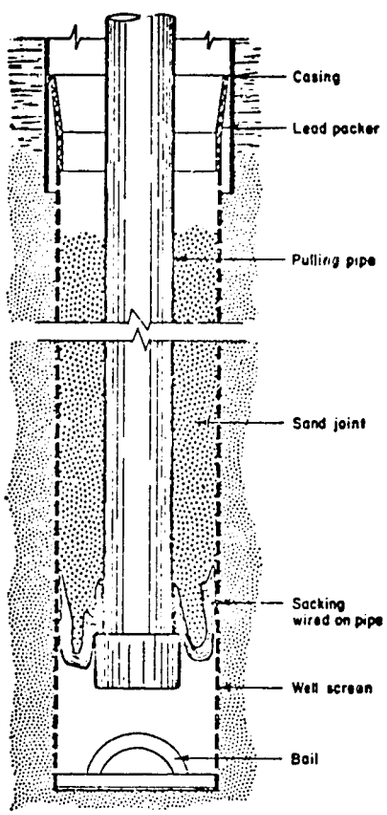


Fig. 5.39 ELEMENTS OF SAND-JOINT METHOD USED FOR PULLING WELL SCREENS.

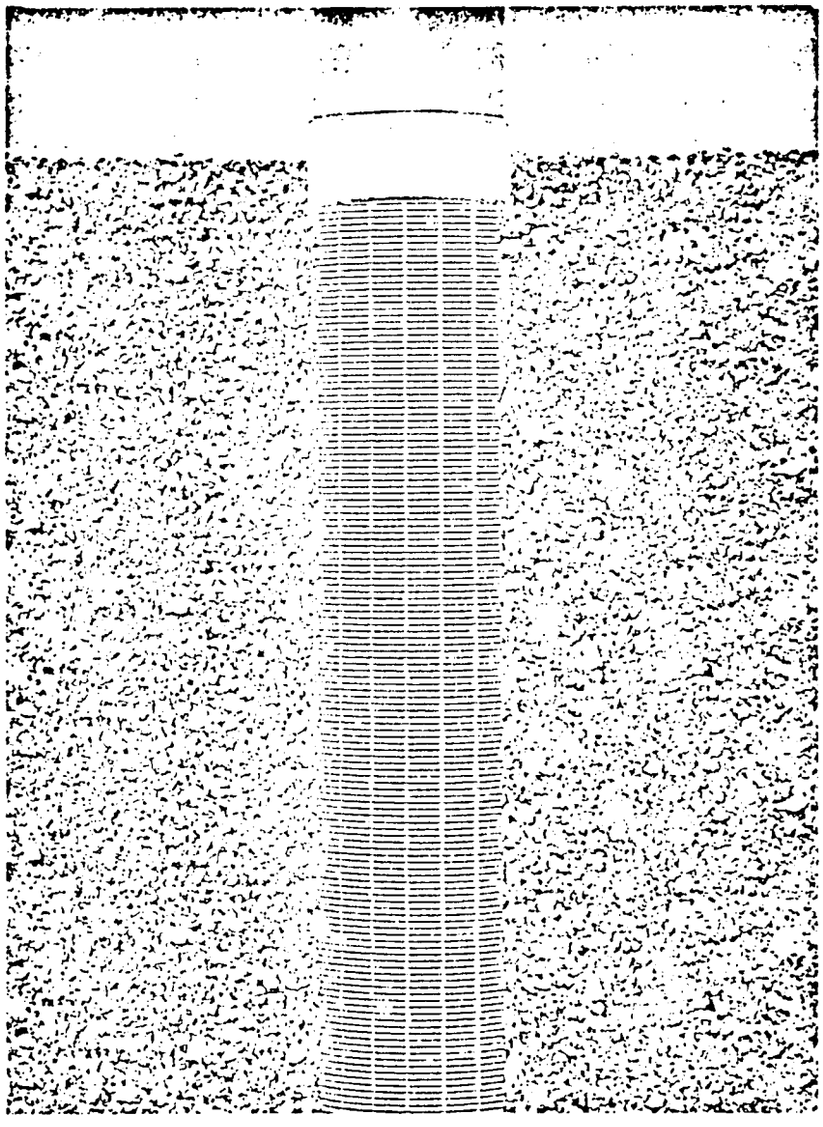


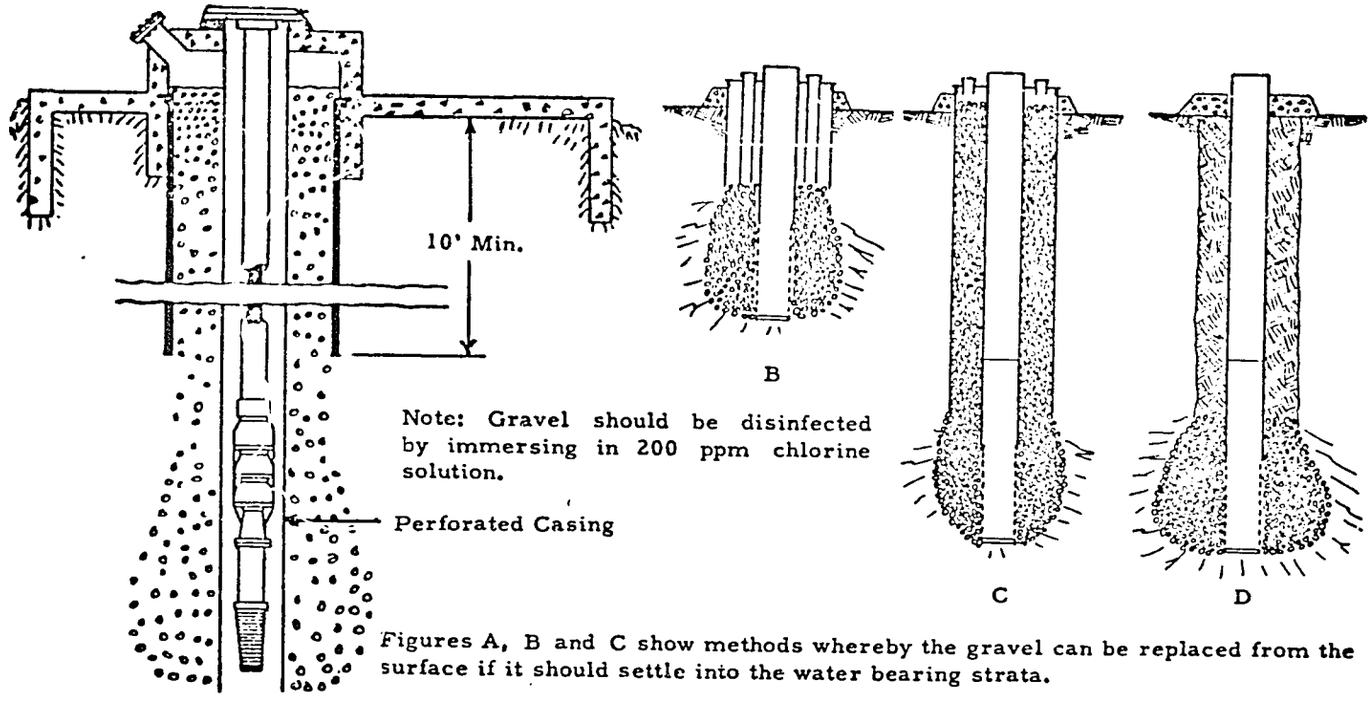
Fig. 6.1 HIGHLY PERMEABLE DEVELOPED ZONE AROUND WELL SCREEN. ALL MATERIAL FINER THAN THE SCREEN OPENINGS HAS BEEN REMOVED. REMAINING MATERIAL GRADED FROM COARSER TO FINER SIZES WITH DISTANCE FROM THE SCREEN.

The development operation, to be effective, must cause reversals of flow through the screen openings and the formation immediately around the well (Fig. 6.2). This is necessary to avoid the bridging of openings by groups of

Well Construction (Continued)

CONSTRUCTION OF GRAVEL PACKED WELLS

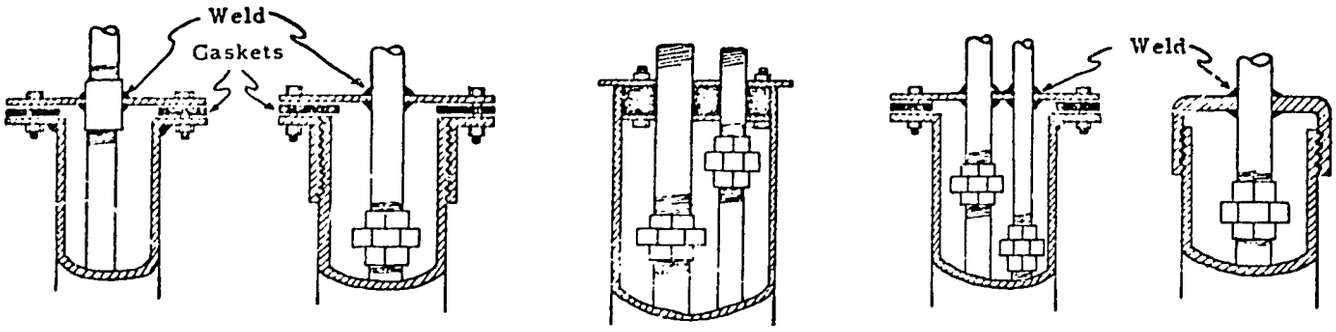
Gravel packing of wells consists of surrounding the well screen with a layer of gravel by means of an outer pit casing. The annular space between the well casing and the pit casing is filled with gravel. Sand is then bailed from the well casing which lowers the casing and surrounding rock into the cavity. The gravel serves to screen the sand from the well screen thus resulting in increased life and greater capacity.



Figures A, B and C show methods whereby the gravel can be replaced from the surface if it should settle into the water bearing strata.

Figure D shows the outer casing removed and the void backfilled with earth.

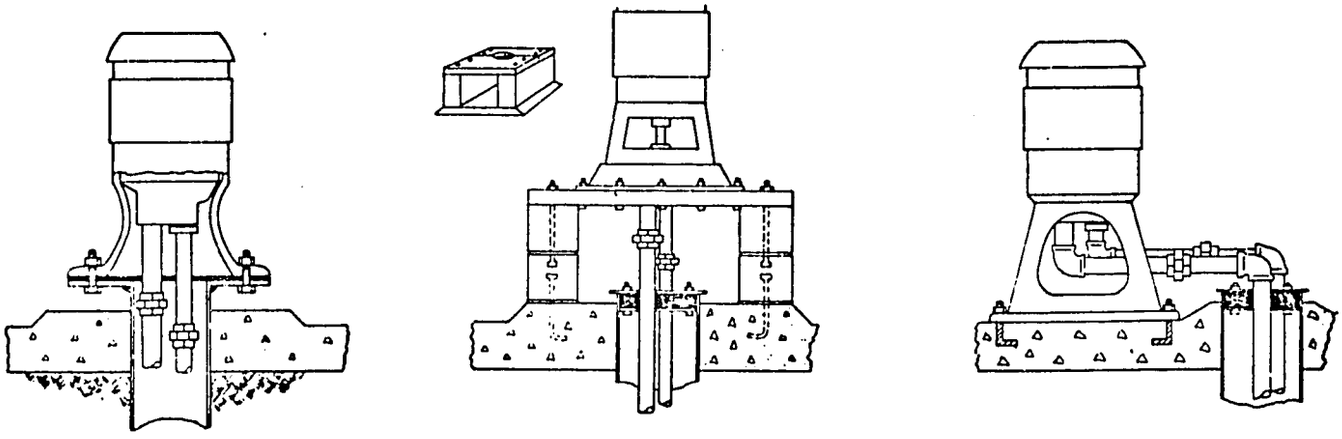
Sanitary Well Seals



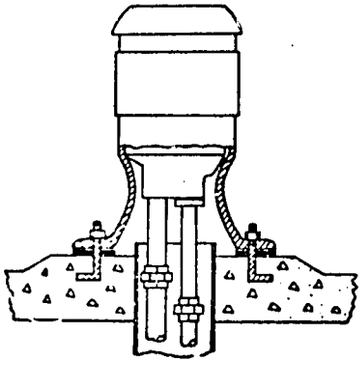
A B C D E

The above figures show five acceptable methods of sealing the well casing. Figure C shows an approved type commercial seal available through most local dealers. Figures A, B, D and E show type seals which can be made locally. NOTE: All joints must be welded or threaded pipe securely joined. Flanges are joined with gaskets and easily removable bolts.

Pump Installations



F G H



I

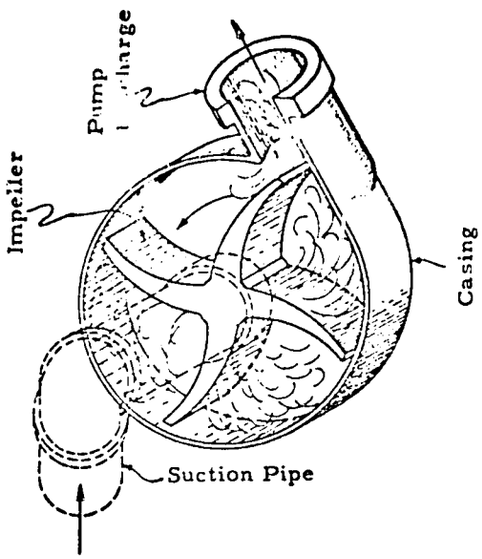
Figure F shows a pump with closed watertight base bolted directly to a flange welded to the casing. This is recommended as a most satisfactory and permanent type installation.

Figure G shows an elevated pump installation supported by concrete blocks providing access to sanitary well seal for maintenance.

Figure H shows a pump offset from casing using a commercial sanitary well seal. This installation can be used where pump has an open base in lieu of Figure G.

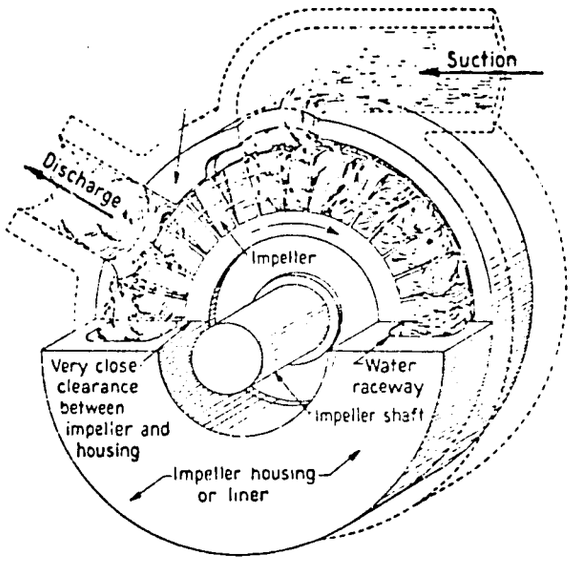
Figure I shows an installation which can only be used when the pump base is completely closed to provide a protective cover for the casing.

CENTRIFUGAL PUMPS



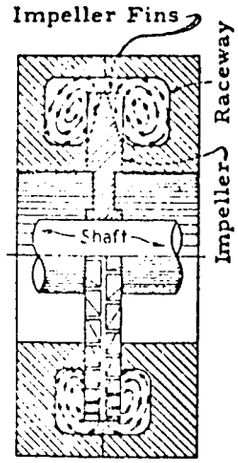
CENTRIFUGAL PUMP

A



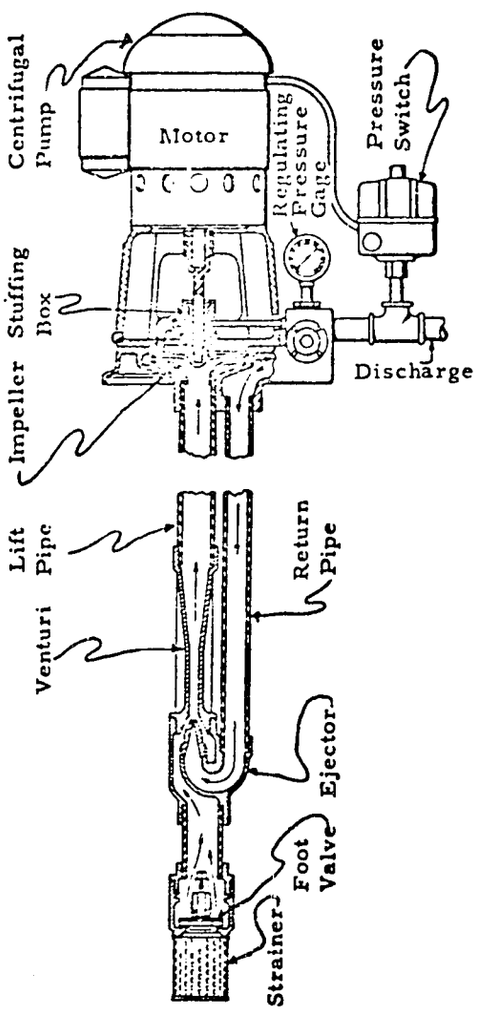
TURBINE PUMP

B



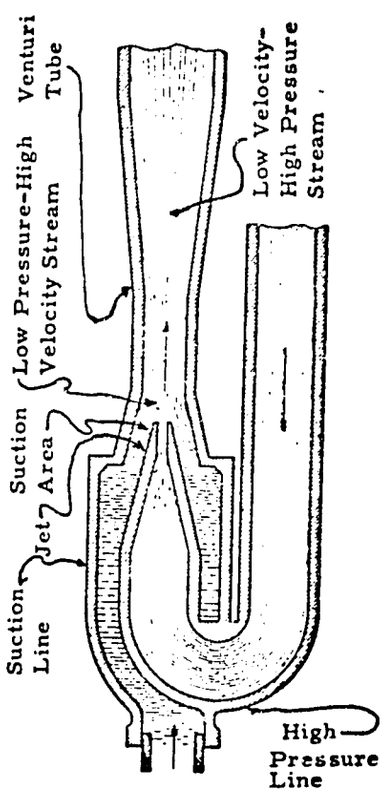
TURBINE CROSS SECTION

C



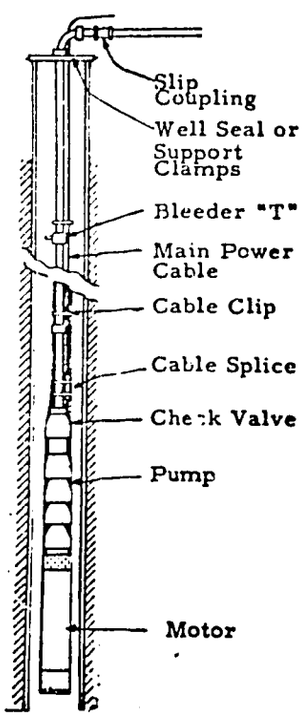
CENTRIFUGAL PUMP WITH EJECTOR (JET PUMP)

D



DETAIL SHOWING EJECTOR

E



SUBMERGIBLE PUMP

F

TABLE 8. – *Information on pumps*

Type of pump	Practical suction lift[1]	Usual well-pumping depth	Usual pressure heads	Advantages	Disadvantages	Remarks
Reciprocating:						
1. Shallow well	22-25 ft.	22-25 ft.	100-200 ft.	1. Positive action.	1. Pulsating discharge.	1. Best suited for capacities of 5-25 gpm against moderate to high heads.
2. Deep well	22-25 ft.	Up to 600 ft.	Up to 600 ft. above cylinder.	2. Discharge against variable heads.	2. Subject to vibration and noise.	2. Adaptable to hand operation.
				3. Pumps water containing sand and silt.	3. Maintenance cost may be high.	3. Can be installed in very small diameter wells (2" casing).
				4. Especially adapted to low capacity and high lifts.	4. May cause destructive pressure if operated against closed valve.	4. Pump must be set directly over well (deep well only).
Centrifugal:						
1. Shallow well						
a. Straight centrifugal (single stage)	20 ft. max.	10-20 ft.	100-150 ft.	1. Smooth, even flow.	1. Loses prime easily.	1. Very efficient pump for capacities above 60 gpm and heads up to about 150 ft.
				2. Pumps water containing sand and silt.	2. Efficiency depends on operating under design heads and speed.	
				3. Pressure on system is even and free from shock.		
				4. Low-starting torque.		
				5. Usually reliable and good service life.		
b. Regenerative vane turbine type (single impeller)	28 ft. max.	28 ft.	100-200 ft.	1. Same as straight centrifugal except not suitable for pumping water containing sand or silt.	1. Same as straight centrifugal except maintains priming easily.	1. Reduction in pressure with increased capacity not as severe as straight centrifugal.
				2. They are self-priming.		
2. Deep well						
a. Vertical line shaft turbine (multi-stage)	Impellers submerged.	50-300 ft.	100-800 ft.	1. Same as shallow well turbine.	1. Efficiency depends on operating under design head and speed.	
				2. All electrical components are accessible, above ground.	2. Requires straight well large enough for turbine bowls and housing.	
					3. Lubrication and alignment of shaft critical.	
					4. Abrasion from sand.	

b. Submersible turbine (multistage)	Pump and motor submerged.	50-400 ft.	50-400 ft.	1. Same as shallow well turbine. 2. Easy to frost-proof installation. 3. Short pump shaft to motor. 4. Quiet operation. 5. Well straightness not critical.	1. Repair to motor or pump requires pulling from well. 2. Sealing of electrical equipment from water vapor critical. 3. Abrasion from sand.	1. 3500 RPM models, while popular because of smaller diameters or greater capacities, are more vulnerable to wear and failure from sand and other causes.
Jet:						
1. Shallow well	15-20 ft. below ejector.	Up to 15-20 ft. below ejector.	80-150 ft.	1. High capacity at low heads. 2. Simple in operation. 3. Does not have to be installed over the well. 4. No moving parts in the well.	1. Capacity reduces as lift increases. 2. Air in suction or return line will stop pumping.	
2. Deep well	15-20 ft. below ejector.	25-120 ft. 200 ft. max.	80-150 ft.	1. Same as shallow well jet. 2. Well straightness not critical.	1. Same as shallow well jet. 2. Lower efficiency, especially at greater lifts.	1. The amount of water returned to ejector increases with increased lift – 50% of total water pumped at 50-ft. lift and 75% at 100-ft. lift.
Rotary:						
1. Shallow well ..... (gear type)	22 ft.	22 ft.	50-250 ft.	1. Positive action. 2. Discharge constant under variable heads. 3. Efficient operation.	1. Subject to rapid wear if water contains sand or silt. 2. Wear of gears reduces efficiency.	
2. Deep well ..... (helical rotary type).	Usually submerged.	50-500 ft.	100-500 ft.	1. Same as shallow well rotary. 2. Only one moving pump device in well.	1. Same as shallow well rotary except no gear wear.	1. A cutless rubber stator increases life of pump. Flexible drive coupling has been weak point in pump. Best adapted for low capacity and high heads.

[1] Practical suction lift at sea level. Reduce lift 1 foot for each 1,000 ft. above sea level.

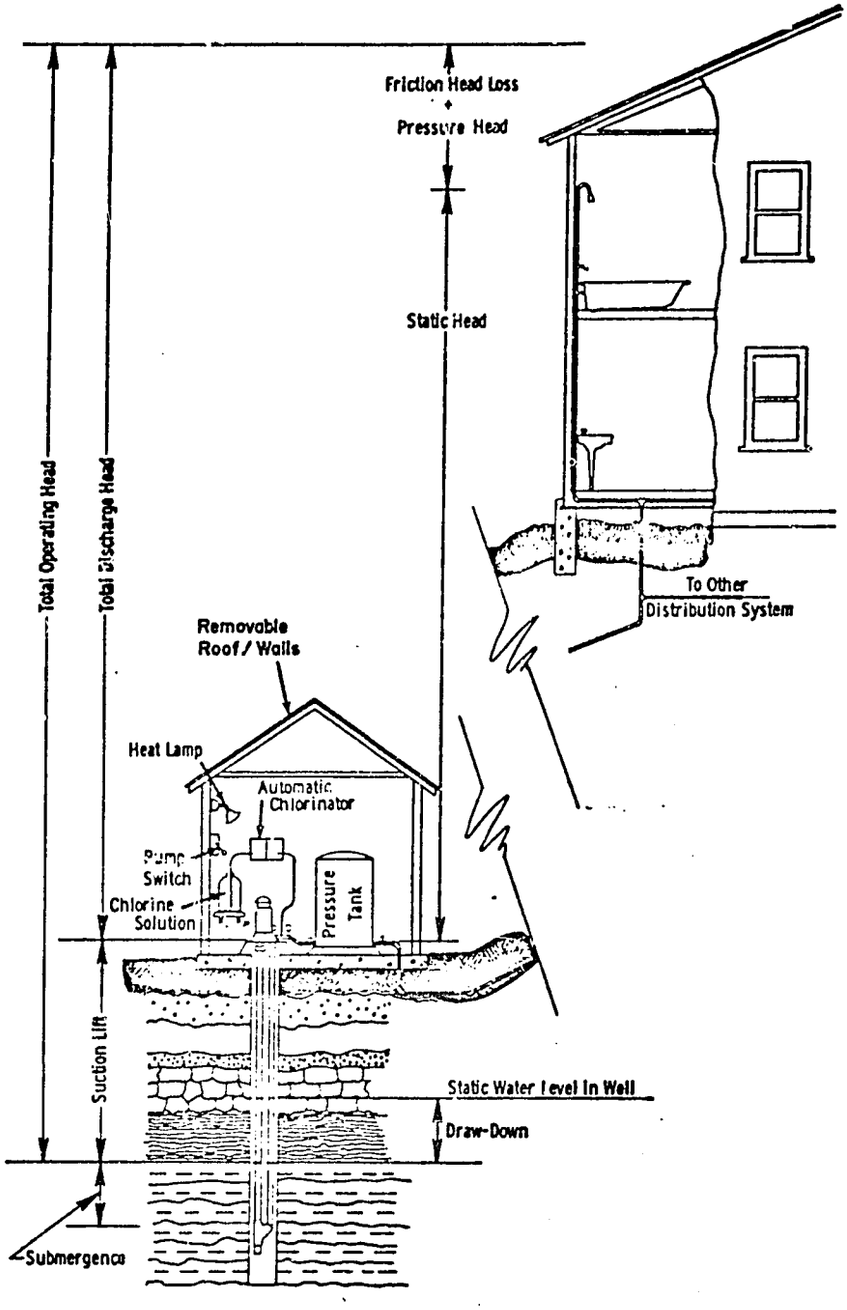
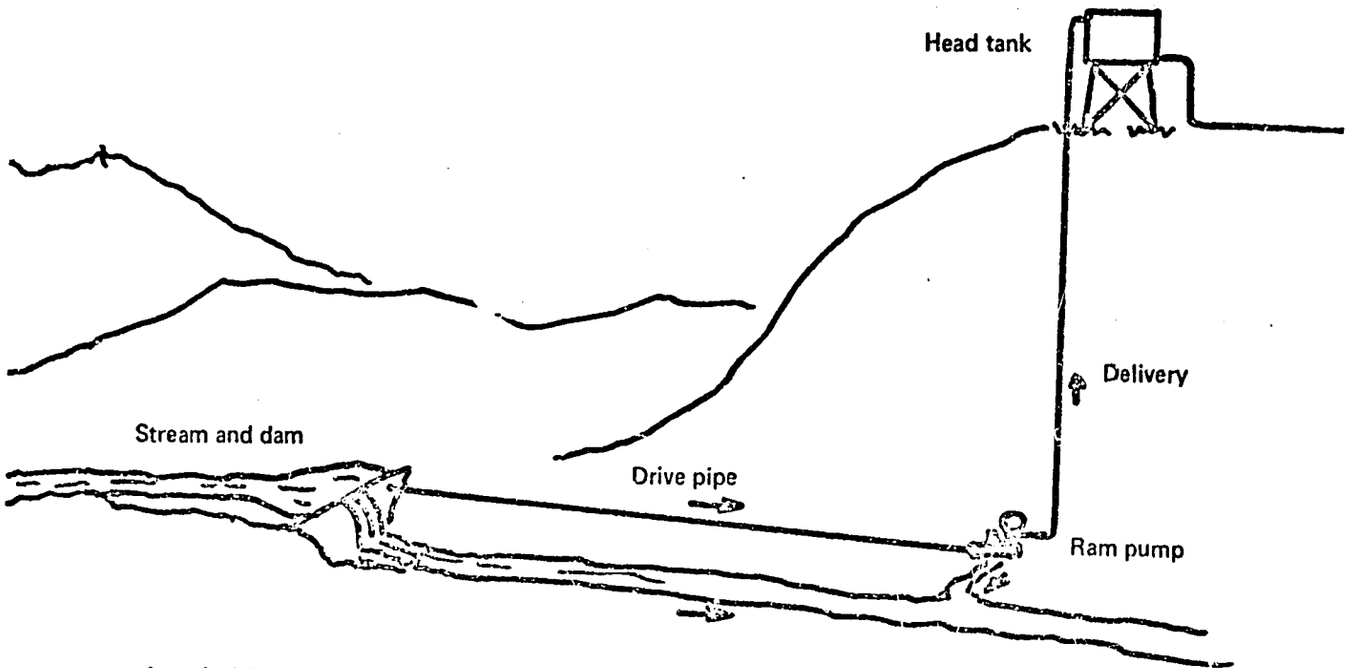
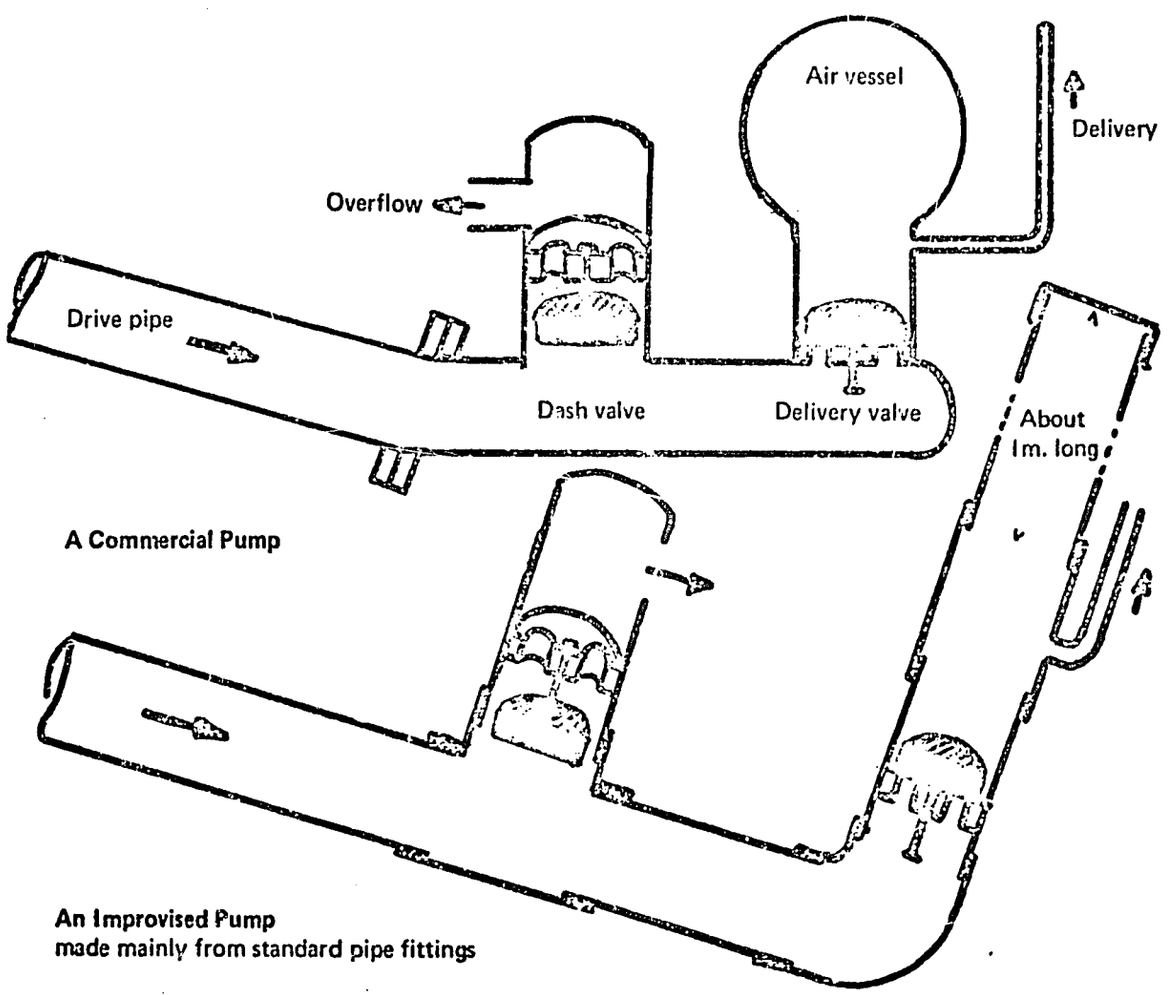


FIGURE 18. Components of total operating head in well pump installations.

Fig. 12. HYDRAULIC RAM PUMPS



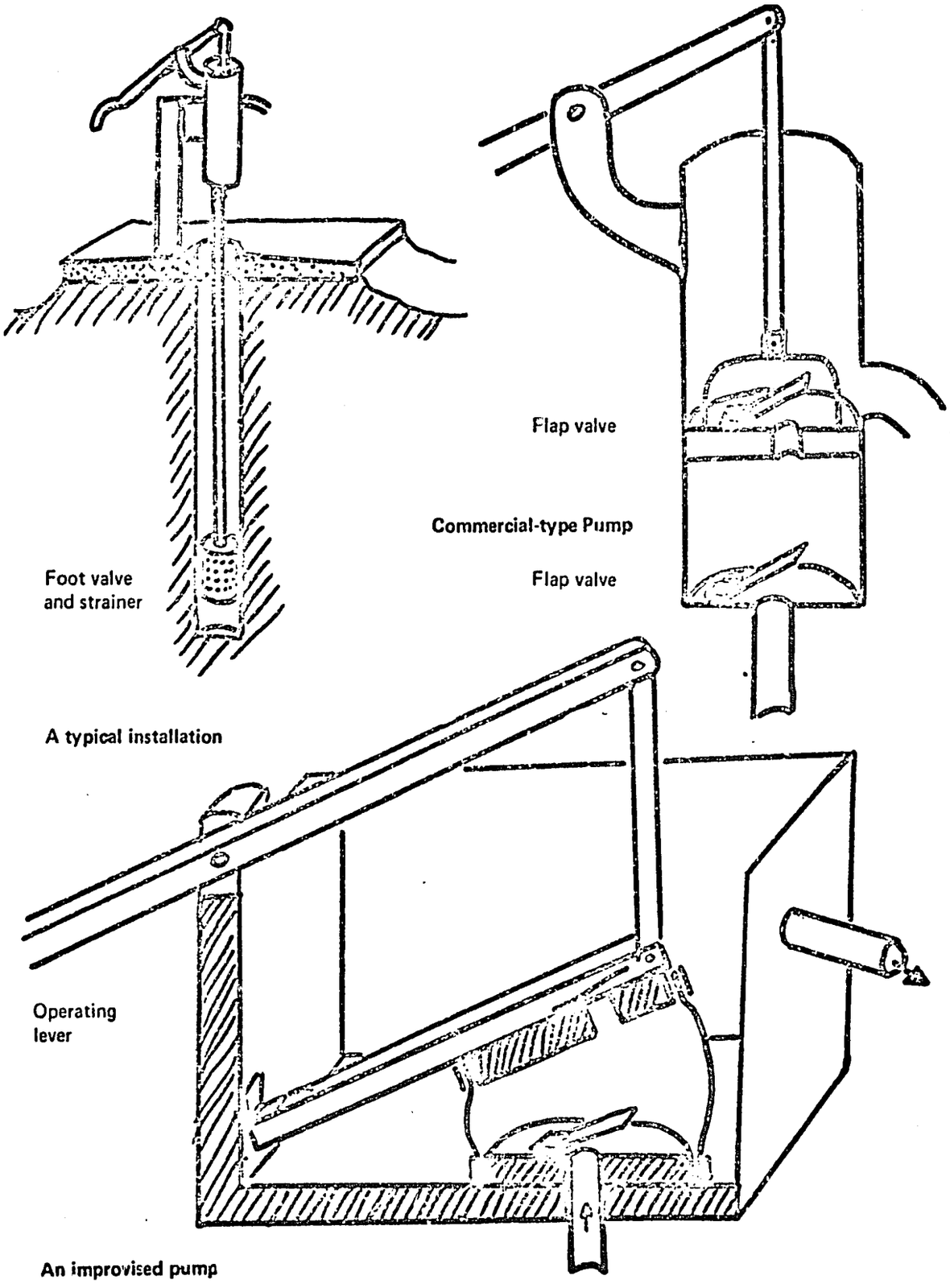
A typical Ram Pump installation



A Commercial Pump

An Improvised Pump
made mainly from standard pipe fittings

Fig. 13. HAND PUMPS



Using a bellows made from a short section cut from car inner tube, and flap valves made from the same material

Fig. 14. THE SIMPLEST PUMP

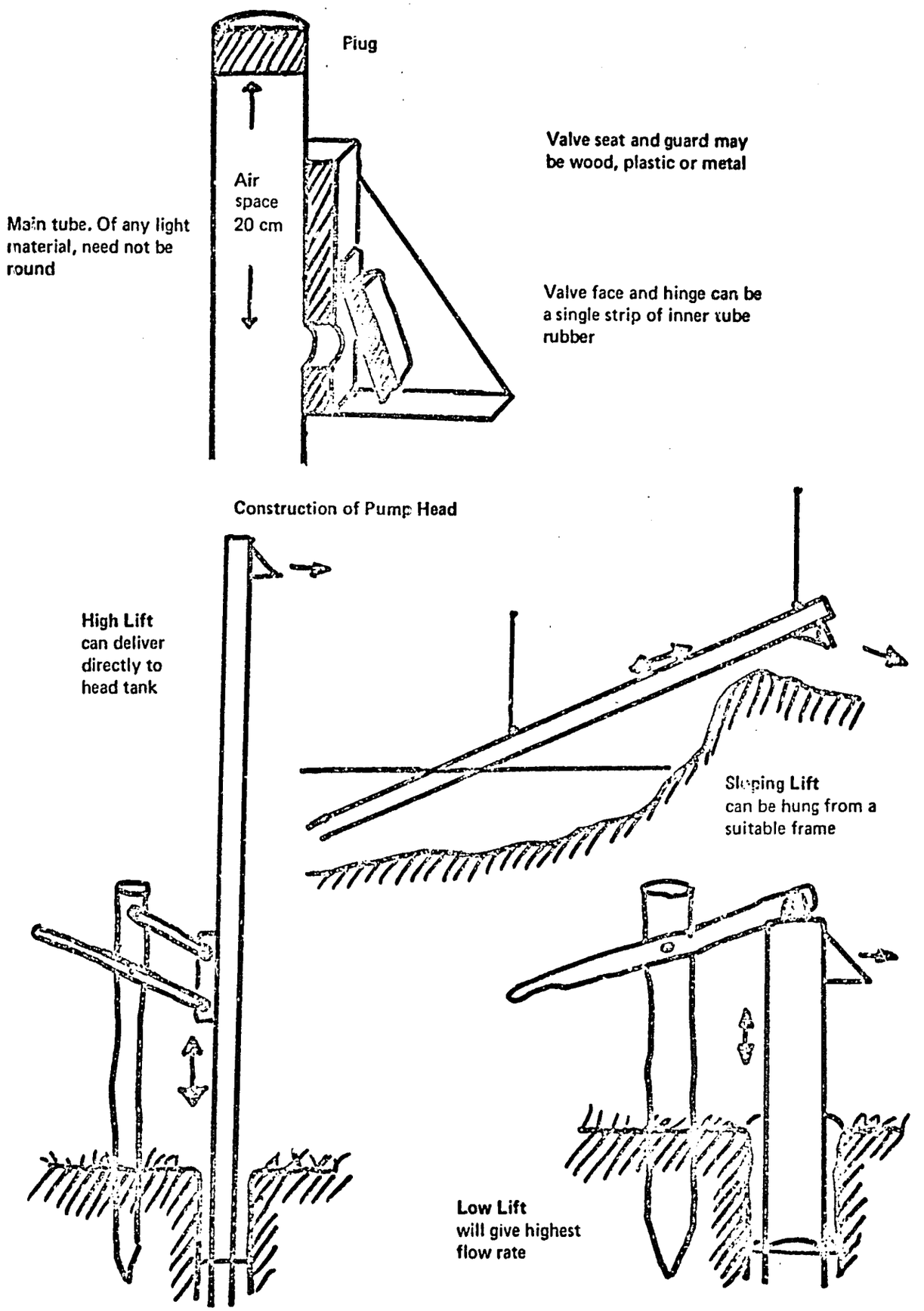
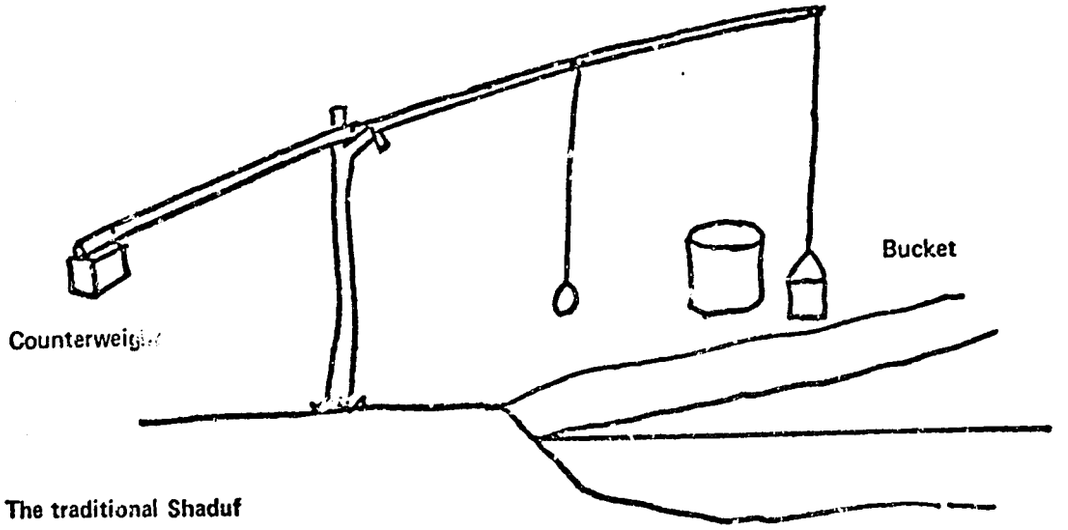
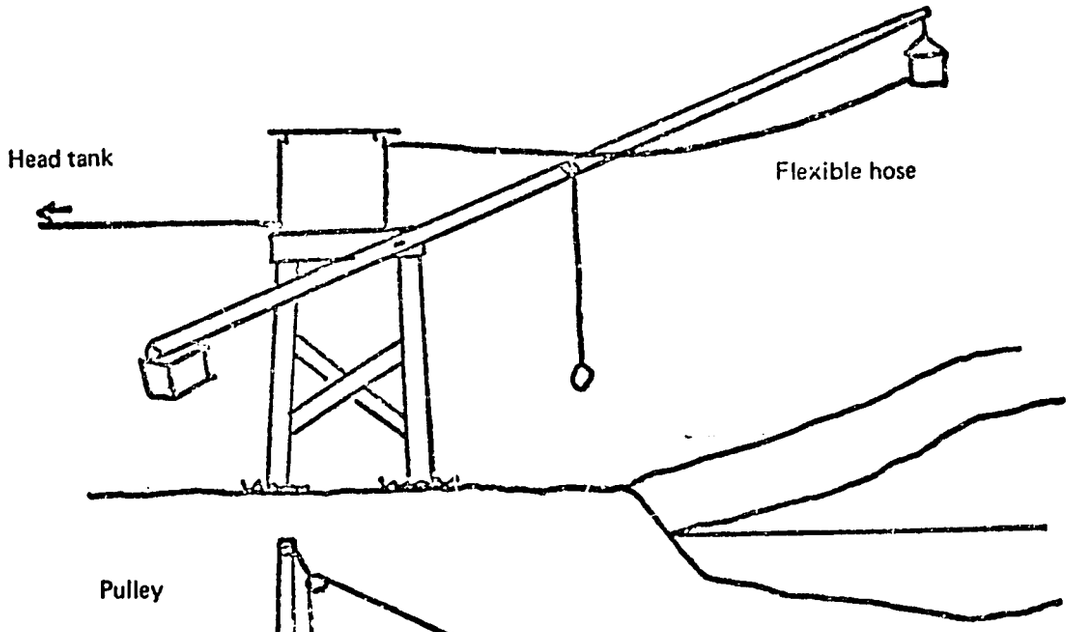
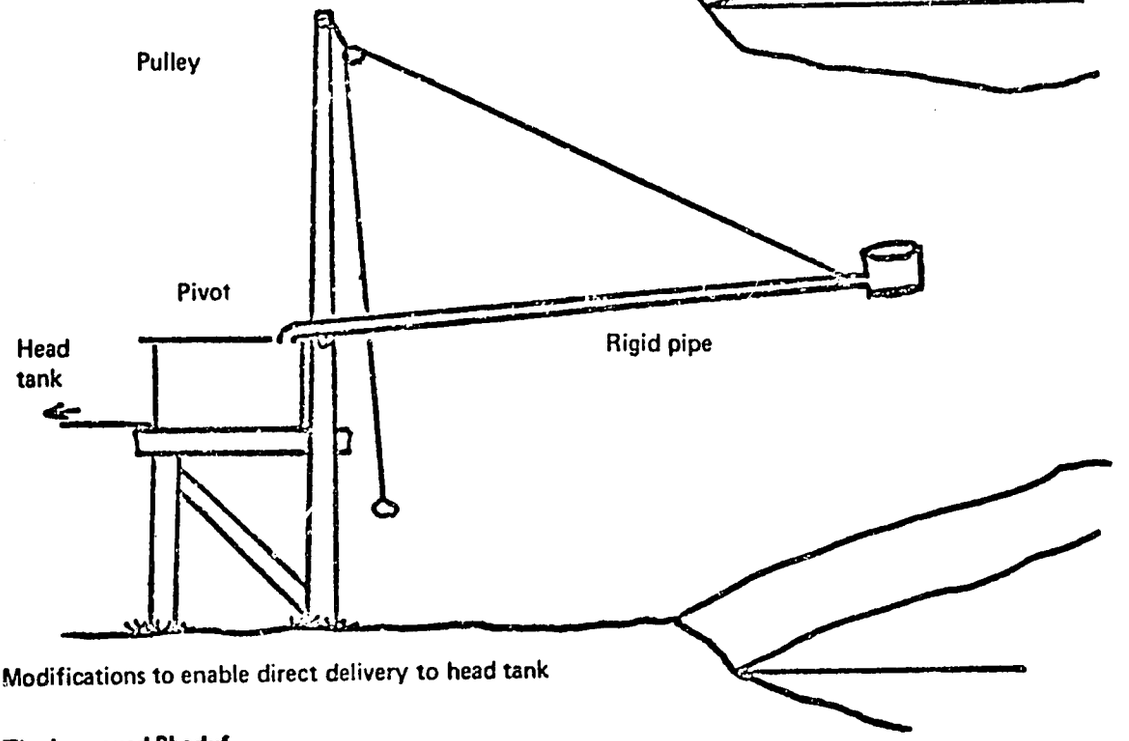


Fig. 17. THE SHADUF



The traditional Shaduf



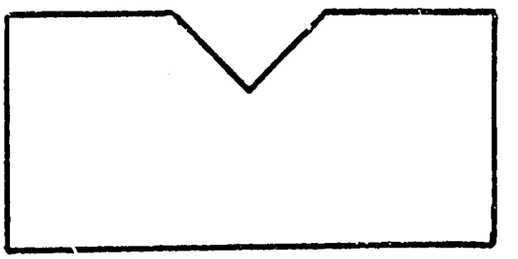


Modifications to enable direct delivery to head tank

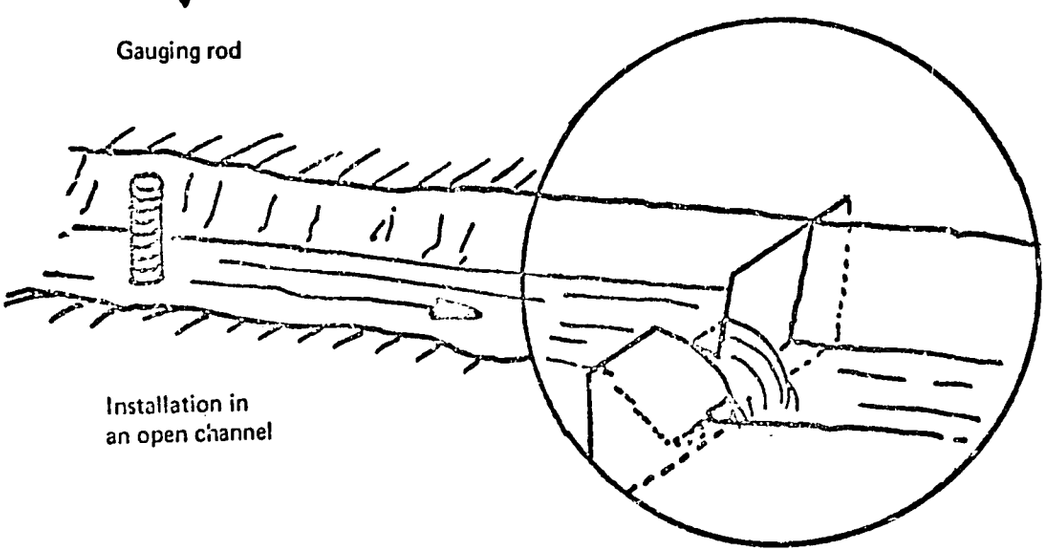
The improved Shaduf

Fig. 7. FLOW MEASUREMENT WITH V-NOTCH PLATES IN OPEN CHANNELS, STREAMS AND FROM PIPES

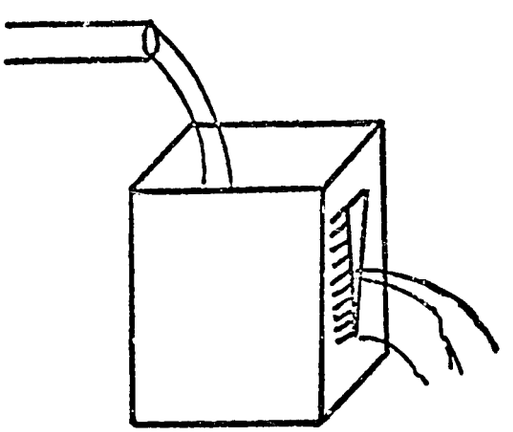
Gauging rod



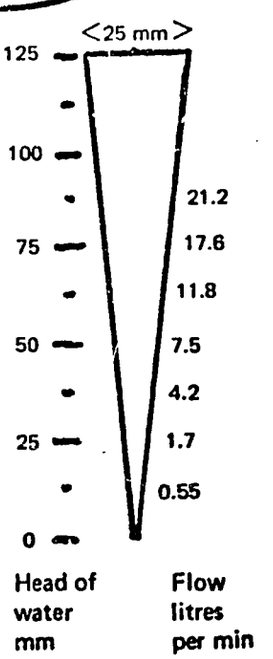
90° V-notch plate made from metal or wood

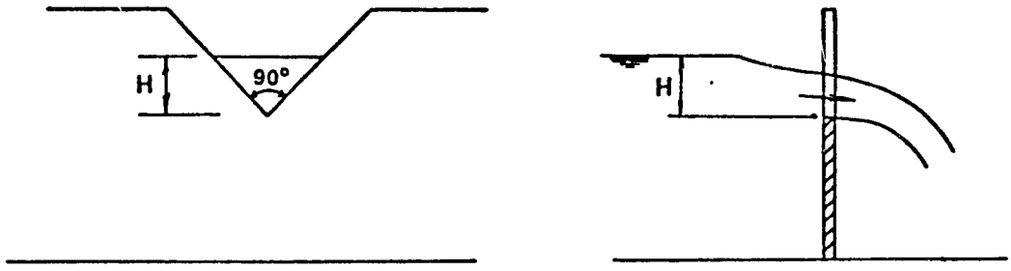


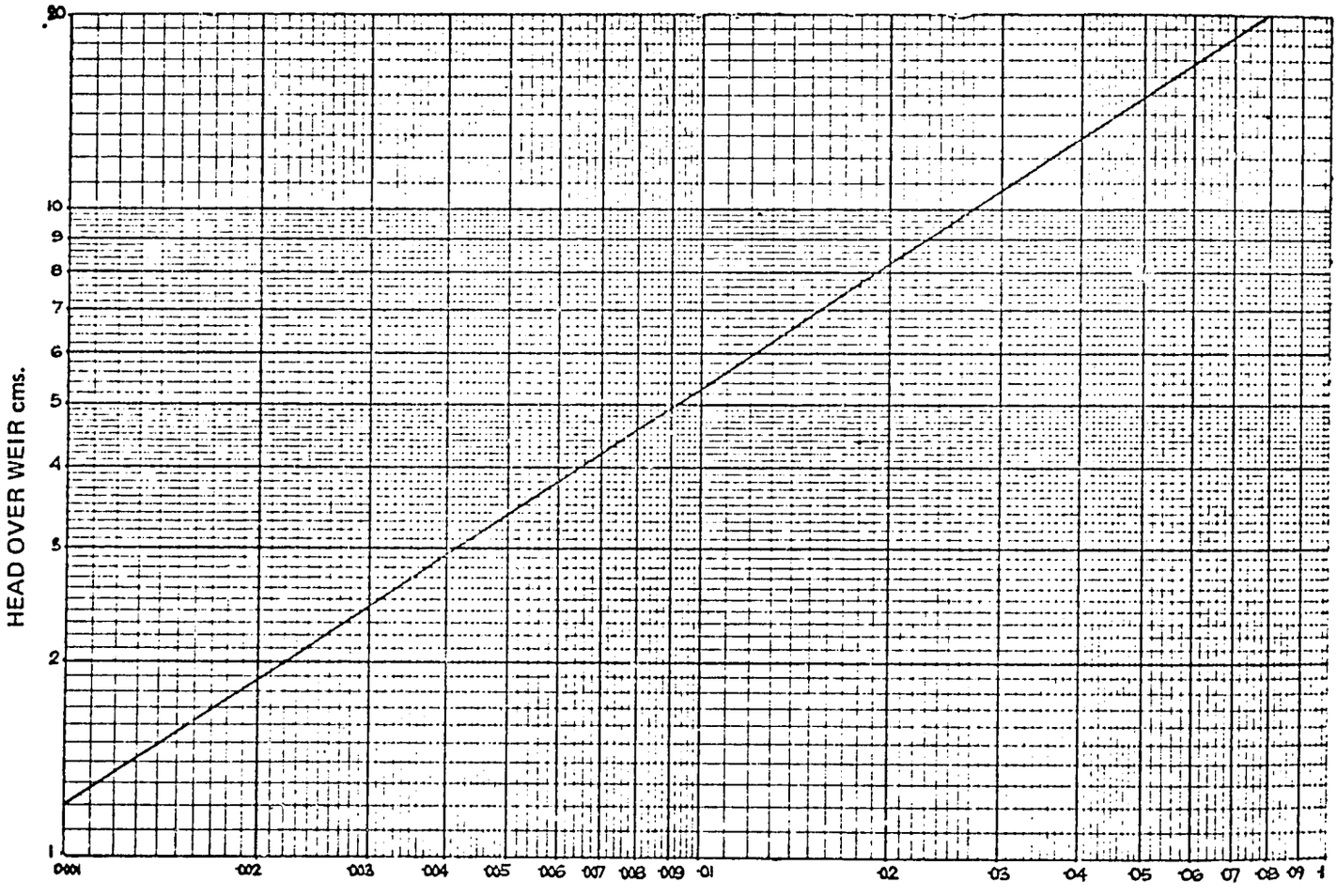
Installation in an open channel



Using a box with a V-notch cut out of the side for measuring the delivery from a pipe





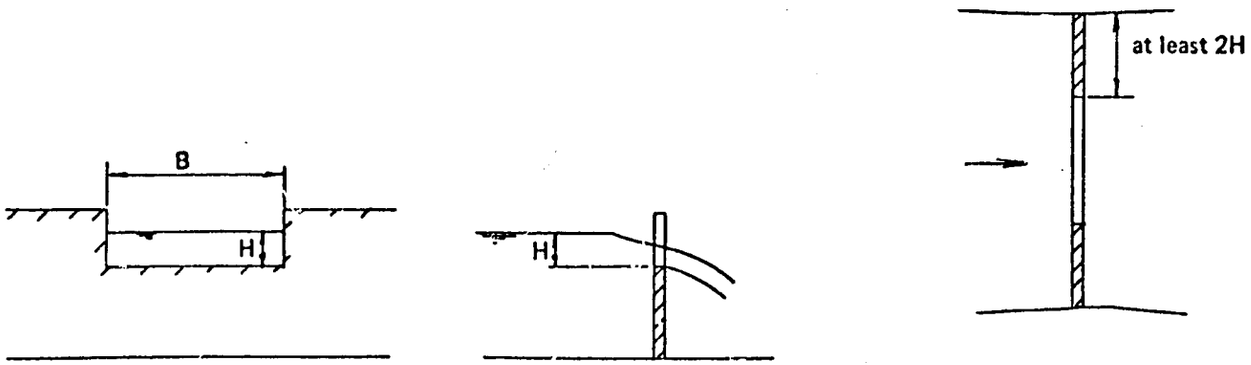


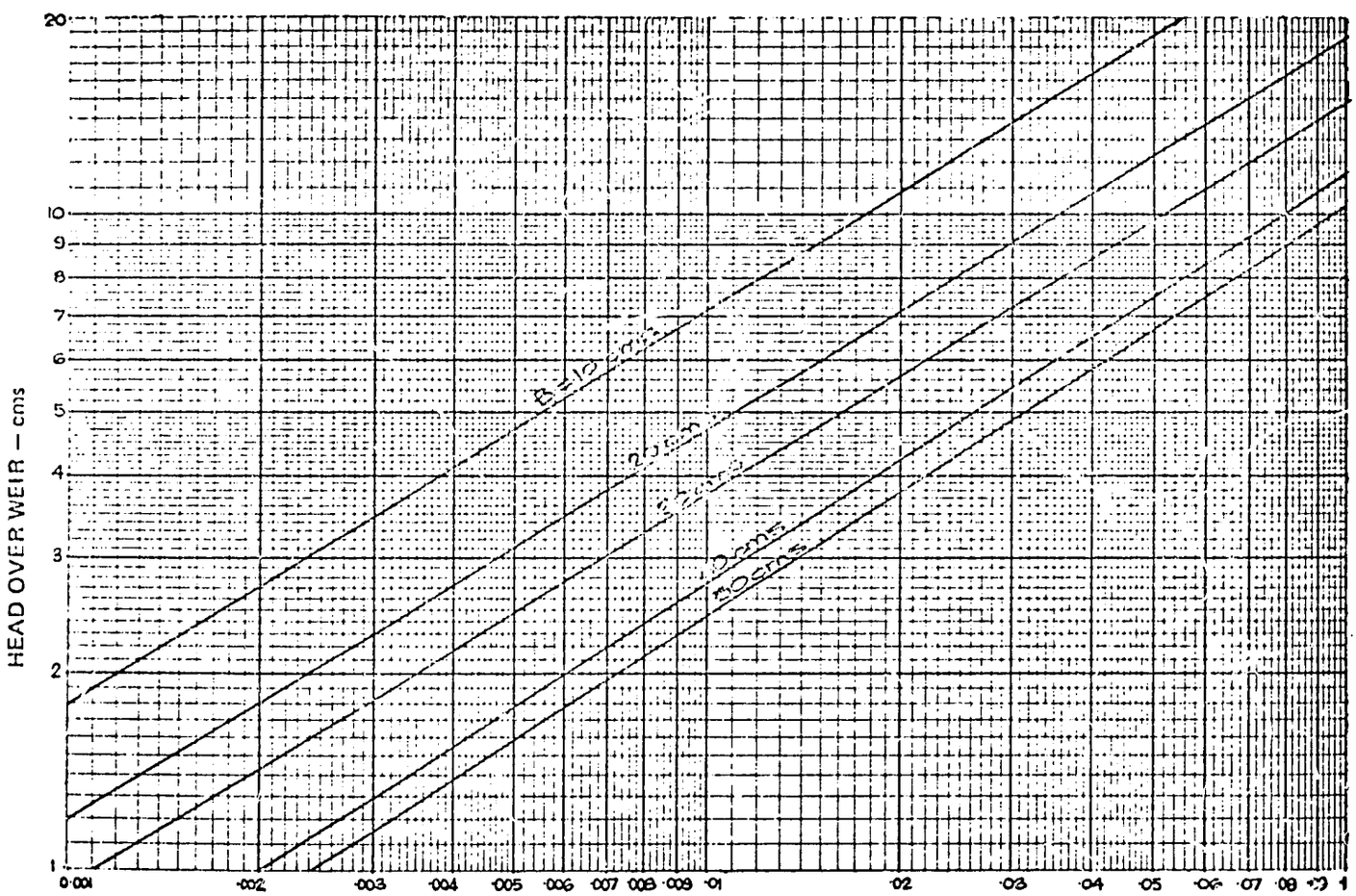
FLOW – Cubic metres per second

$Q = 4.55\ H^{5/2}$

(Q = cubic metres per second)
(H = head – metres)

Fig. 8. FLOW MEASUREMENT WITH A 90° V-NOTCH WEIR





$Q = 5.64\ BH^{3/2}$

B = Width of weir — metres

H = Head — metres

Fig. 9. MEASUREMENT OF FLOW OVER HORIZONTAL WEIRS

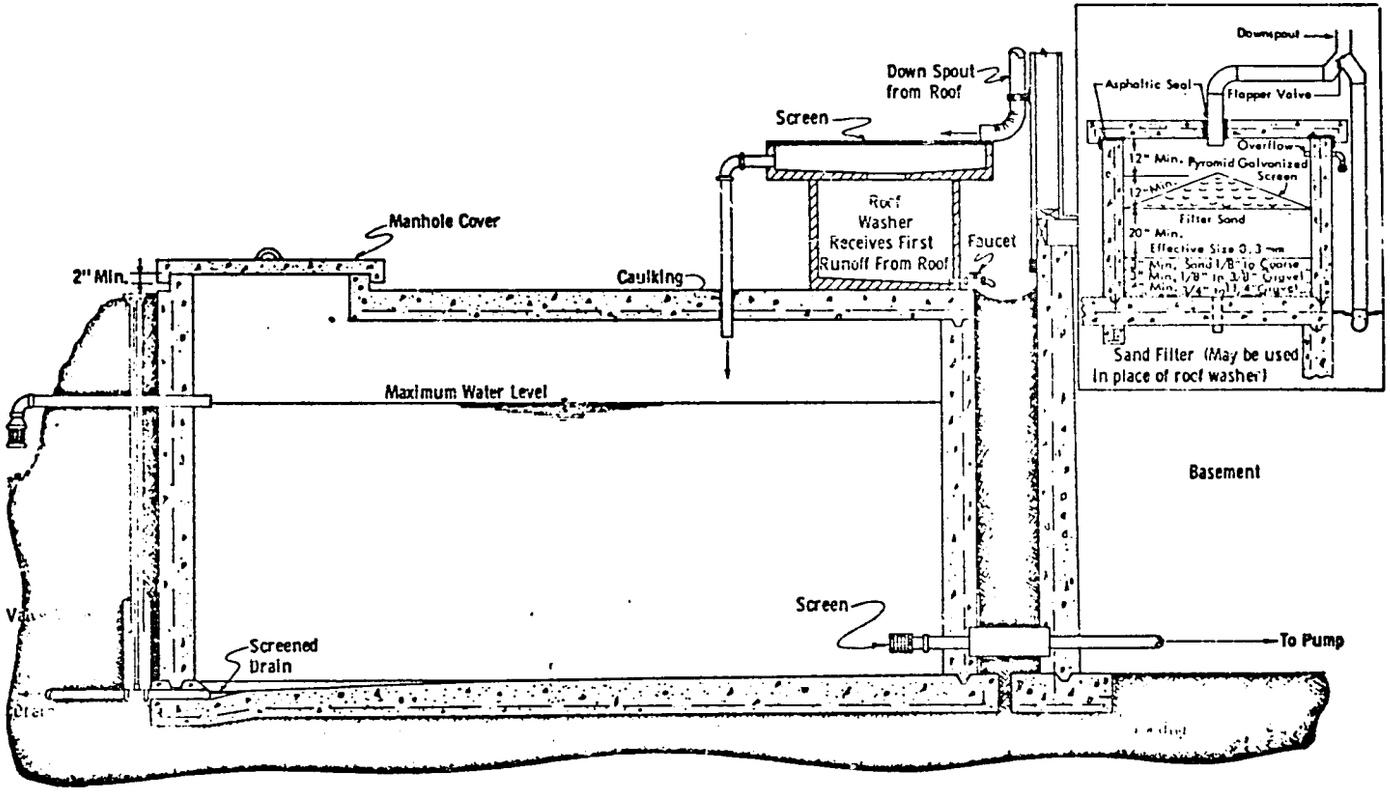


FIGURE 12. Cistern.

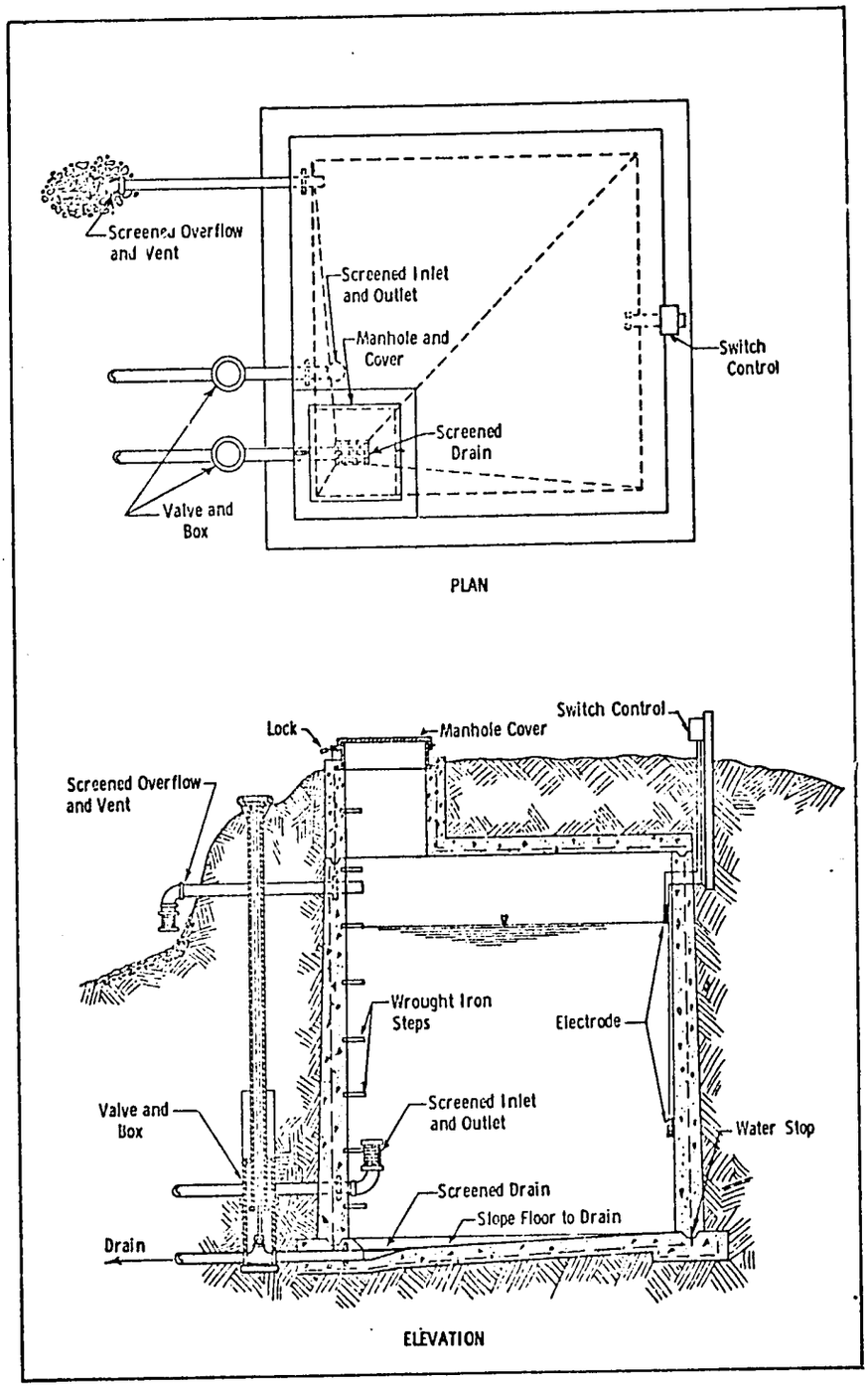


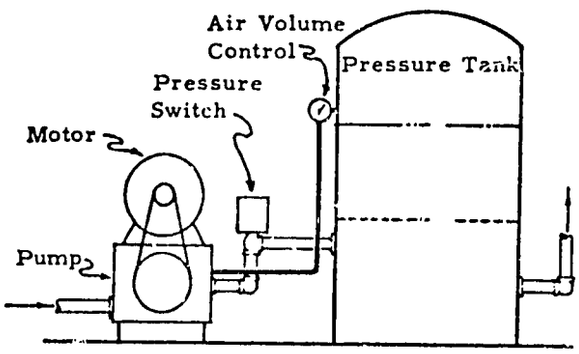
Figure 7.—Typical concrete reservoir.

AUTOMATIC WATER SYSTEMS

Pressure System (closed tank)

A pressure water system consists of a motor and pump, pressure switch, pressure tank and an air volume control. The water enters the closed tank from the pump compressing air in the tank. The compressed air forces water from the tank to opened faucets until the pressure drops to 20 pounds at which point the pressure switch starts the pump. The pump operates until the pressure switch stops the motor at 40 pounds pressure. The air volume control is a device designed to force air into the tank on each pumping cycle to replenish the air lost by absorption thru the water.

A larger column of water can be delivered by a pressure tank by precharging the tank with air prior to filling with water. This reduces the number of pumping cycles on the pump, lowering the cost of operation. The following table shows the amount of water delivered between 40 psi and 20 psi when pressure tank is at 0 or atmospheric pressure when filled with water as compared to a tank filled when precharged pressures up to 20 psi are present in the tank. You will note that a tank precharged with 20 pounds pressure will deliver 36.6% of the total tank capacity as compared to only 15.5% when tank is filled at atmospheric pressure.

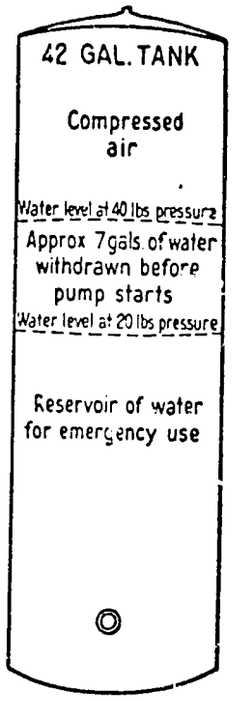


A

Volume of water delivered with precharged tank

Tank Size Gallons	Water Delivered	
	0 PSI	20 PSI
42	6.5	15.3
600	93.0	219.6
	15.5%	36.6%

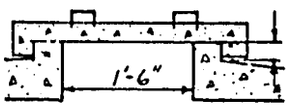
B



C

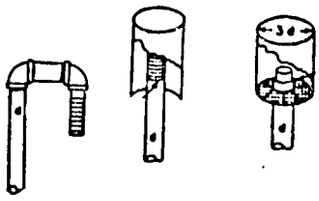
Gravity System (elevated storage)

A gravity water system consists of a motor and pump with an elevated storage tank. The motor may be controlled by a float switch or operated manually to fill the tank. The supply pressure is governed by the height of the column of water less pipe friction loss. Since a column of water 1 inch square 1 foot high weighs .433 pounds the total pressure exerted is found by multiplying the total height in feet of the water in storage tank by .433 pounds.



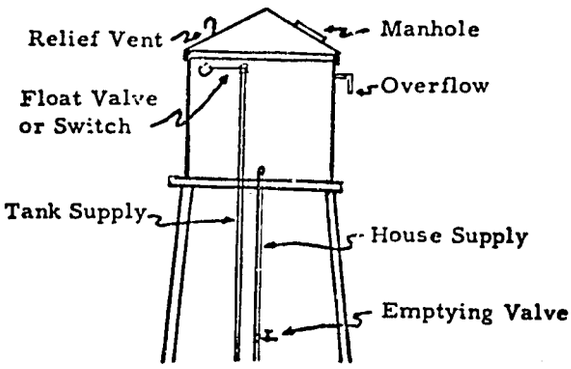
Overlapping type manhole required for storage tanks, filter clear wells, and dug well covers.

D



Air relief vents for storage tanks or well seals.

E



F

Hydro-Pneumatic
Booster System

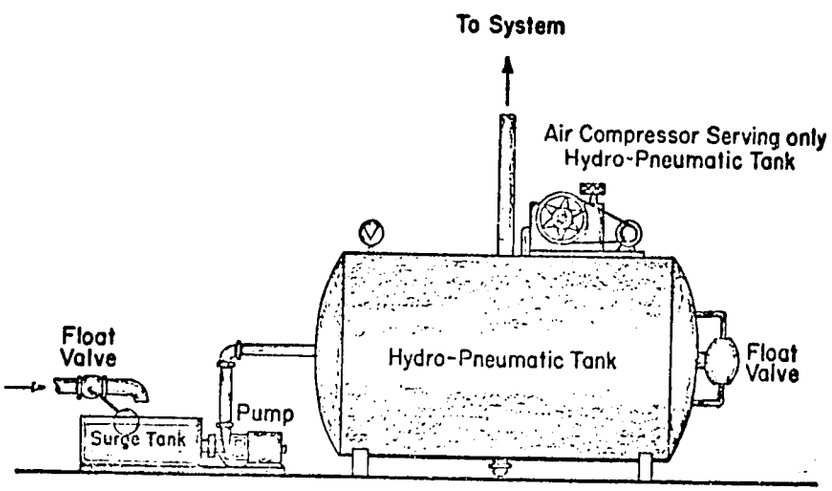


FIGURE 15

House Booster System

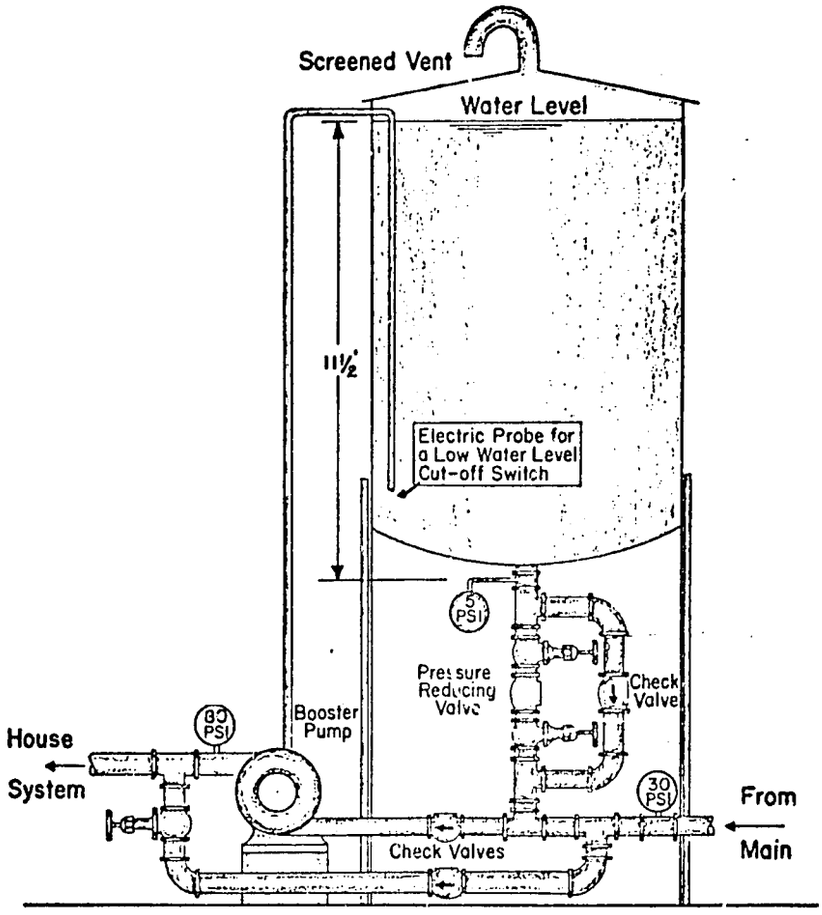
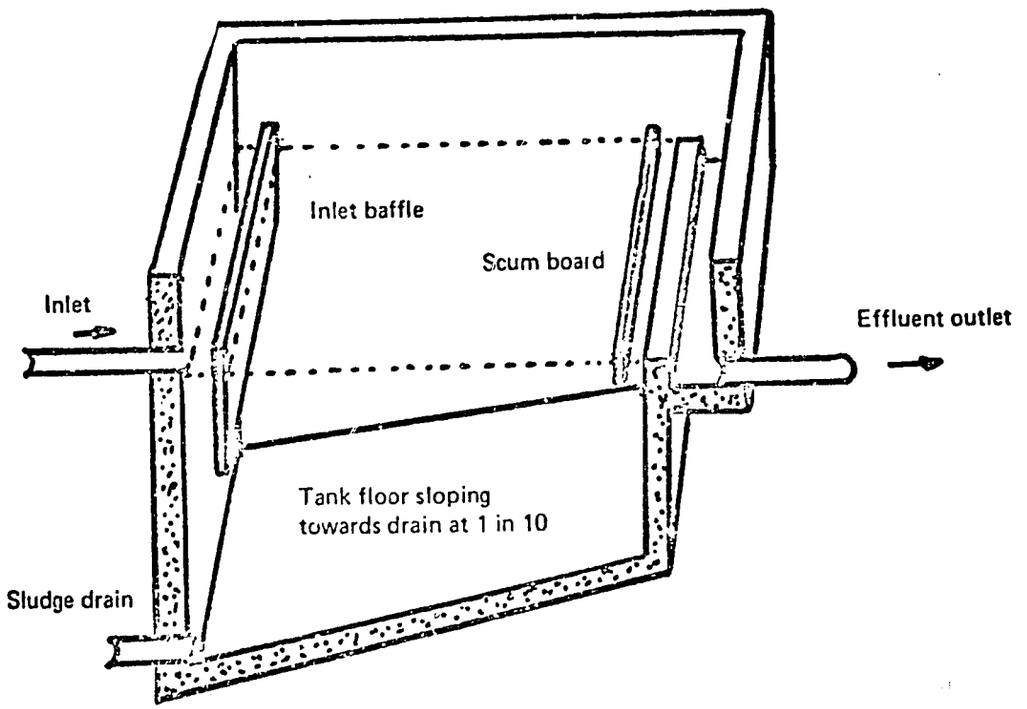
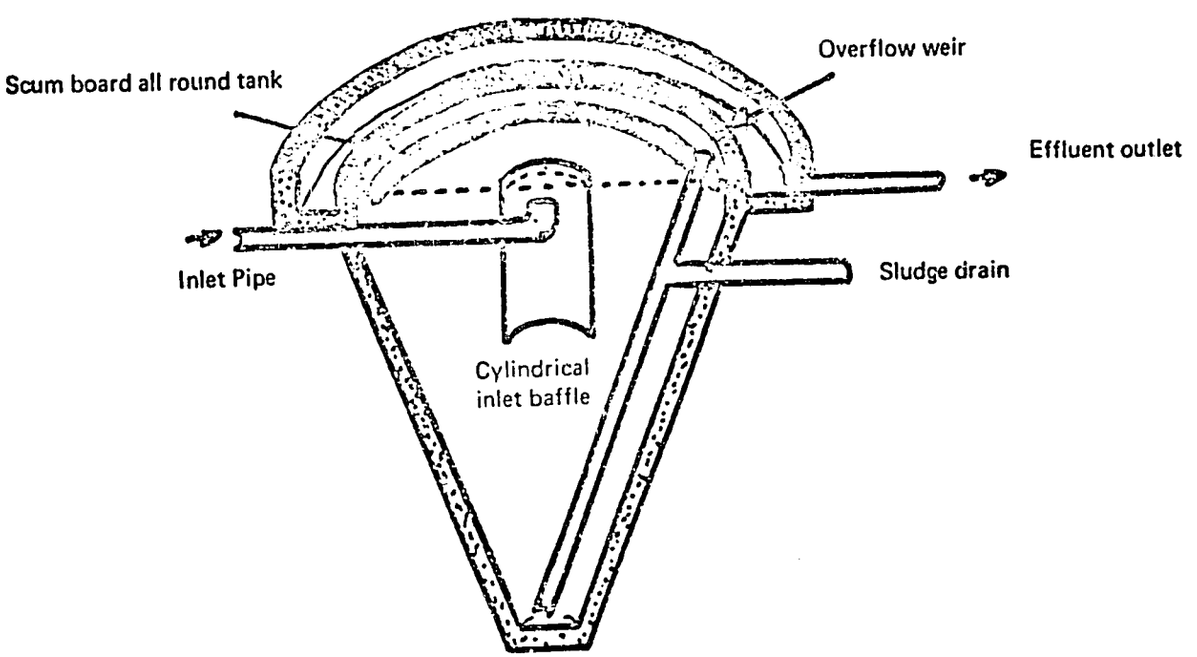


FIGURE 16

Fig. 18. SEDIMENTATION TANKS

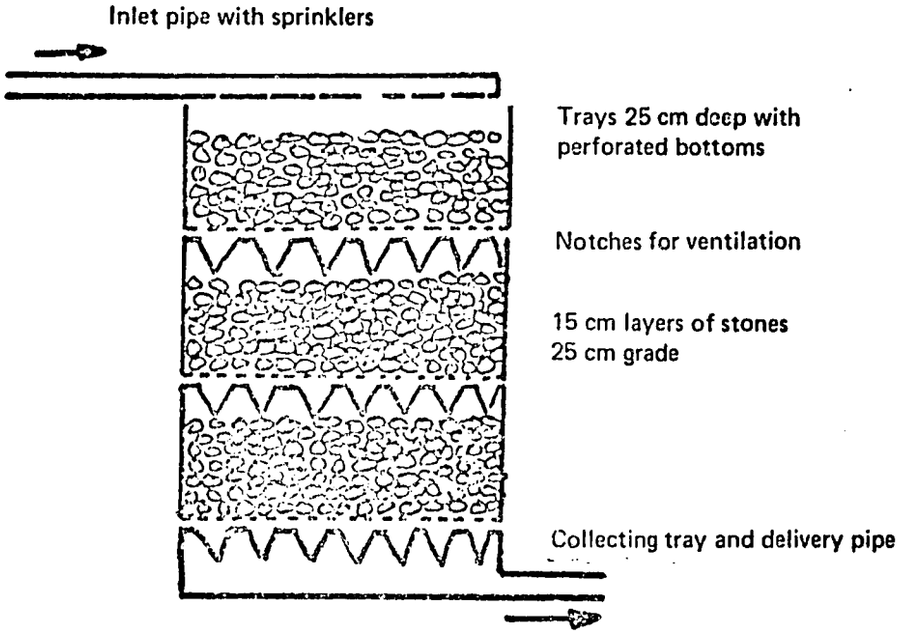


Horizontal flow type



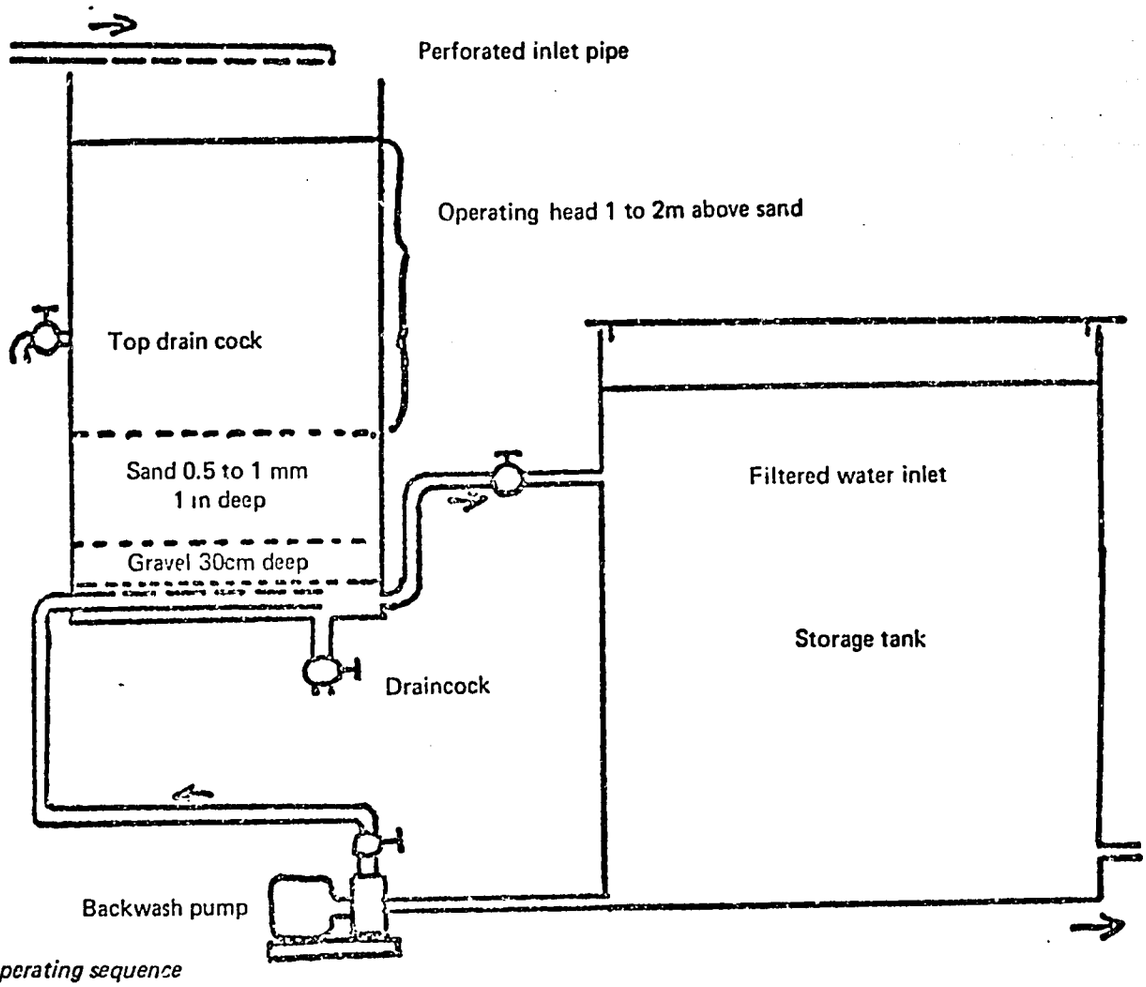
Vertical flow type

Fig. 24. TRICKLING FILTER FOR AERATION AND IRON REMOVAL



The approximate rate of flow through this type of filter, is up to 1600 litres per hour, per m^2 area. The number of trays should be found by trial.

Fig. 20. RAPID GRAVITY SAND FILTERS



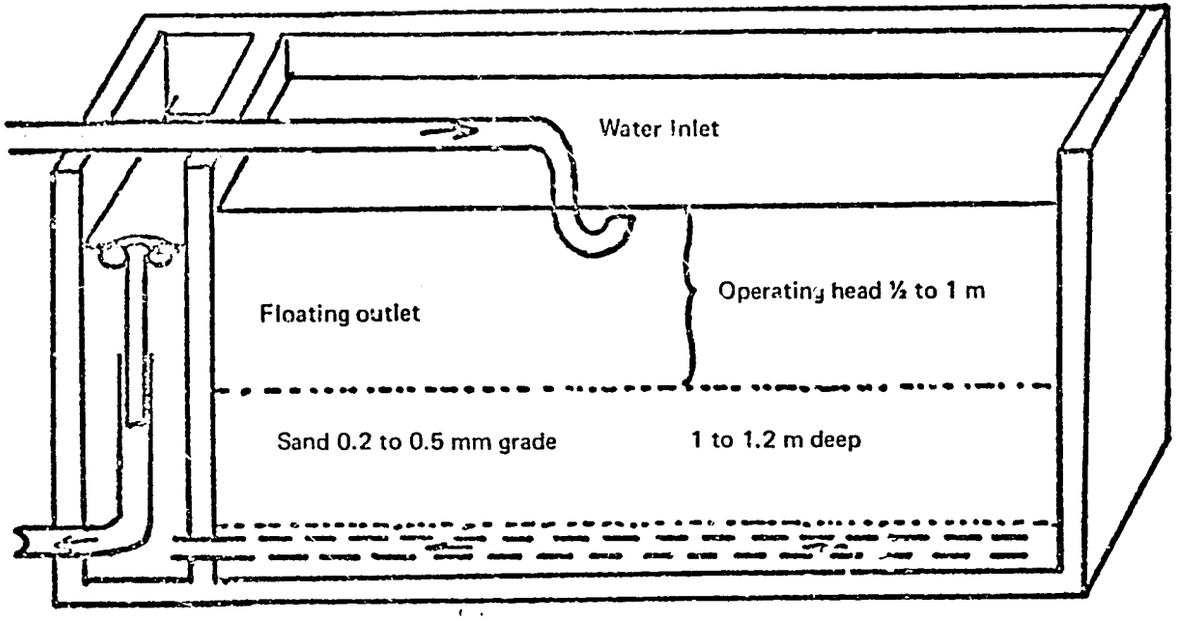
Operating sequence

While the filter is operating keep the draincocks and the stopcock in the backwash line closed.

To backwash, shut off flow of incoming water, close filtered water stopcock. Open top draincock until the water above the sand has drained. Open the valve in the backwash pipe and start the pump. Allow surplus water to overflow through the top draincock until the sand is clean.

In some filters this operation may be assisted by raking the sand from above or by blowing air from a compressor through the sand bed from below. After backwashing is completed, reset the valves and restart filtering.

Fig. 21. SLOW SAND FILTER



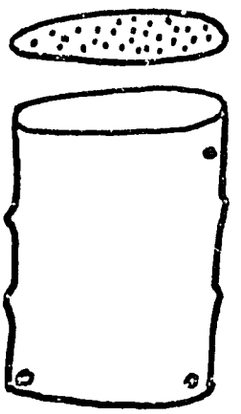
Support bed of graded gravel with underdrains

Operating sequence

When the filter becomes blocked, it may be cleaned by stopping the flow of incoming water. Drain the bed to expose the sand. The surface layer of 3 to 5 cm of soiled sand may then be removed with shovels. When this operation has been carried out 3 or 4 times a fresh layer of clean sand should be put in position to maintain the thickness of the bed.

Fig. 22. THE UPWARD FLOW SAND FILTER

Preparation



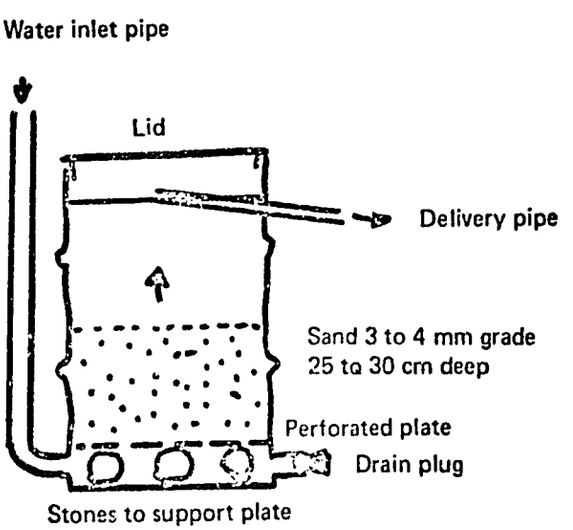
1) Remove the top and trim it to fit inside. Pierce with 2 to 3mm holes 5 cm apart all over

2) Pierce the drum to fit the inlet pipe, outlet pipe and the delivery pipe

3) Paint all inside metal surfaces with bituminous paint to prevent rusting.

44 gallon drum will make a filter able to treat 230 litres (50 gal) per hour

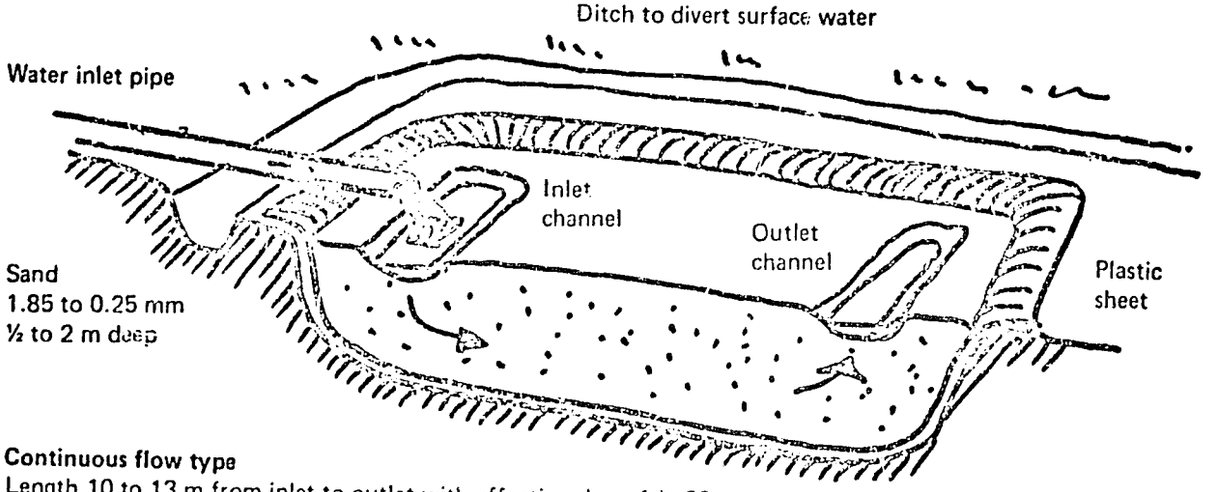
Assembly



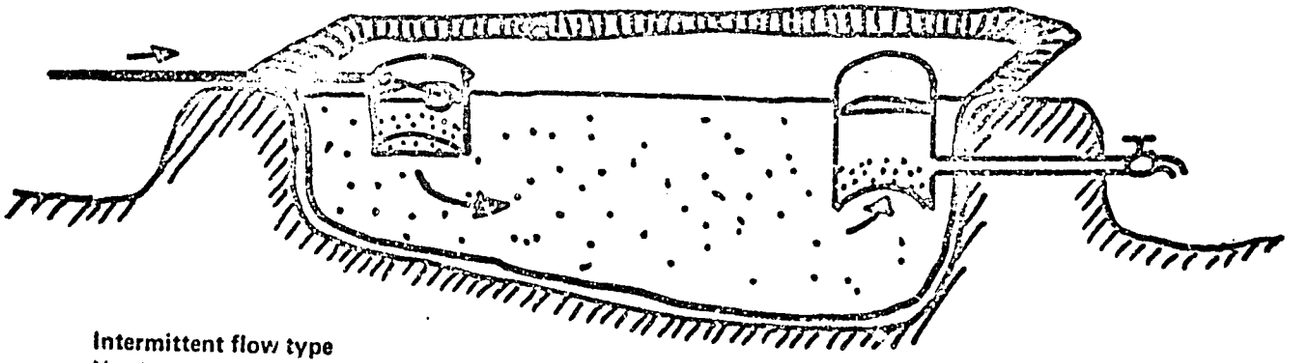
Operating Sequence

Allow water to filter at up to 230 litres per hour. To backwash stop flow, remove drain plug, allow dirt to flow out. Replace drain plug and restart flow.

Fig. 23. THE HORIZONTAL SAND FILTER

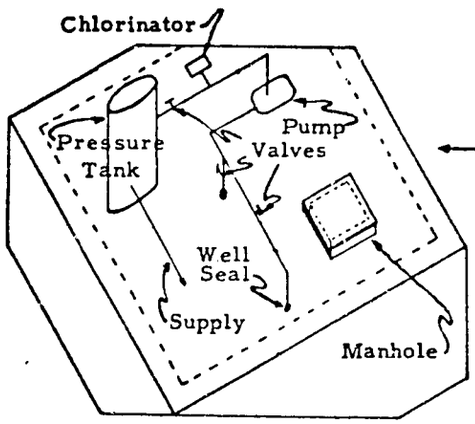


Continuous flow type
Length 10 to 13 m from inlet to outlet with effective slope 1 in 20.
When inlet channel becomes blocked, divert flow to new channel cut 1 m below first.
The first channel can then be cleaned and normal flow resumed.

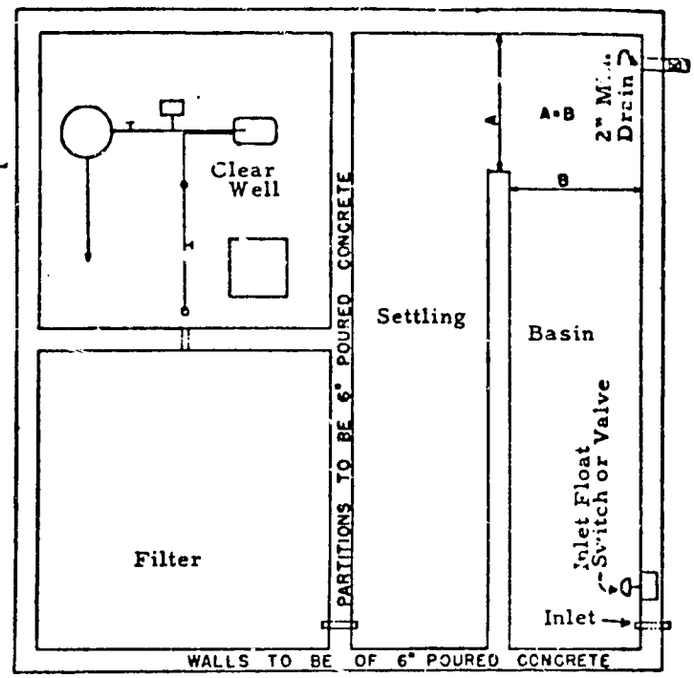


Intermittent flow type
Needs to be only slightly larger than flow demand.
To clean inlet, remove drum and ball valve and refit to one side while dirty sand is removed.

Modified Slow Sand Filter for Treating Surface Water

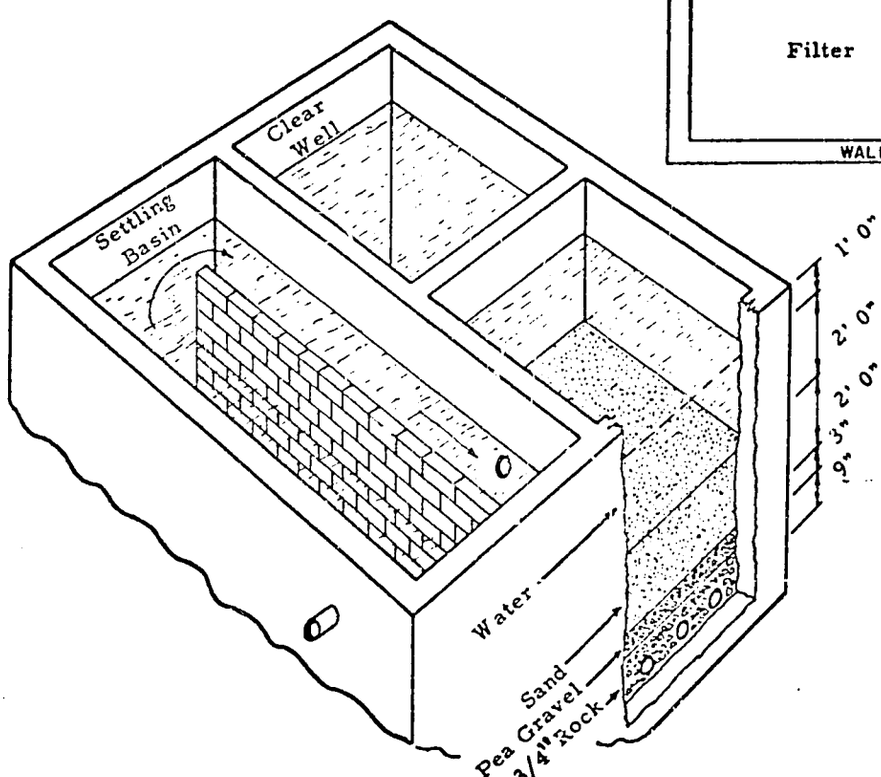


A



Plan

B



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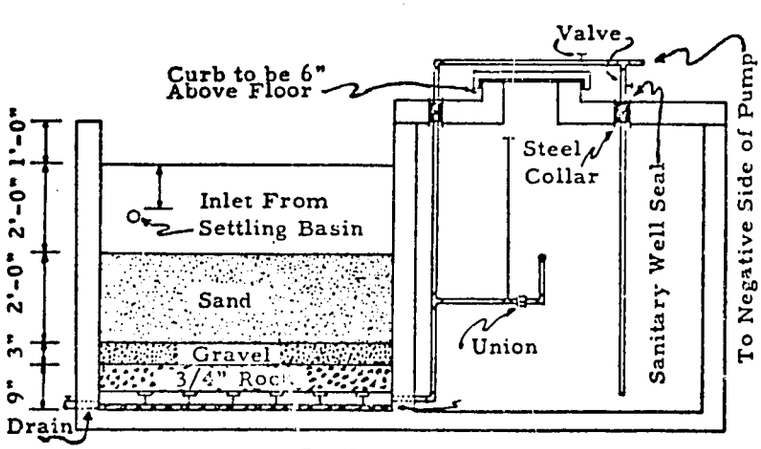


Section

D

Figure A shows the piping arrangement with valves which can be manipulated to back flow water th u filter. The filter can also be pumped down leaving the clear well full for usage during cleaning periods.

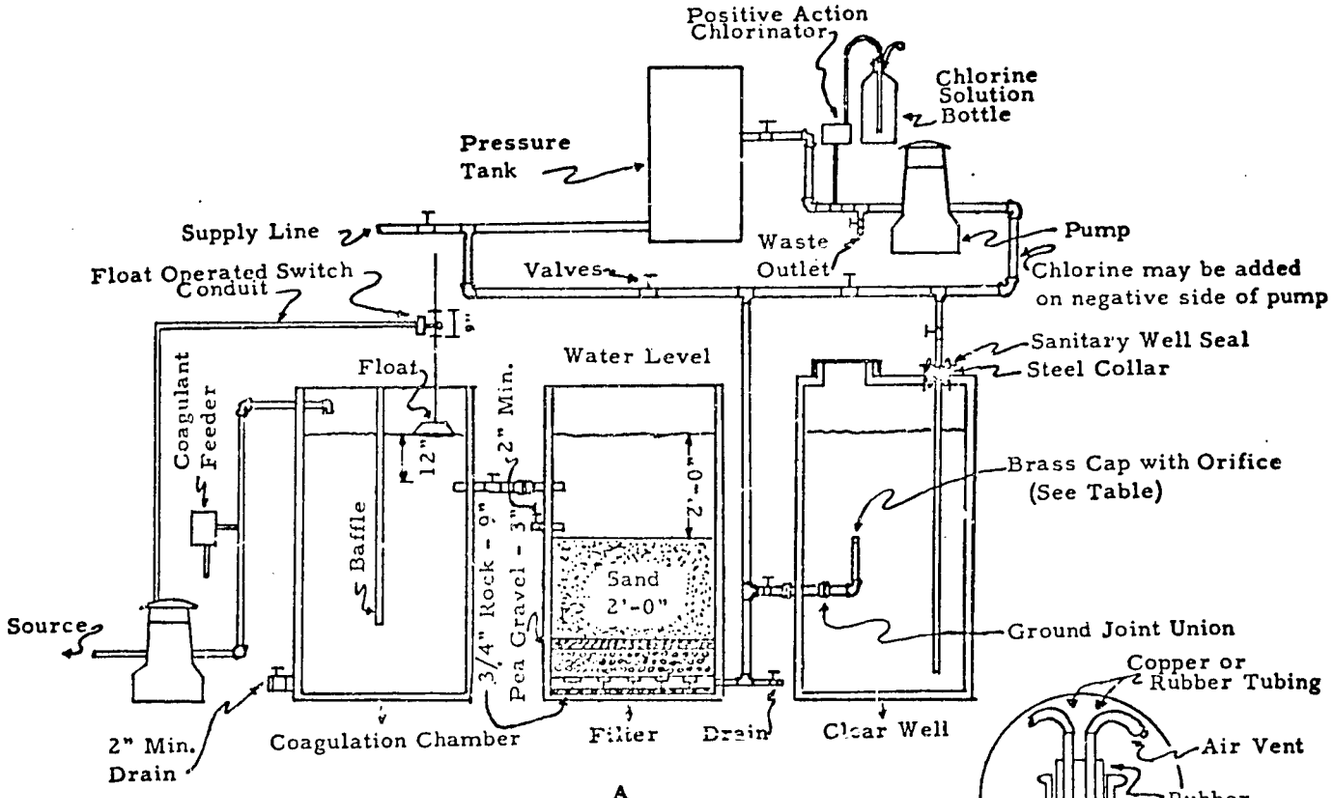
Figure B shows a typical plan for a rectangular concrete filter unit.

Figure C shows an isometric view of the unit.

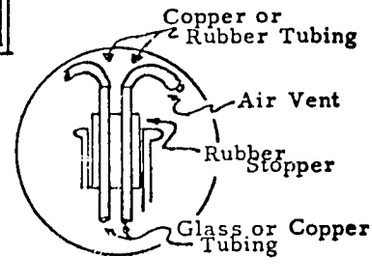
Figure D shows a cross section of the filter and clear well with the additional piping arrangement needed. All piping can be done thru the side wall of filter and clear well into a pump house constructed at ground level.

Slow Sand Filter (Continued)

ALTERNATE DESIGN



A



Chlorine Bottle Top

B

TABLE IV

Table showing water flow thru orifice sizes at 2' to 8' head pressure.

Size Orifice in Inches	Head in Feet			
	2'	4'	6'	8'
	Gallons Water Delivered per Day			
1/16	107	153	182	215
1/8	434	619	757	873
3/16	960	1370	1675	1930
1/4	1740	2475	3030	3495
5/16	2660	3780	4640	5340
3/8	3630	5160	6320	7280
7/16	5260	7500	9200	10580
1/2	6850	9750	11950	13750
3/4	16800	23950	29300	33400
1	27900	39500	48400	55000
1-1/4	47500	67400	82500	93900
1-1/2	63000	89200	109300	124500
1-3/4	86400	122300	150000	170500
2	140000	198500	243000	276000

DESIGN FACTORS

The area of the filter must be not less than one square foot per 50 gallons of water per day.

The clear well volume should be designed to store the maximum amount of water needed for peak period demand considering that the recovery thru filter amounts to only 2 gallons per square foot per hour. Minimum volume should be considered at least 3/4 of the total daily demand.

The volume of the coagulation chamber depends on turbidity of the water source. It serves to reduce the need for cleaning filter sand. Coagulants correctly used in the chamber will further extend normal functioning time of the filter. Coagulation chambers may be omitted in instances where the water source is from clear springs, wells or cisterns.

The orifice controlling the flow thru filter into clear well is extremely important in that the flow must not exceed the design rate of 50 gallons per square foot of filter area. The table (Figure C) shows flow rates at various heads for use in determining the correct orifice size.

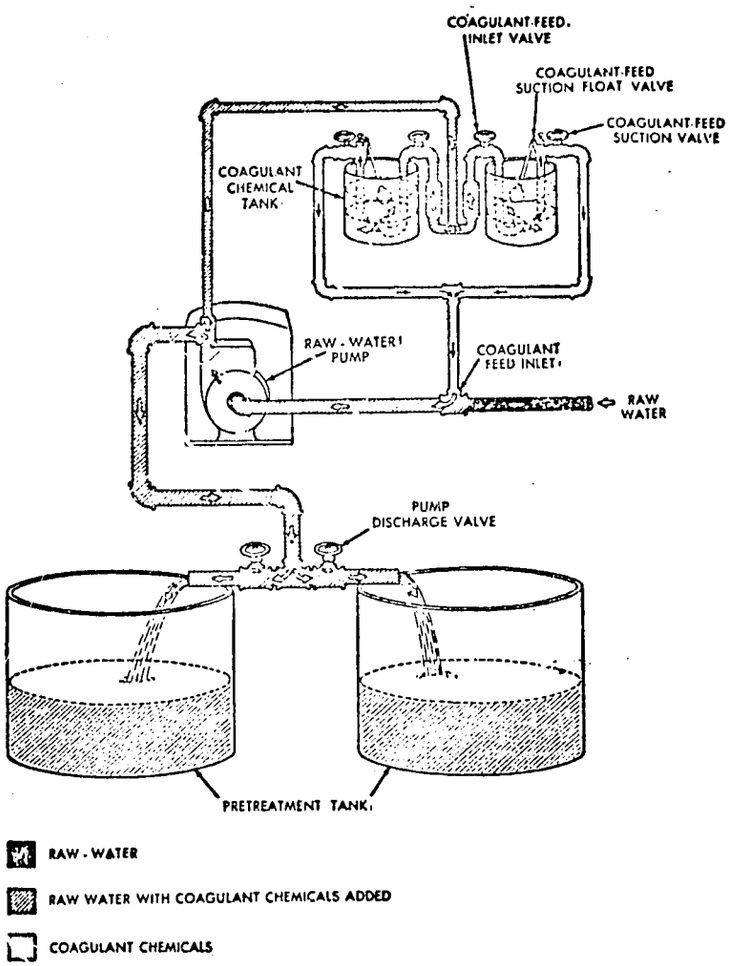


Figure 66.1. (Added.) *Flow diagram during pretreatment of raw water in water purification set No. 5.*

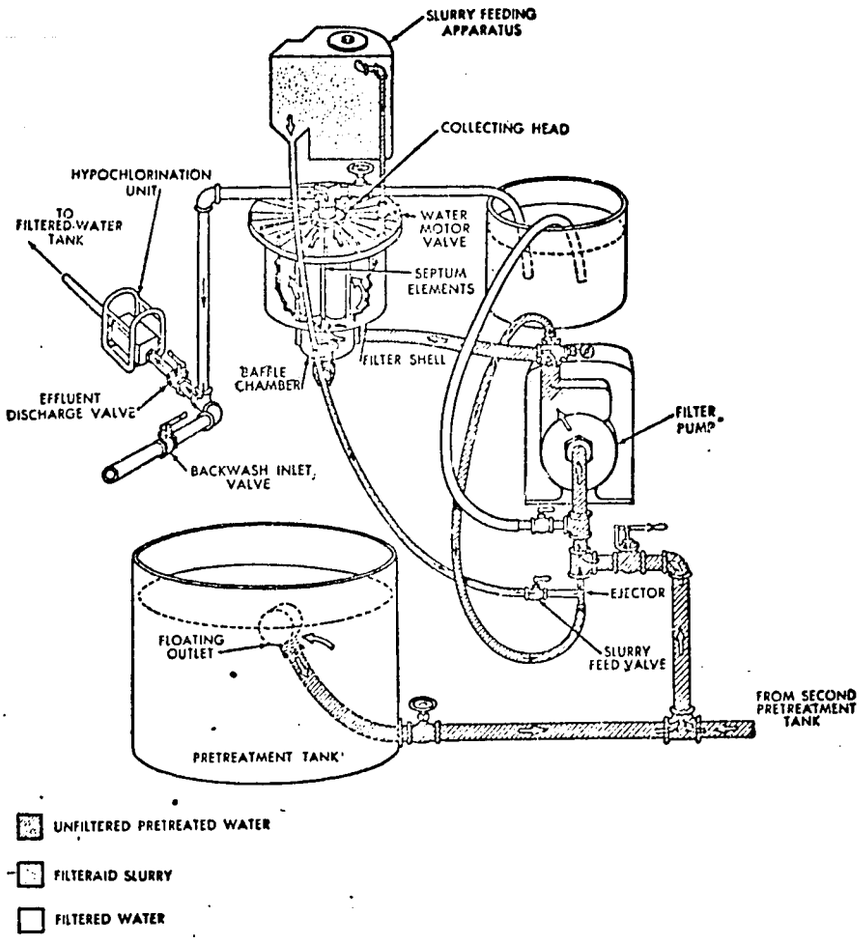


Figure 66.2. (Added.) ***Flow diagram during filtering of pretreated water in water purification set No. 5.***

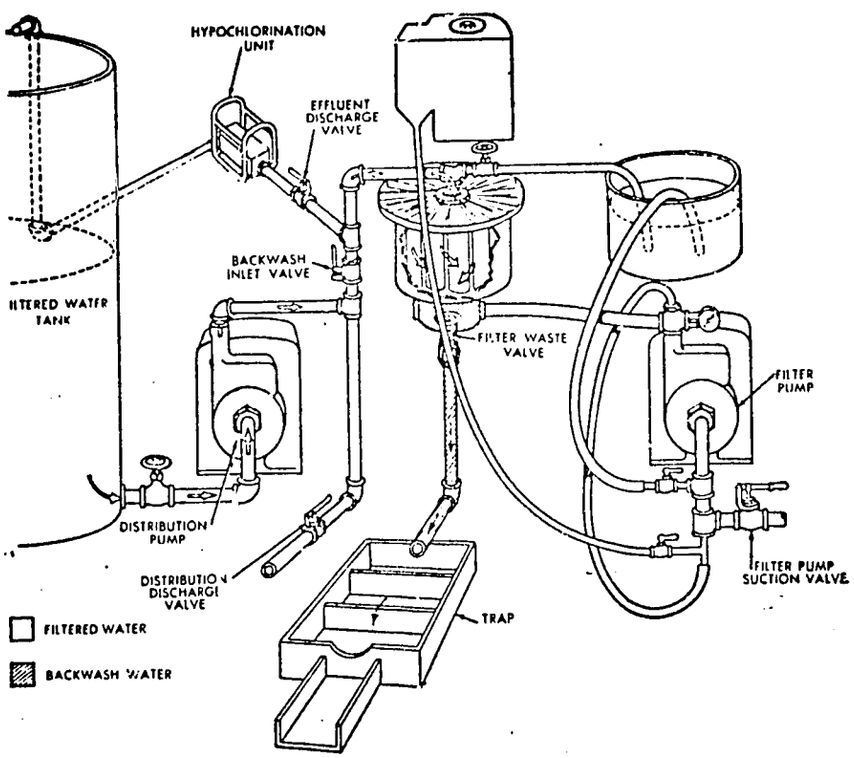


Figure 66.3. (Added.) *Flow diagram during backwashing in water purification set No. 5.*

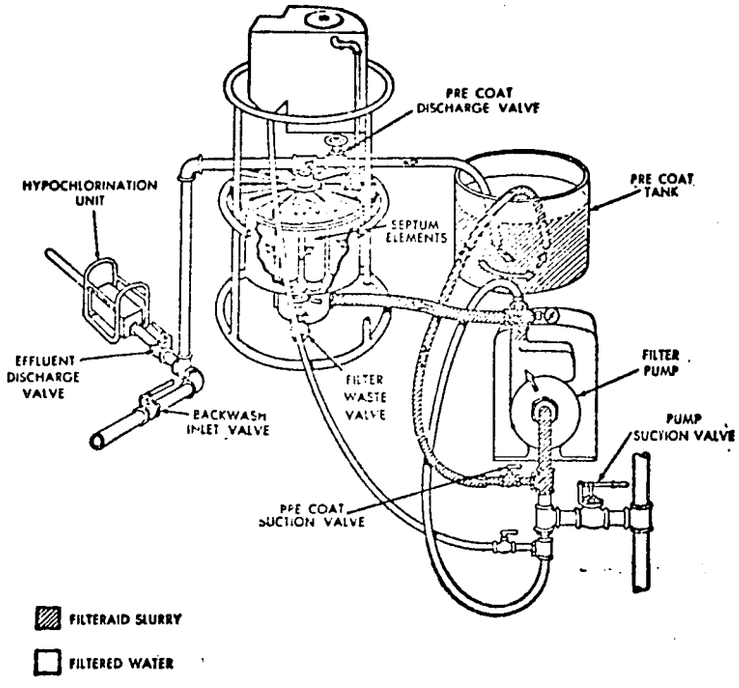


Figure 66.4. (Added.) *Flow diagram during precoating filter in water purification set No. 5.*

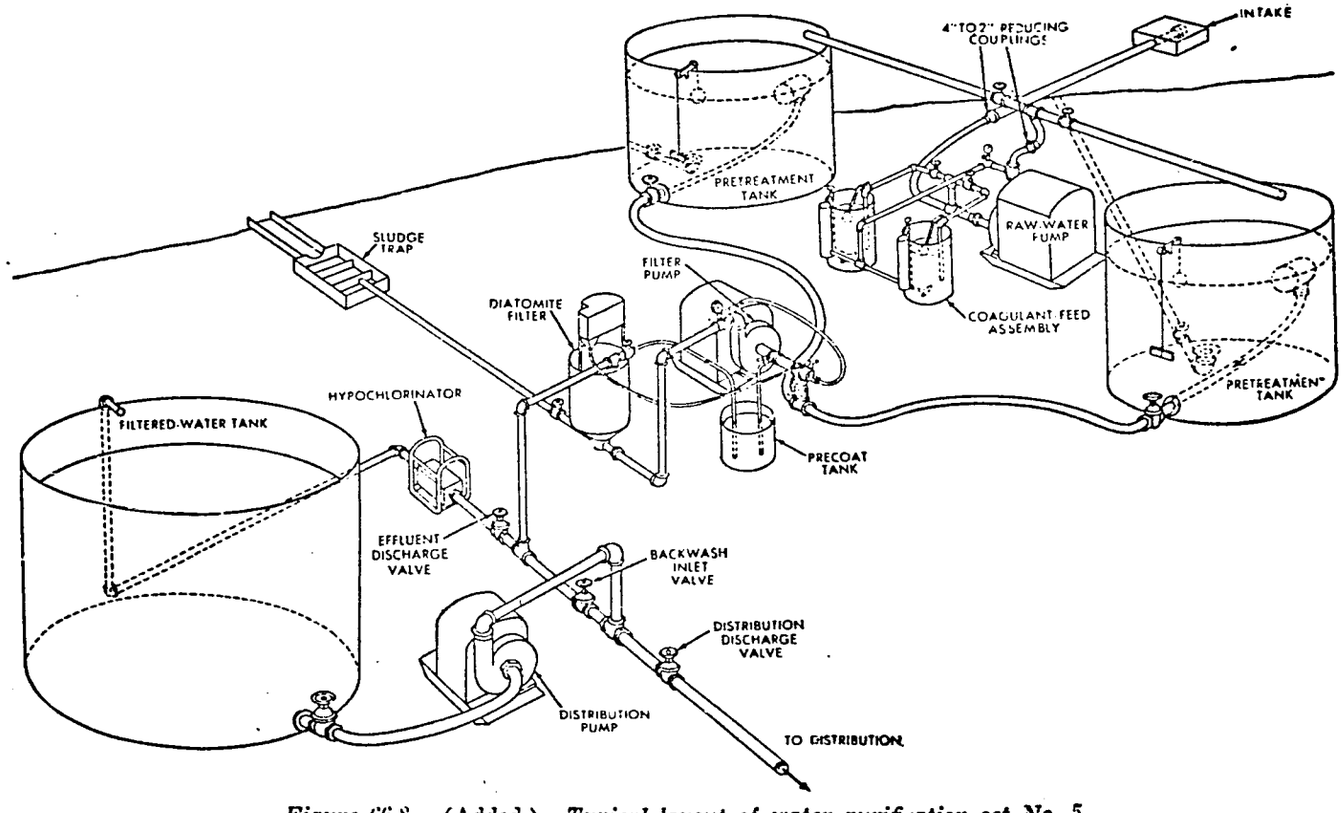


Figure C6.8. (Added.) *Typical layout of water purification set No. 5.*

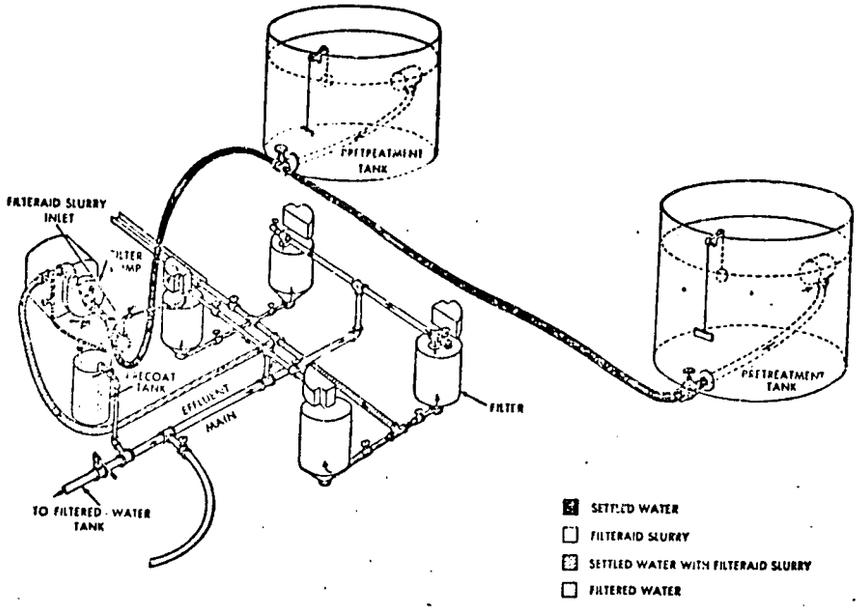


Figure 66.11. (Added.) *Flow diagram during filtering or prétreated water in water purification set No. 6.*

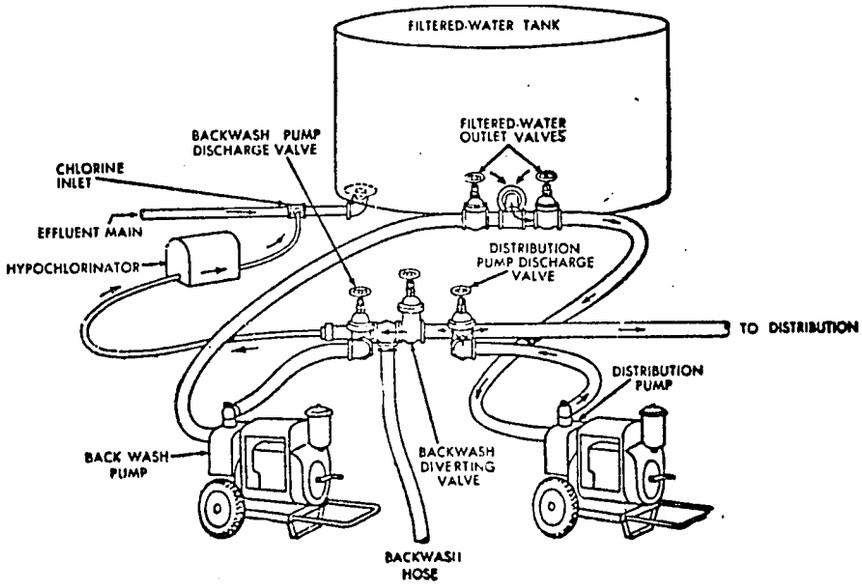


Figure 66.12. (Added.) *Flow diagram during distribution of filtered water in water purification set No. 6.*

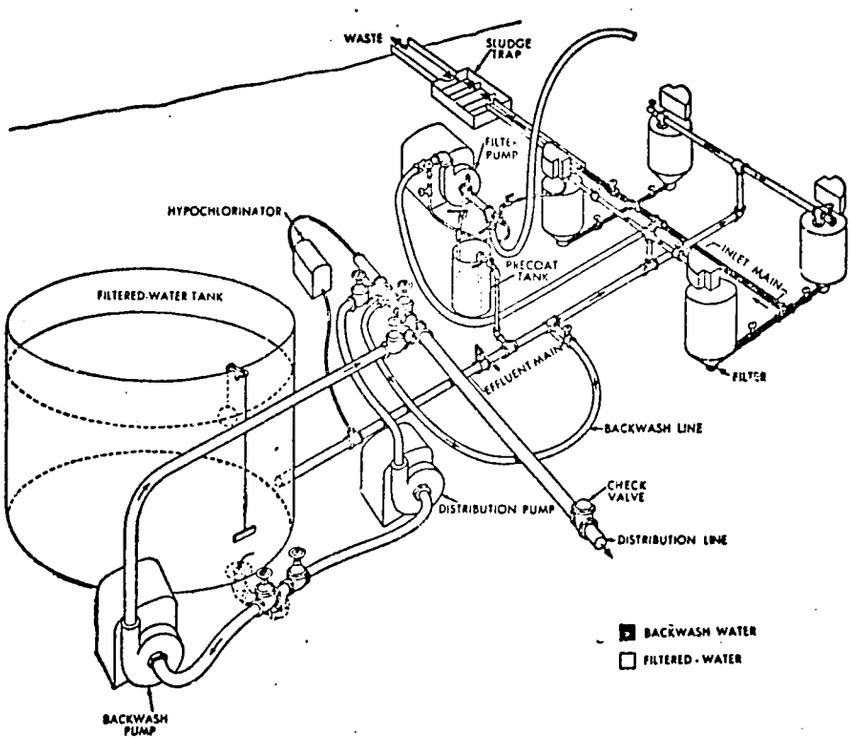


Figure 66.13. (Added.) *Flow diagram during backwashing in water purification set No. 6.*

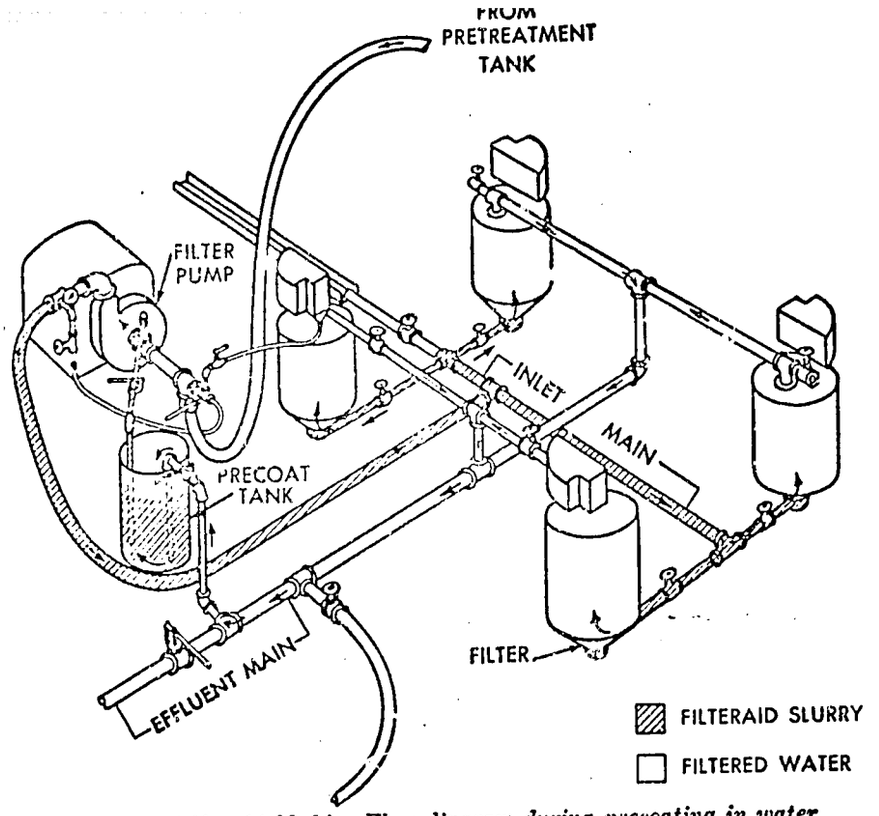


Figure 66.14. (Added.) *Flow diagram during precoating in water purification set No. 6.*

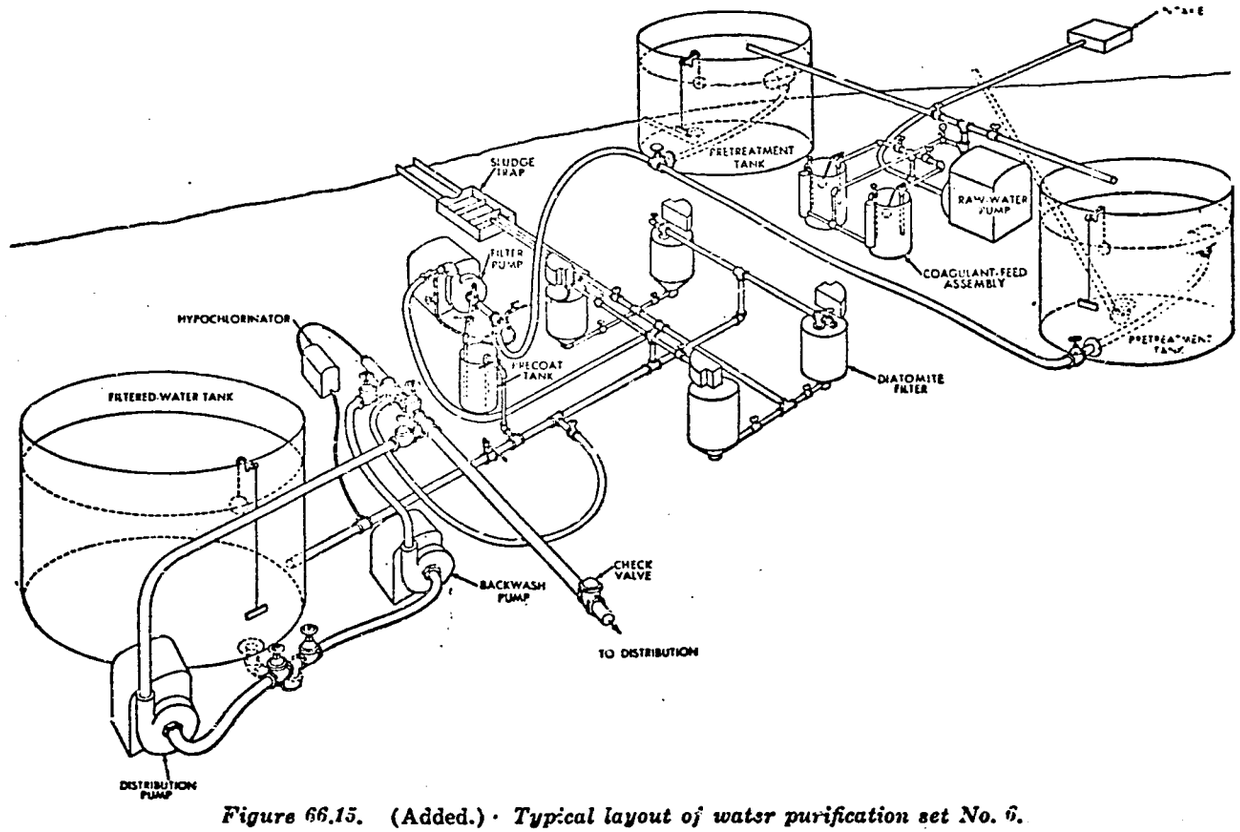


Figure 66.15. (Added.) · *Typical layout of watsr purification set No. 6.*

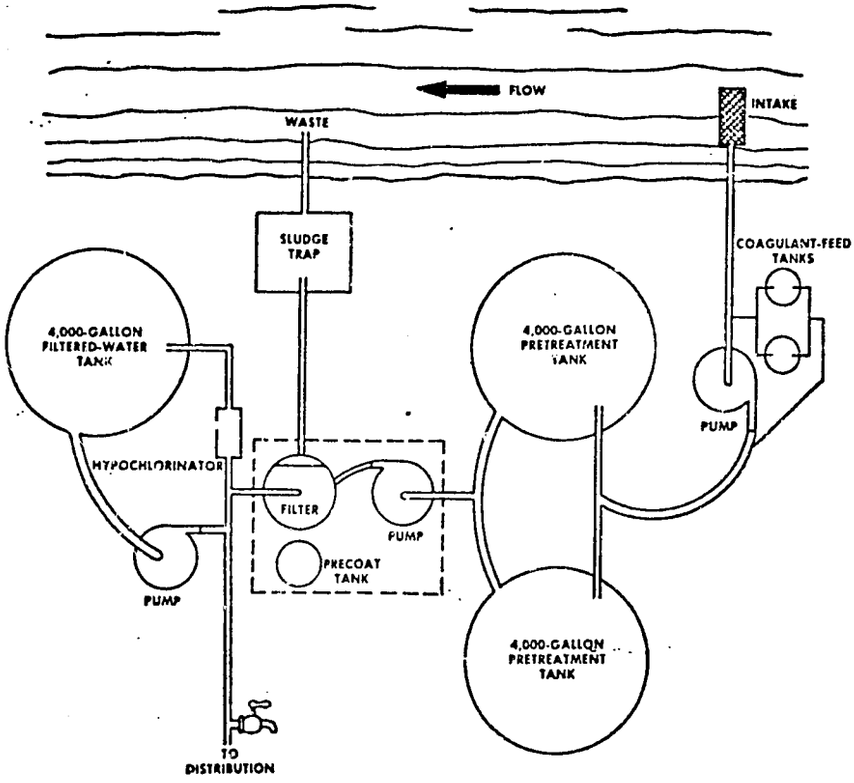


Figure 170.1. (Added.) *Layout for 50-gpm diatomite stationary water purification equipment.*

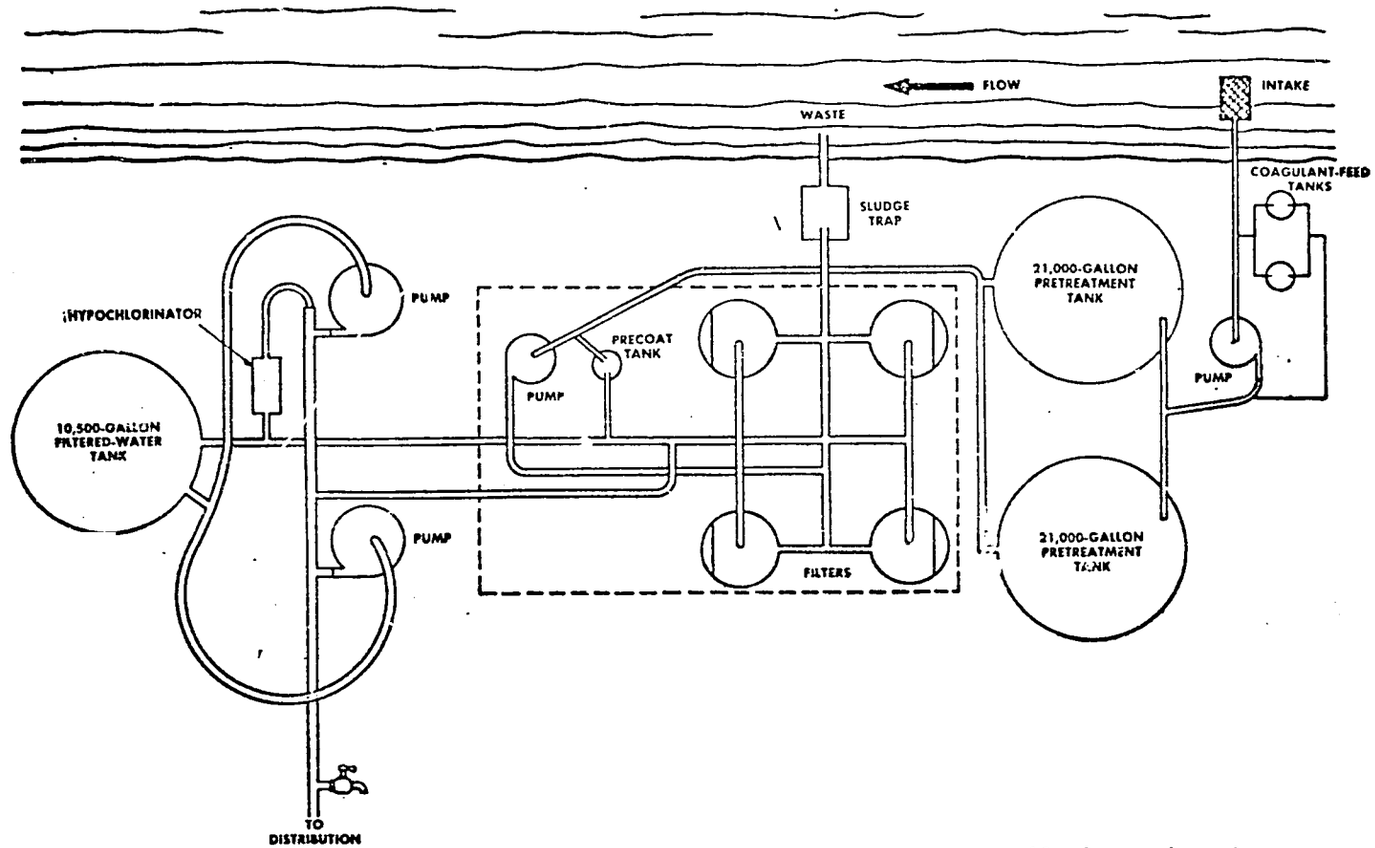


Figure 170.2. (Added.) *Layout for 200-gpm diatomite stationary water purification equipment.*

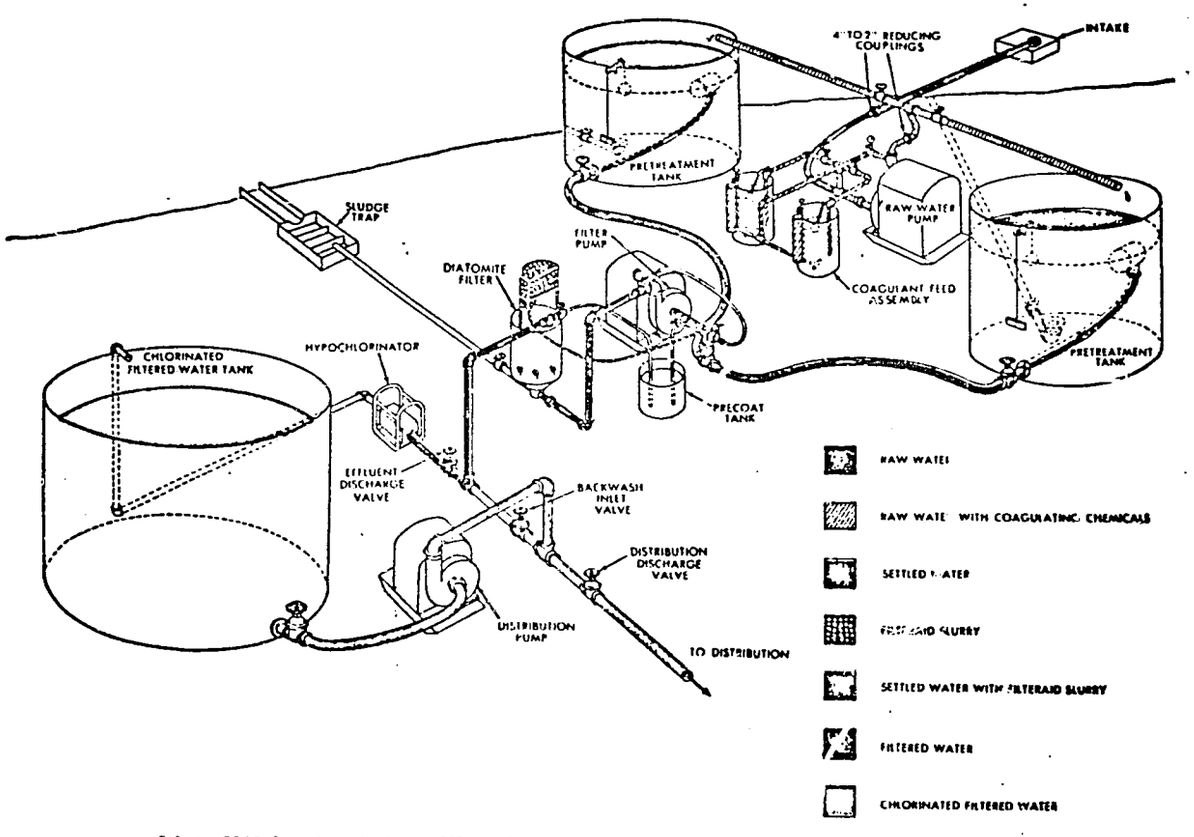


Plate VII.1. (Added.) *Flow diagram of water during production of filtered water in water purification set No. 5.* (*See par. 85.3a.*)

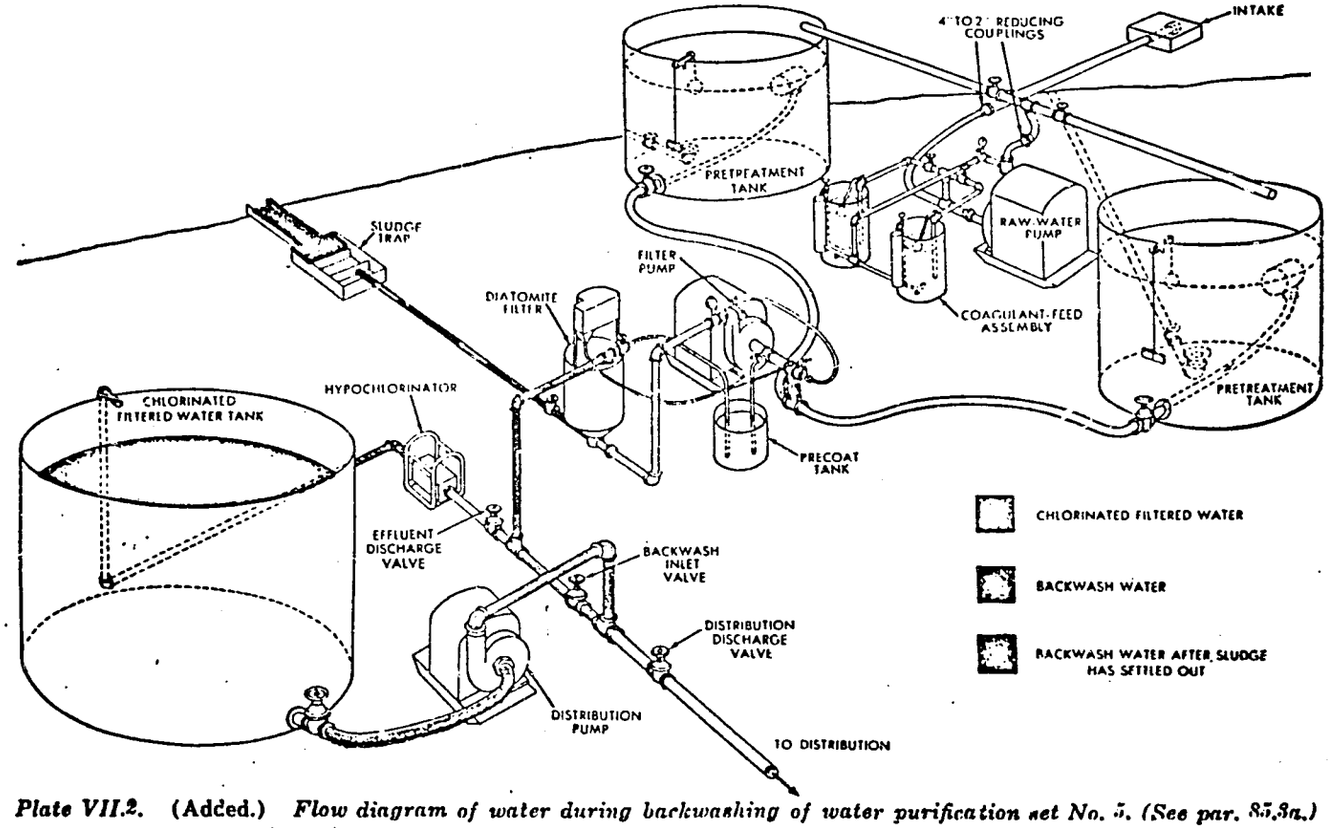


Plate VII.2. **(Added.)** ***Flow diagram of water during backwashing of water purification set No. 5. (See par. 85.3a.)***

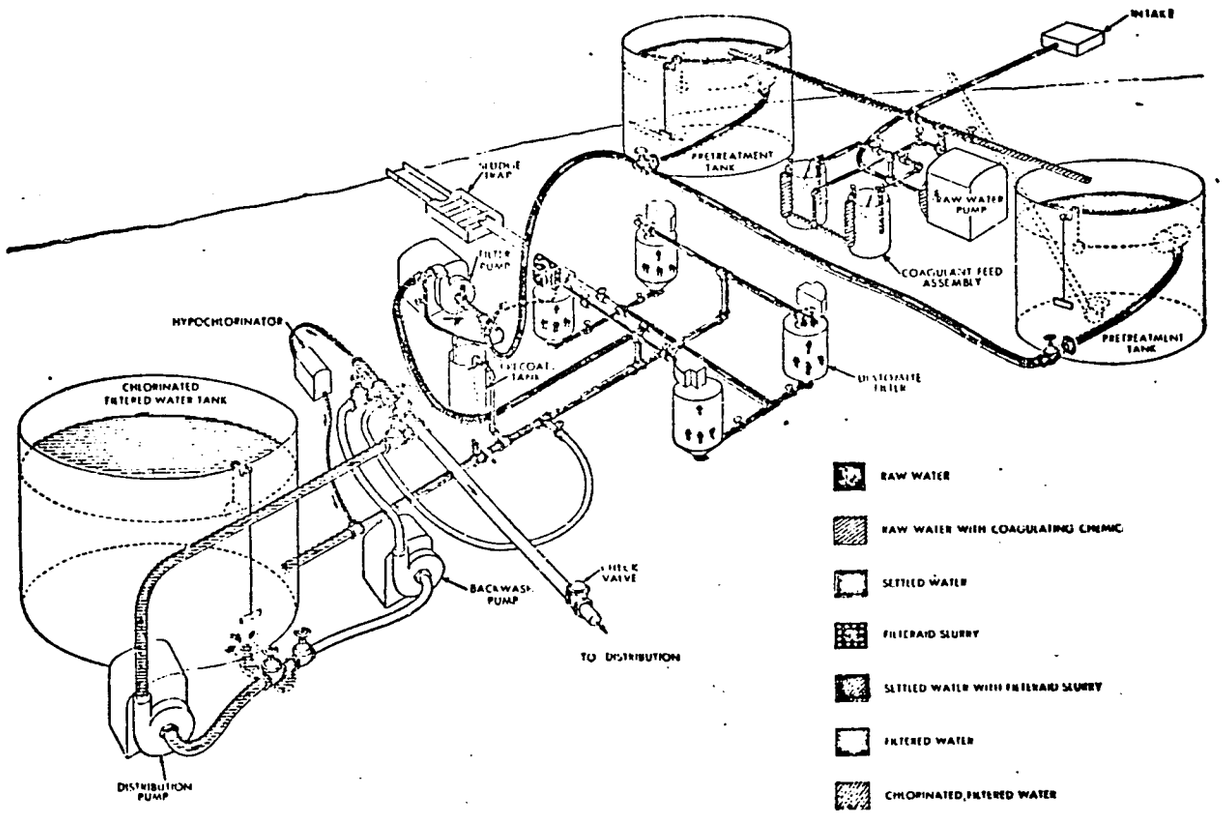


Plate VII.3. (Added.) *Flow diagram of water during production of filtered water in water purification set No. 6. (See par. 85.11a.)*

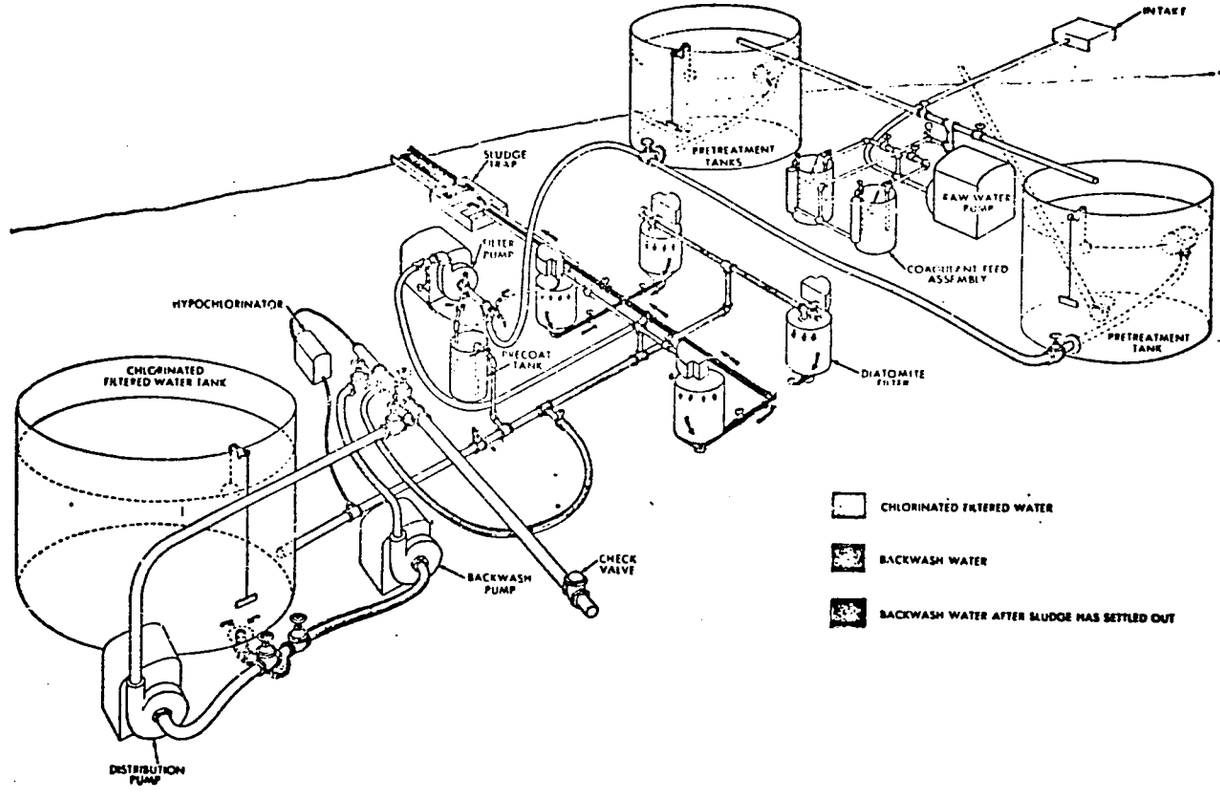
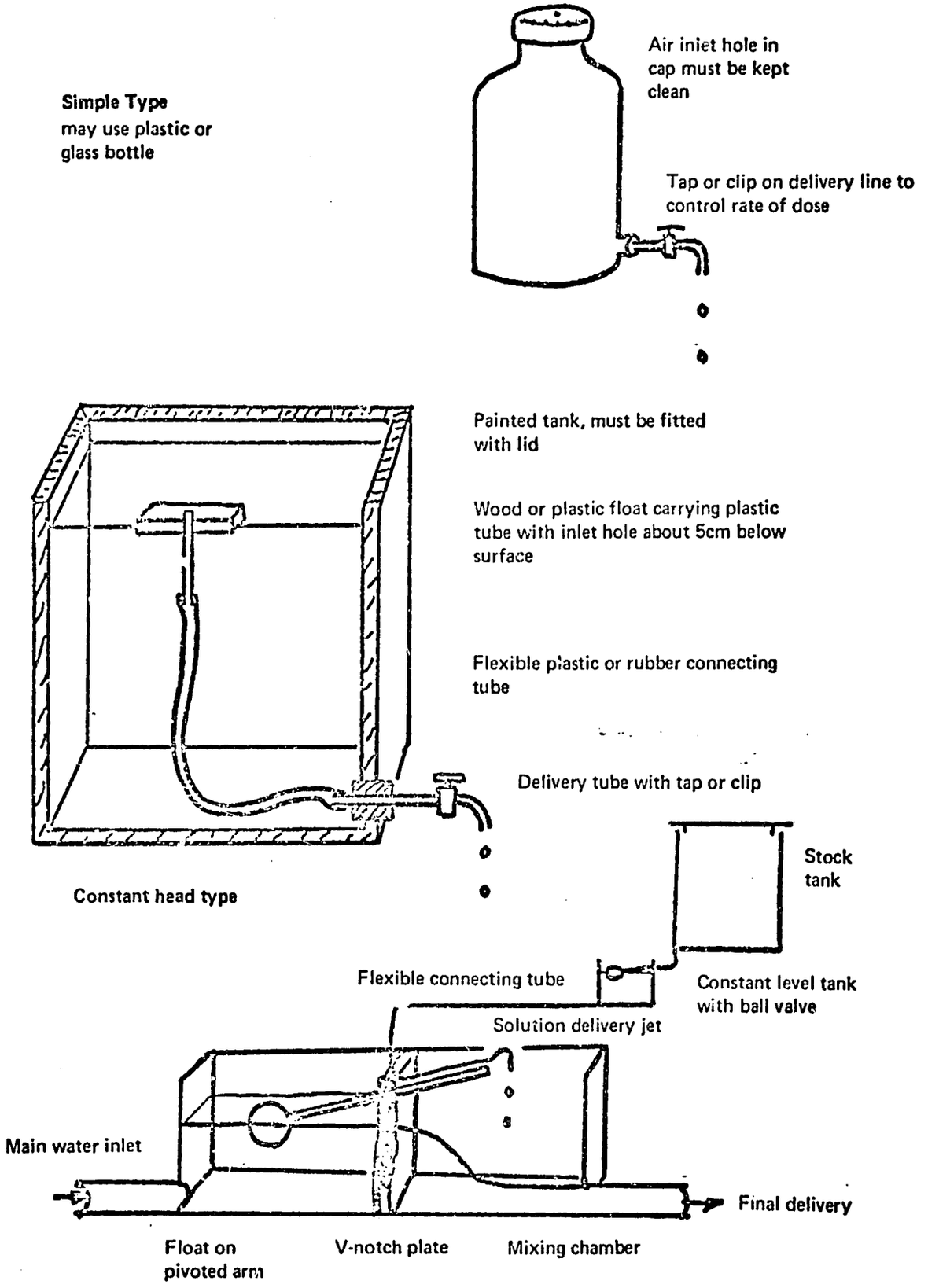


Plate VII.4. (Added.) *Flow diagram of water during backwashing of water purification set No. 6. (See par. 85.11a.)*

Fig. 19. DOSERS FOR SOLUTIONS OF COAGULANTS OR CHLORINE



Variable Head type coupled to V-notch measurement of flow gives a dose rate approximately proportional to flow rate.

FIG. 21. FLOATING BOWL HYPOCHLORINATOR *

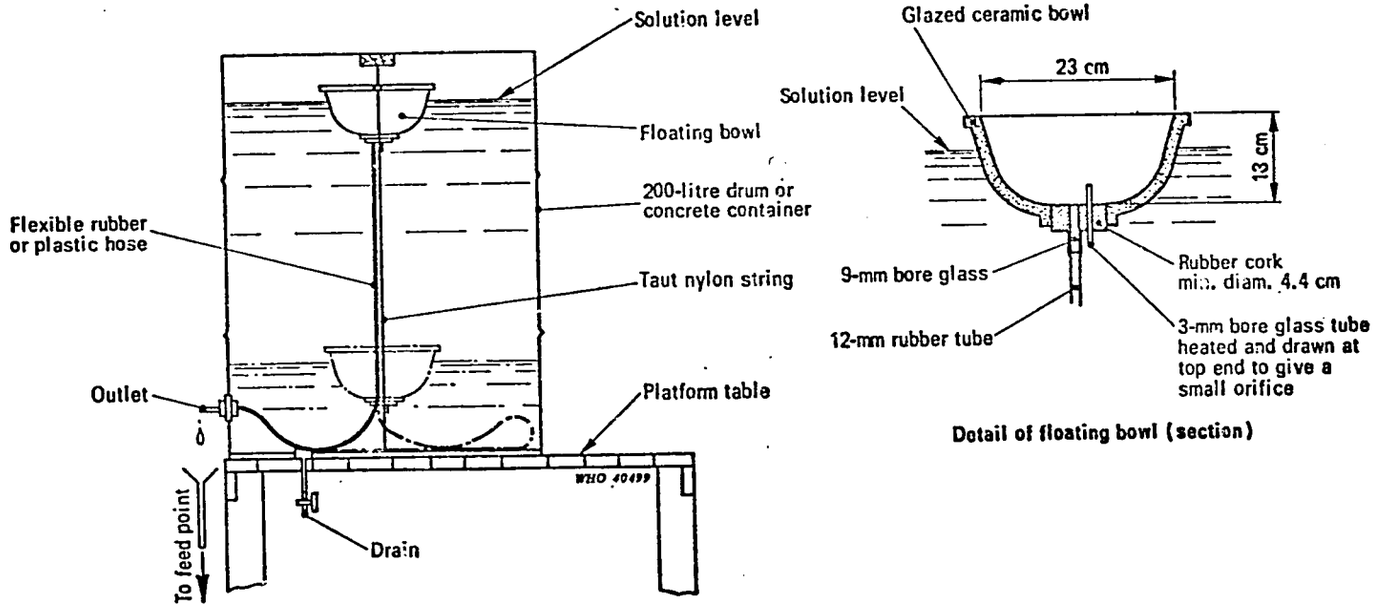
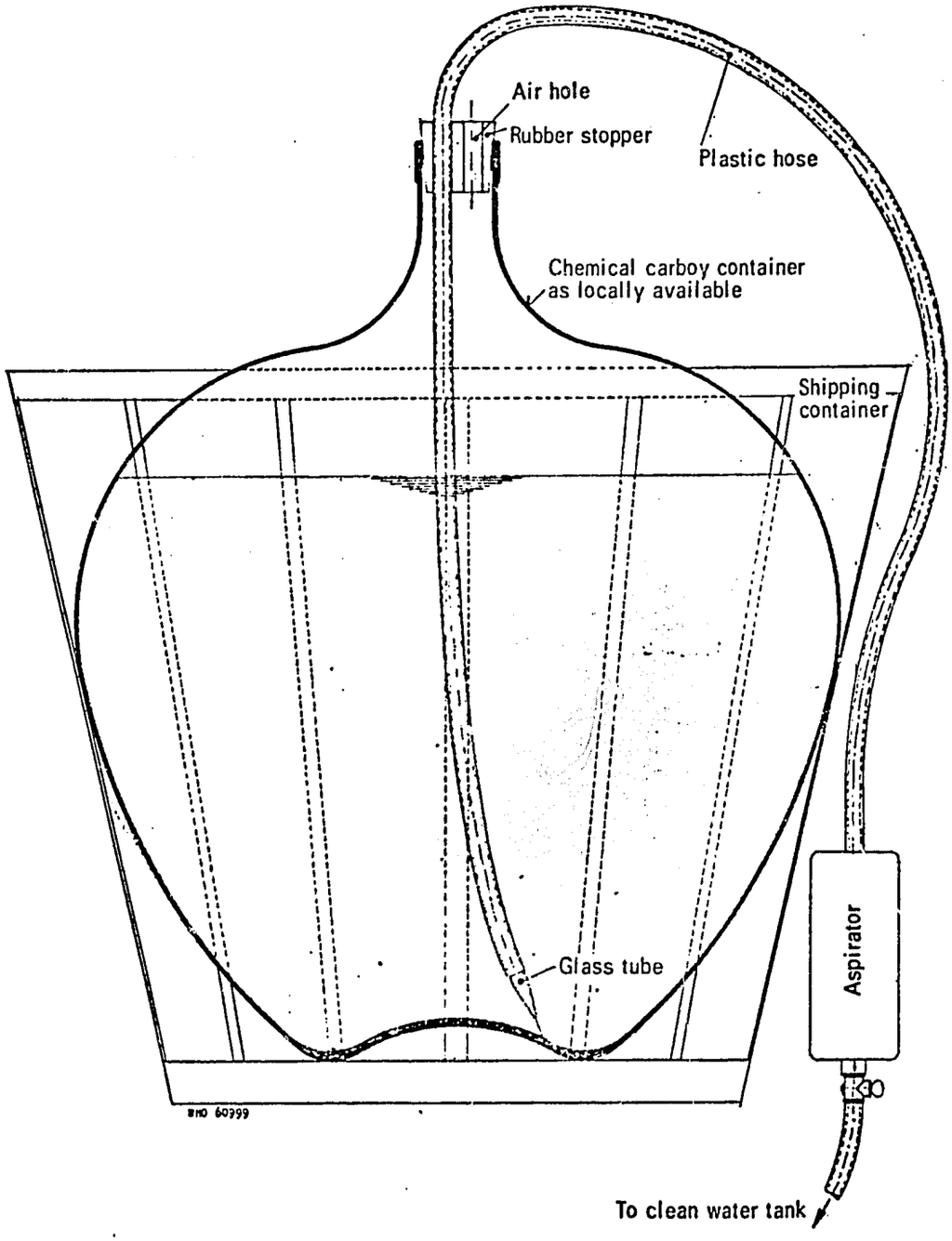
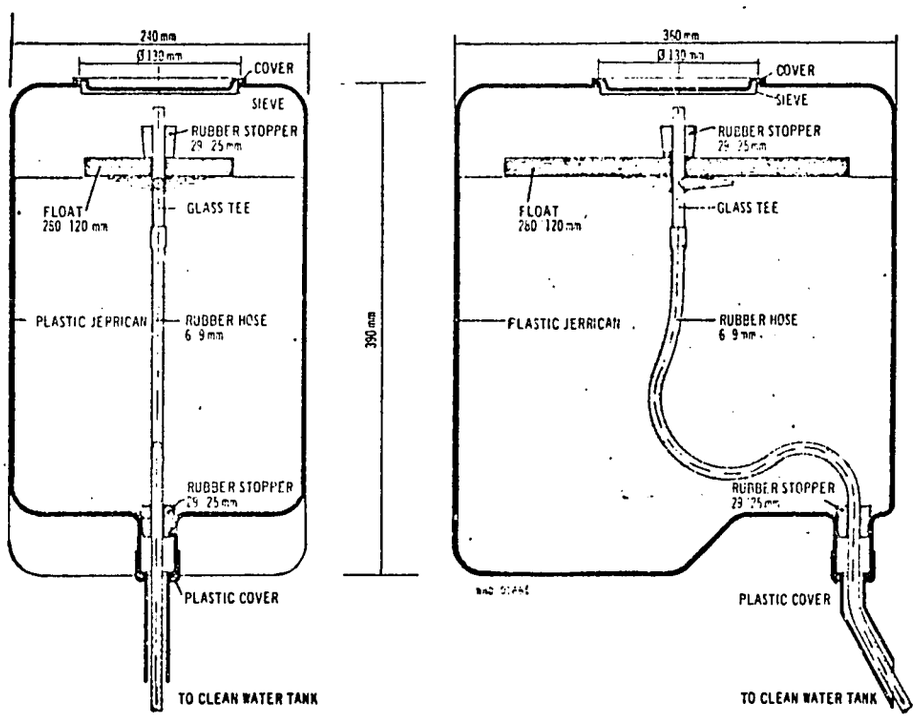


FIG. 22. CARBOY HYPOCHLORINATOR



SANITATION IN NATURAL DISASTERS

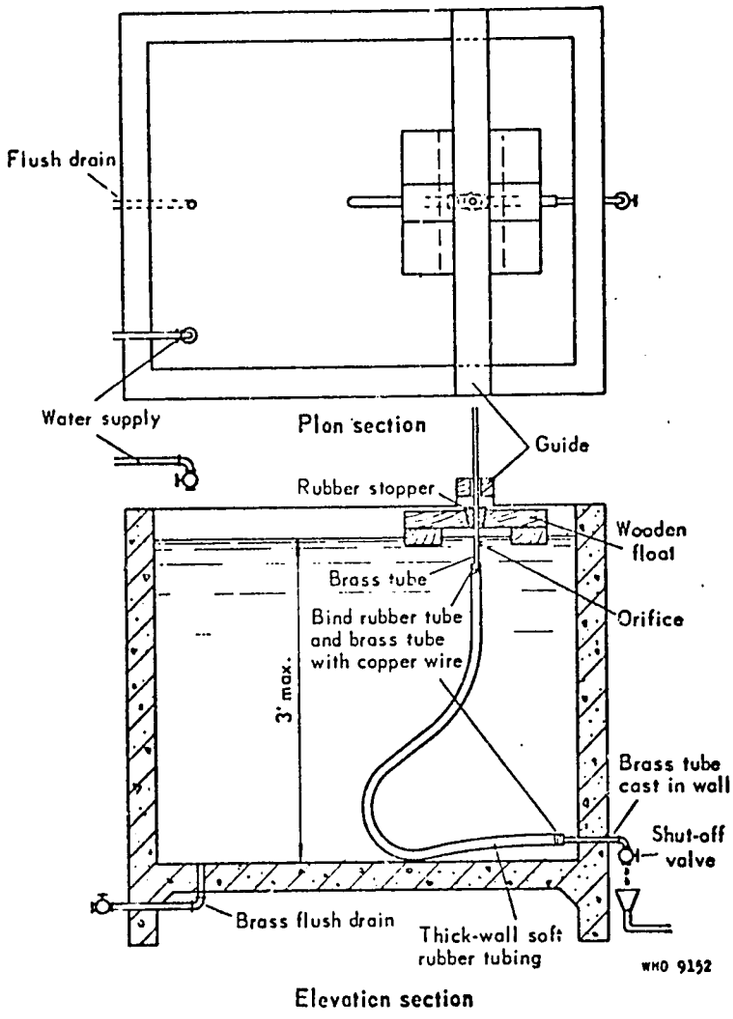
FIG. 15. PLASTIC JERRICAN CHLORINATOR



Auxiliary materials:

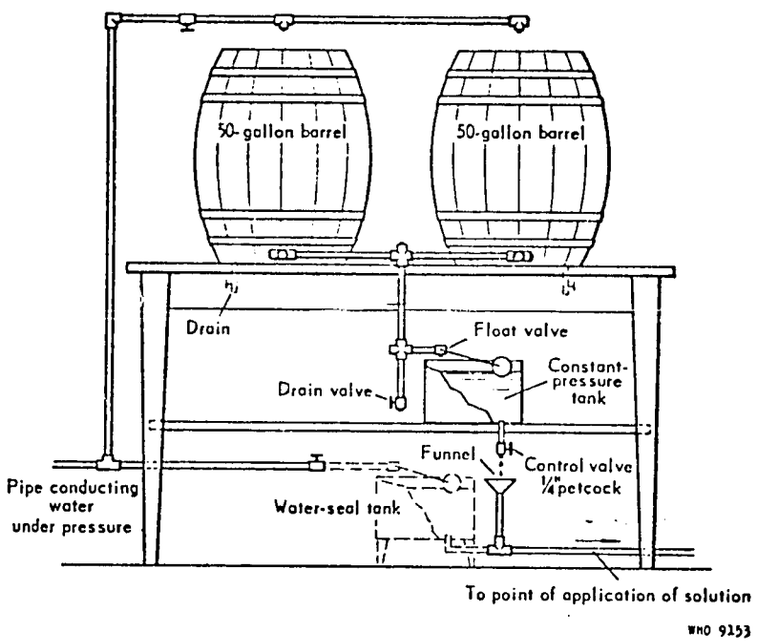
1 plastic funnel
1 measuring cup
1 plastic tube, external diameter 12 mm, internal diameter 9 mm, length as required (about 10 m)
2 plastic 5-litre buckets for preparing chlorine solution

FIG. 13. EQUIPMENT FOR FEEDING HYPOCHLORITE SOLUTION



Reproduced from Bulletin No. 21, New York State Department of Health, USA.
Note: Brass material may be replaced by plastic.

FIG. 14. APPARATUS FOR HYPOCHLORINATION



The water-seal tank and connecting piping are not needed when the solution is discharged into an open conduit, pump well, etc., but must be used when the solution is discharged into the suction side of the pump.

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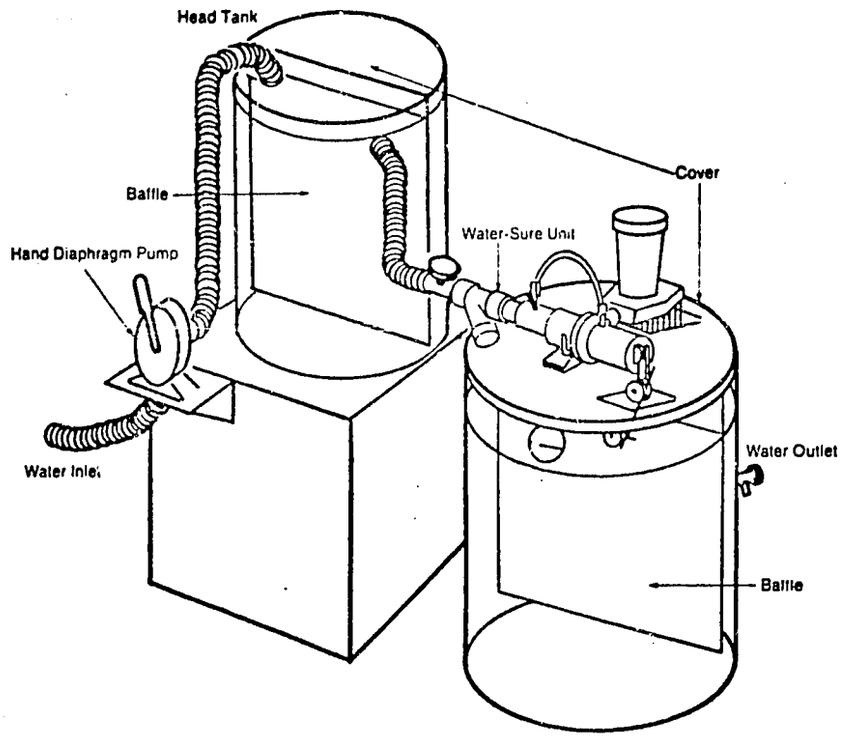
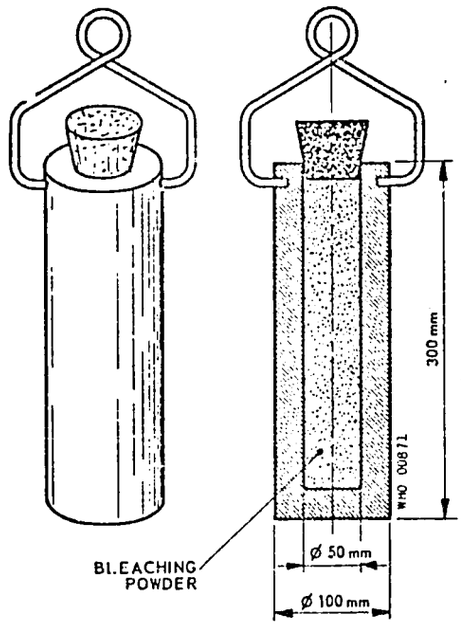


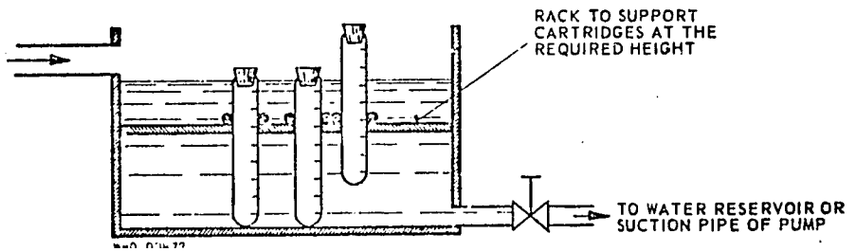
7. Diagrammatic sketch showing the installation of a split-flow erosion type hypochlorinator for field use in a situation lacking electrical power.

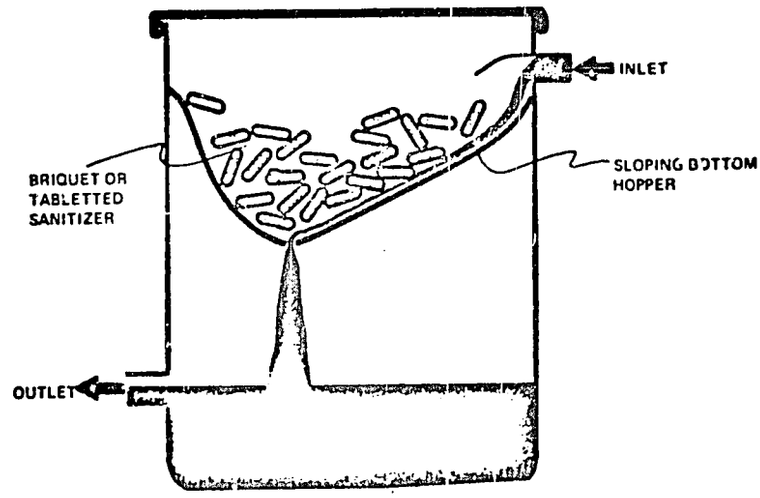
FIG. 16. STANDARD DOSING CARTRIDGE FOR CHLORINATION OF DRINKING-WATER



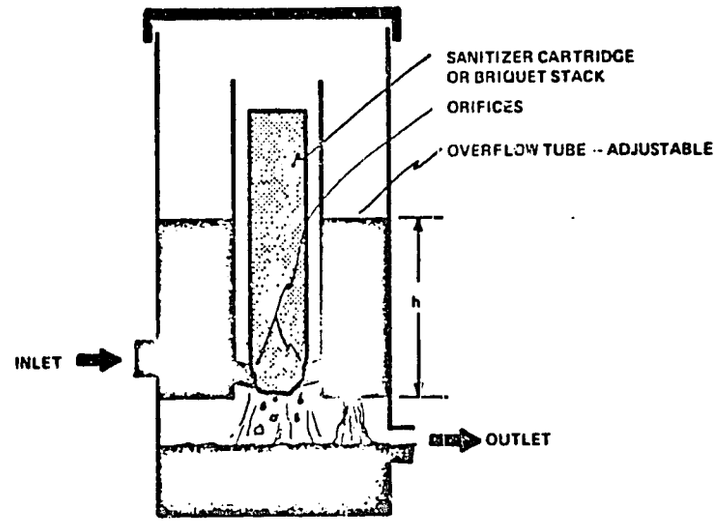
This cartridge has a capacity of 480 g of bleaching powder and an active chlorine release rate of about 40 mg per hour.

FIG. 17. VESSEL WITH DOSING CARTRIDGES FOR CONTINUOUS CHLORINATION

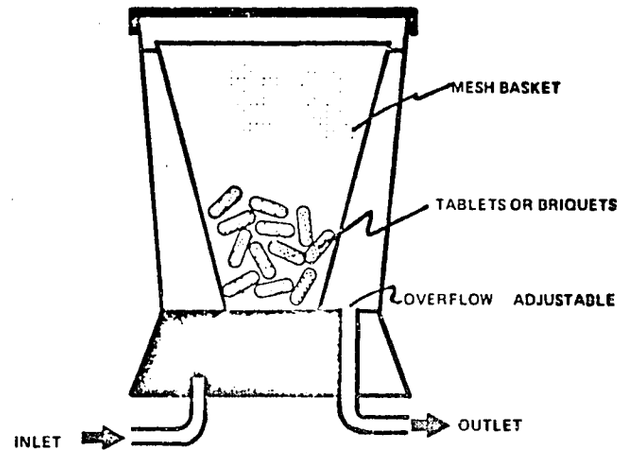




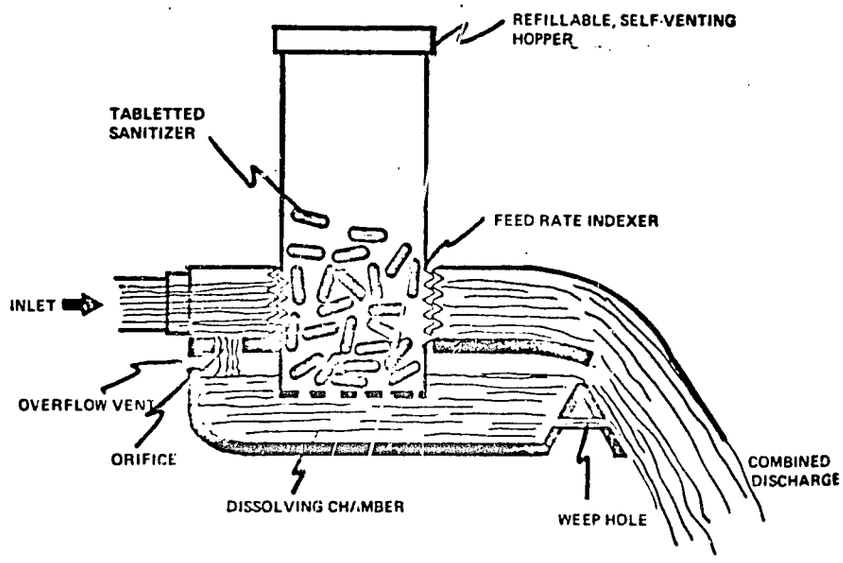
2. Diagrammatic sketch of the sloping bottom type erosion feeder for use with briquets or tablets of a disinfectant.



3. Diagrammatic sketch of the impingement type erosion feeder. The rate of dissolving or erosion is varied by changing the head of water "h" on the eroding stream of water.



4. Diagrammatic sketch of the suspended mesh basket type erosion feeder for use with a disinfectant in the forms of tablets or briquets. Note the adjustable overflow which permits some variation on the rate of chemical application.



5. Diagrammatic sketch of the split-flow type erosion feeder.

TABLE 2. CHEMICALS USED TO COAGULATE WATER OR ADJUST ITS ALKALINITY*

Chemical (common names in parentheses)	Appearance	Use	Emergency sources	Dose grains/gal (mg/l)	Effective pH range	Natural alkalinity required in grains/gal or mg/l to react with one grain/gal or mg/l of coagulant	Artificial alkalinity required in grains/gal or mg/l to react with one grain/gal or mg/l of coagulant			Remarks
							Hydrated lime	Quick lime	Soda ash	
Aluminium sulfate (alum, filter alum, sulfate of alumina)	Light tan to grey-green crystals	Coagulant	Hardware store, fertilizer store or chemist's shop (pharmacy)	0.3–3.0 (5.1–51.0)	4.4–6.0 5.7–8.0 9.0–10.5	0.45	0.35	0.28	0.48	4.4 to 6.0 pH range used for highly coloured water. 5.7 to 8.0 pH range used for turbid and moderately coloured water. 9.0 to 10.5 pH range used in alum coagulation of carbonates in lime-soda softening.
Aluminium ammonium sulfate (ammonia alum)	White crystals	Coagulant	Large swimming pools	0.3–6.0 (5.1–103.0)	5.7–8.0	0.29 approx.	0.23 approx.	0.18 approx.	0.31 approx.	Less soluble than filter alum. Use is generally restricted to swimming pools and pressure filters. Ammonium content is available.

Ferrous sulfate (copperas, iron sulfate, sugar sulfate, green vitriol)	Green to brownish-yellow crystals	Coagulant	Fertilizer store	0.3–3.0 (5.1–51.0)	8.5–11.0	—	0.27	0.22	Not normally used	
Sodium carbonate (soda ash)	White lumps, crystals, or powder	To adjust pH or remove permanent hardness	Hardware store or chemist's shop (pharmacy)	0.1–2.0 (1.7–34.0) for pH adjustment	—	—	—	—	—	Readily soluble.
Calcium hydroxide (slaked lime)	White lumps or powder	To adjust pH or remove carbonate hardness	Fertilizer store	0.1–3.5 (1.7–60.0) for pH adjustment	—	—	—	—	—	Only slightly soluble, so fed as a suspension.
Calcium carbonate (limestone, chalk)	White lumps	To adjust pH	Fertilizer store	0.1–3.5 (1.7–60.0)	—	—	—	—	—	Must be crushed to powder before use.
Sodium hydroxide (caustic soda, lye)	White flakes	To adjust pH	Grocery store, hardware store	0.1–2.0 (1.7–34.0)	—	—	—	—	—	Readily soluble and very corrosive.

* Adapted from: US Department of Health, Education and Welfare (1961) *Health mobilization course manual*, Washington, D.C.

FARM LAYOUT
WATER SUPPLY PROBLEM

Figure 2

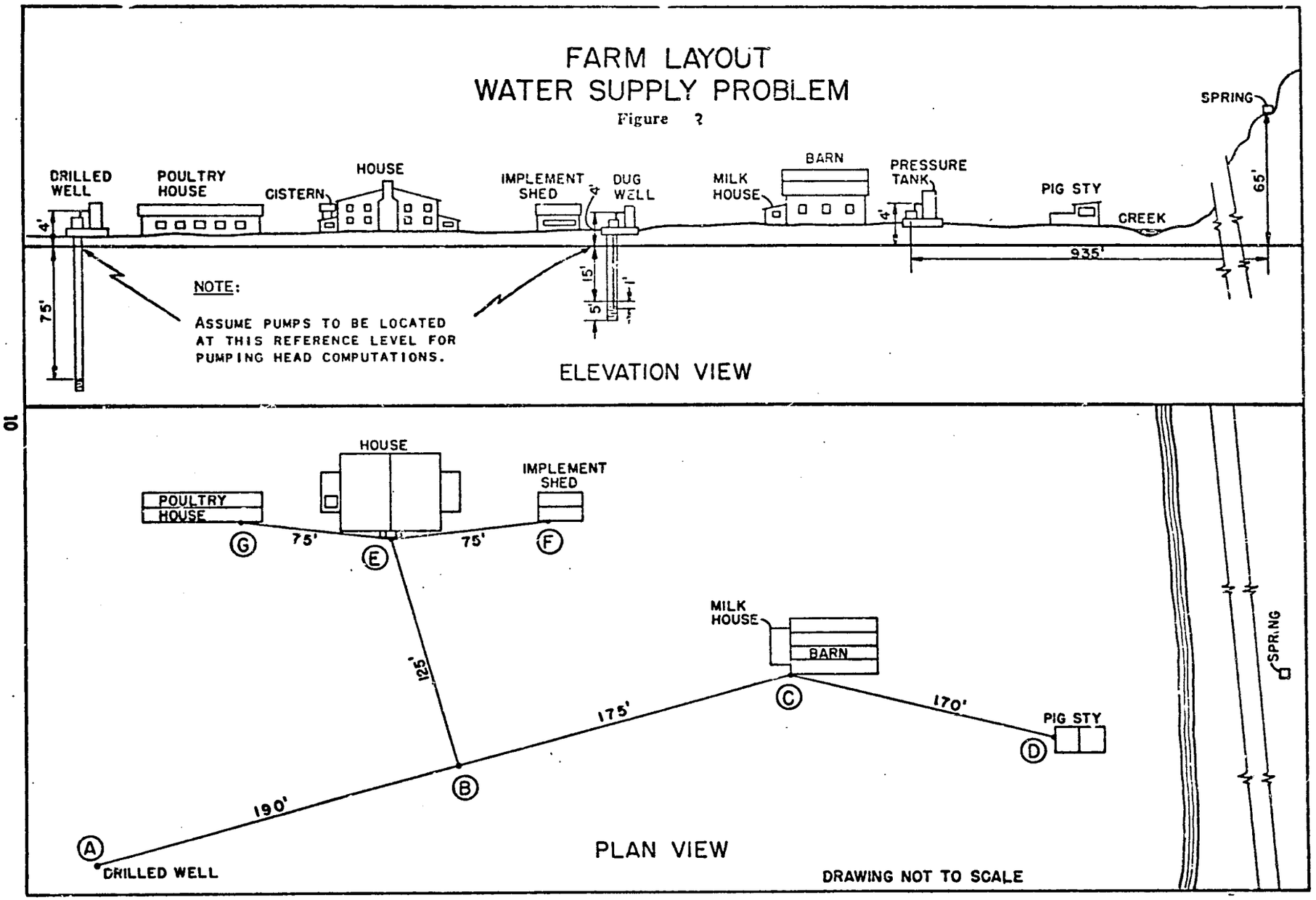


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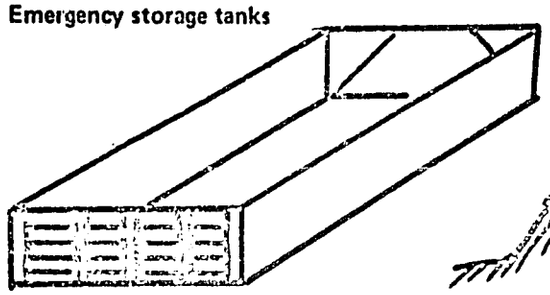
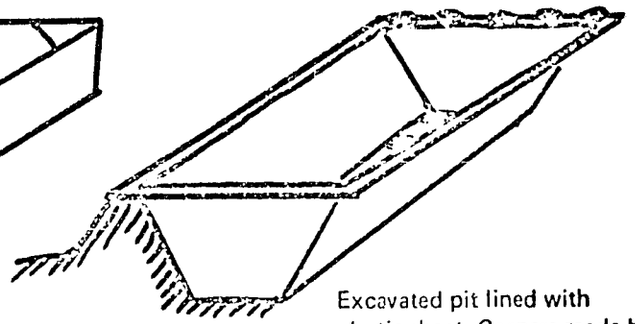
Fig. 38. WATER TREATMENT FOR EMERGENCIES

Emergency storage tanks



Wooden sides with uprights at 1 m spacing or less, lined with plastic sheet.
Maximum water depth 1 m

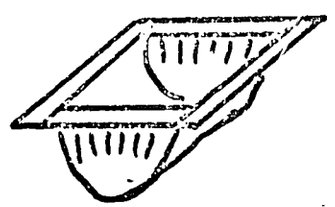


Excavated pit lined with plastic sheet. Corners made by folding. Stones or sacks of earth on bottom and rim maintain shape.

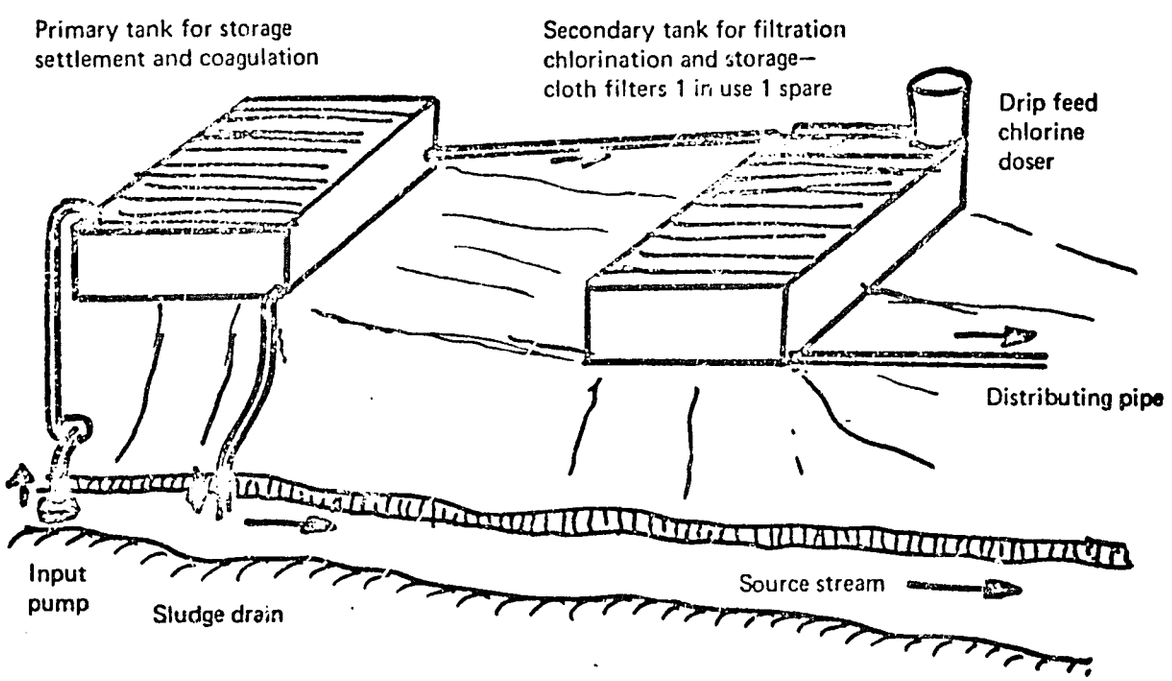
Length of plastic tube (lay flat) laid between earth banks to support upturned ends.

Cloth filter

Wooden frame supporting 2 or 3 layers of cloth without joints or seams.
Removes suspended matter only.



Emergency supply layout



All tanks should be covered. Plastic sheet will suffice.

Solar distillation should be considered a possible method for water-supply under the following circumstances:

(a) Natural fresh water is not available and saline water is available;

(b) The climate is good (i.e., the solar radiation levels are high);

(c) The potable water needs for the community or user are below about 50,000 gpd;

(d) Reasonably level land is available for solar-still sites

(e) Such land is in isolated locations where inexpensive power and highly trained manpower are not always available.

Figure 2. Schematic cross-section of basin-type solar still

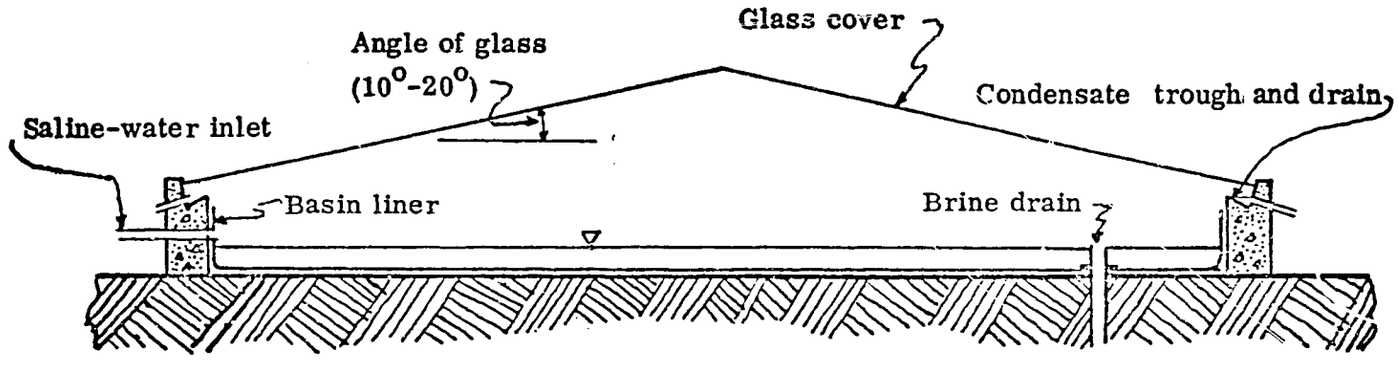


Figure 3. Schematic diagram of solar distillation plant, showing major items of equipment

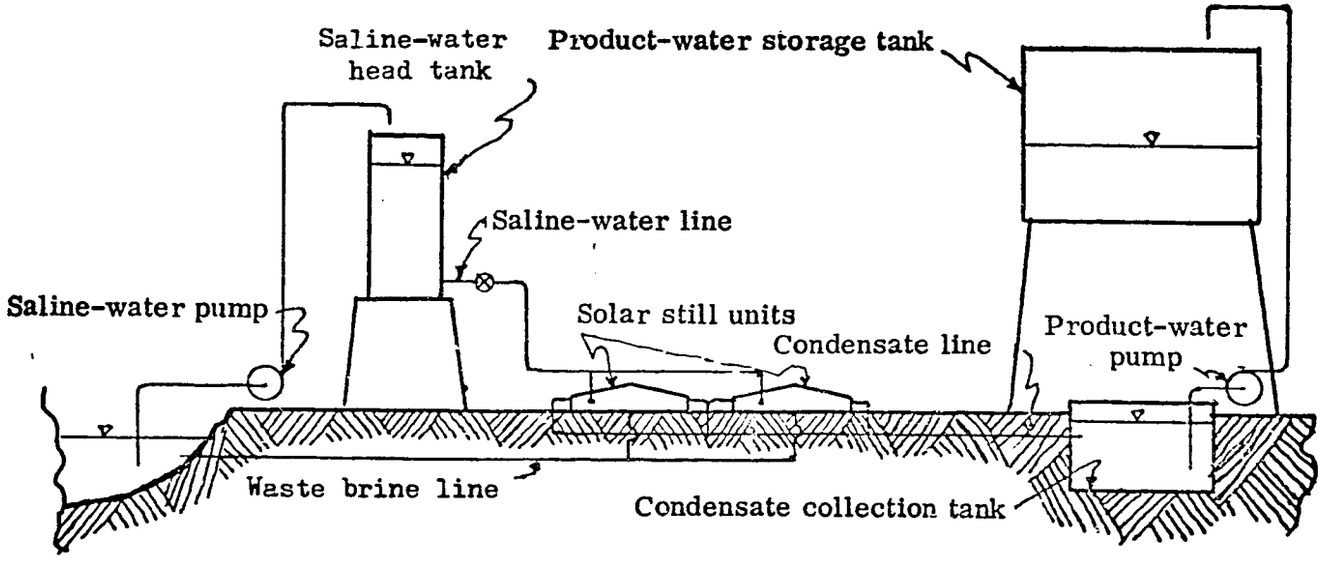
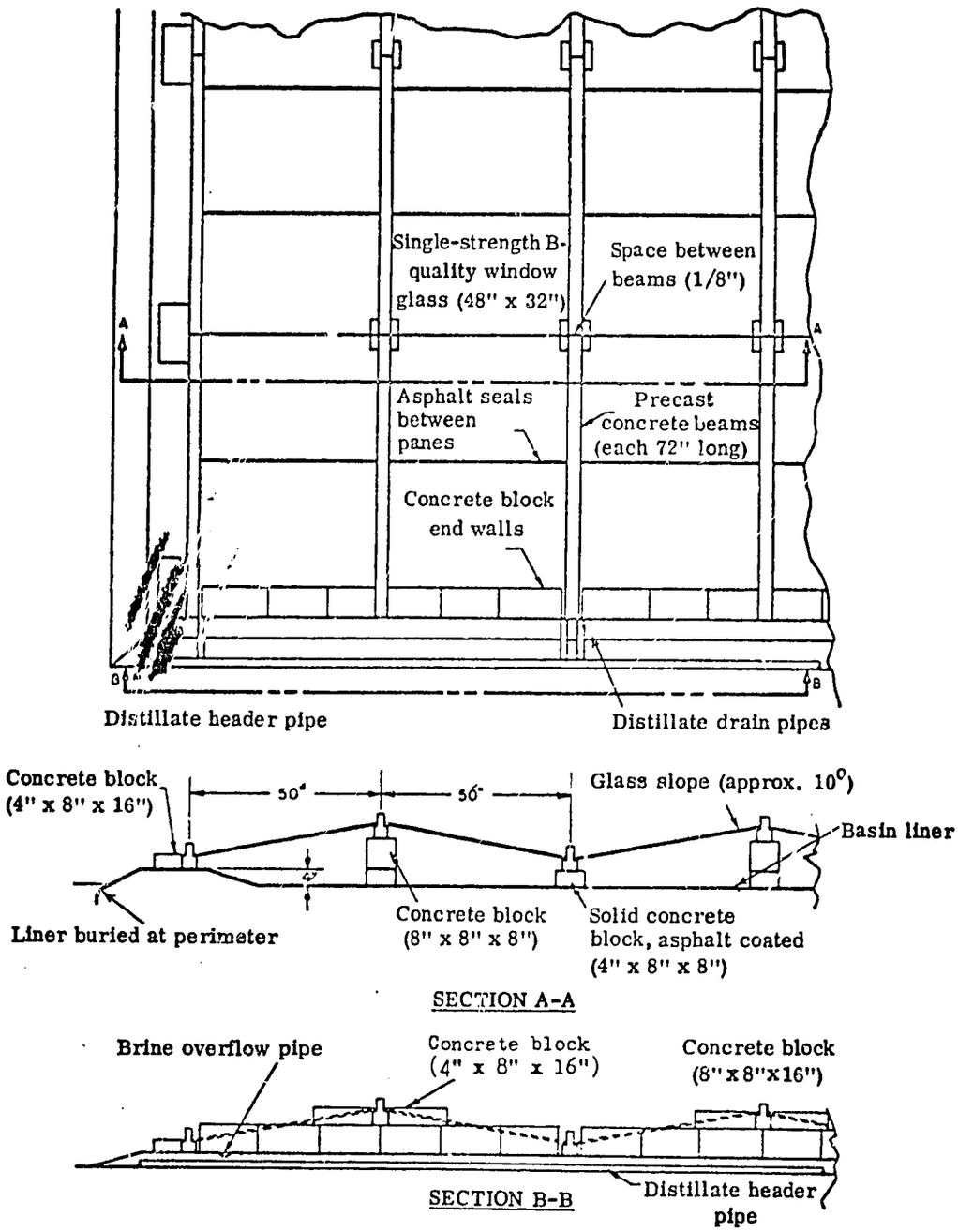
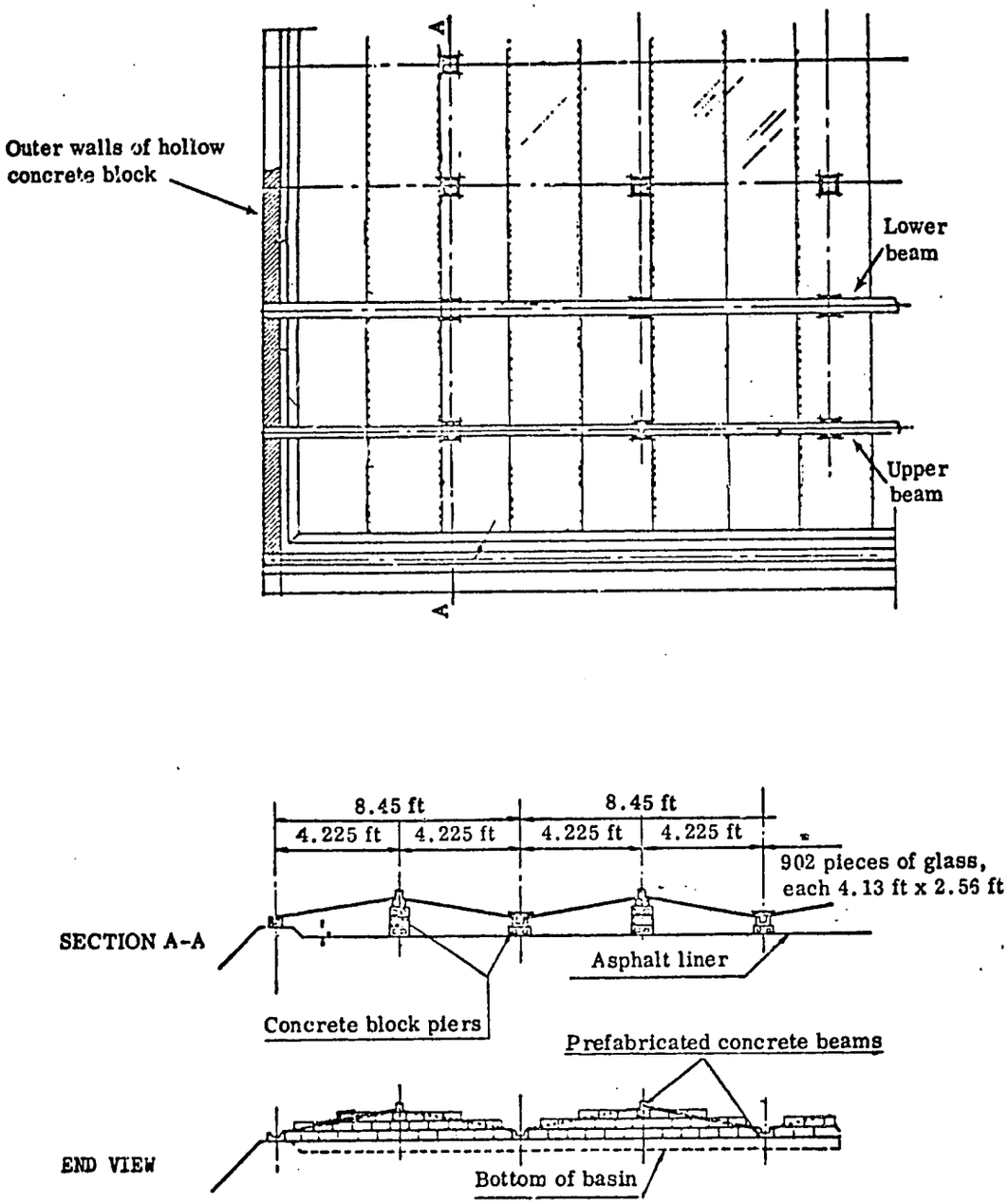


Figure 4. Plan and sections of basin-type solar still, Daytona Beach, United States of America



Source: Battelle Memorial Institute, Design of a Basin-Type Solar Still, Office of Saline Water Research and Development Report No. 112 (Washington, D.C., United States Department of the Interior, 1964).

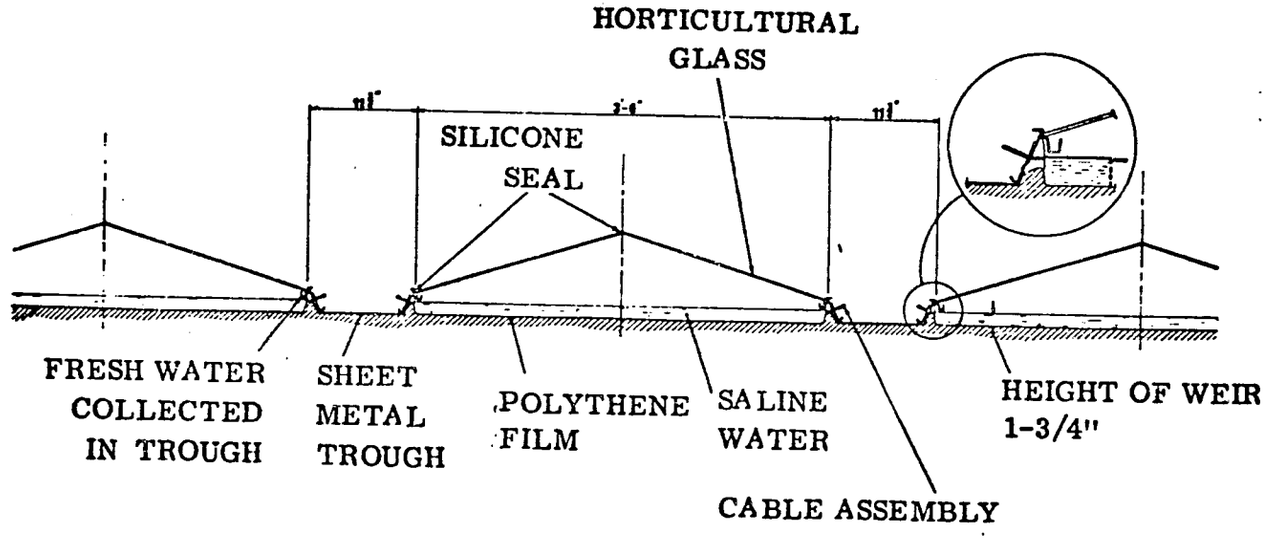
Figure 6. Plan and sections of solar still, Las Marinas, Spain



Sources: P. Blanco, C. Gomella and J.A. Barasoain, Installation Pilote de Potabilisation Solaire de "Las Marinas" (Espagne), Coopération Mediterranéen pour L'Energie Solaire Bulletin No. 9 (Marseilles, France, 1965); P. Blanco, C. Gomella and J.A. Barasoain, Installation de Potabilisation d'eau de mer et d'eau saumatre à Las Marinas (Almeria), Coopération Mediterranéen pour L'Energie Solaire Bulletin No. 11 (Marseilles, France, 1966); P. Blanco, C. Gomella and J.A. Barasoain, Projet de Distillateur Solaire pour l'Ile de Neuva Tabarca (Alicante), Coopération Mediterranéen pour L'Energie Solaire Bulletin No. 12 (Marseilles, France, 1967).

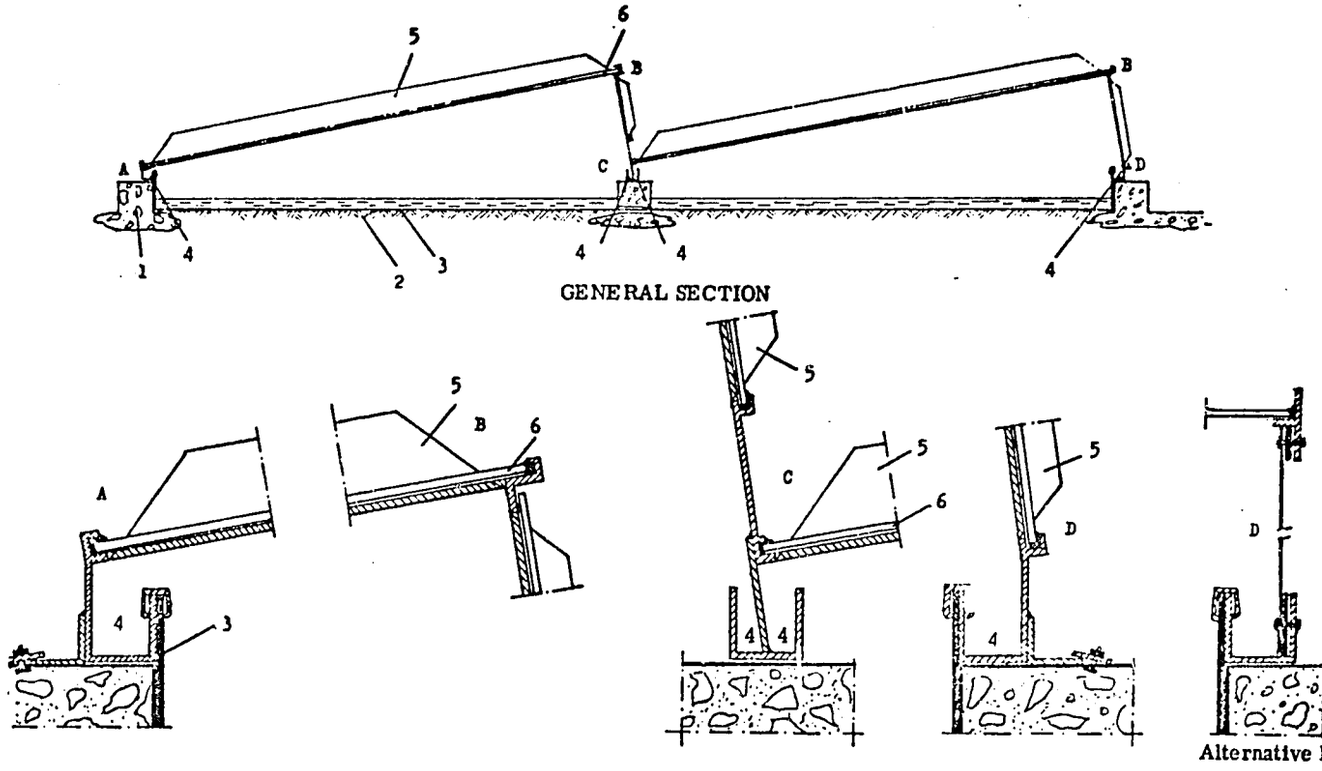
Note: There are eleven upper glass-support beams and ten lower glass-support beams, each mounted on fifteen concrete block piers.

Figure 8. Section of basin-type solar still, Commonwealth Scientific and Industrial Research Organization, Australia



Source: R.N. Morse and W.R.W. Read, "The development of a solar still for Australian conditions", Proceedings of the Conference on Power Production and Energy Conversion, 1966 (Sydney, Australia, Institution of Engineers, 29-30 November 1966).

Figure 9. Section and frame details of basin-type solar still, Technical University of Athens, Greece

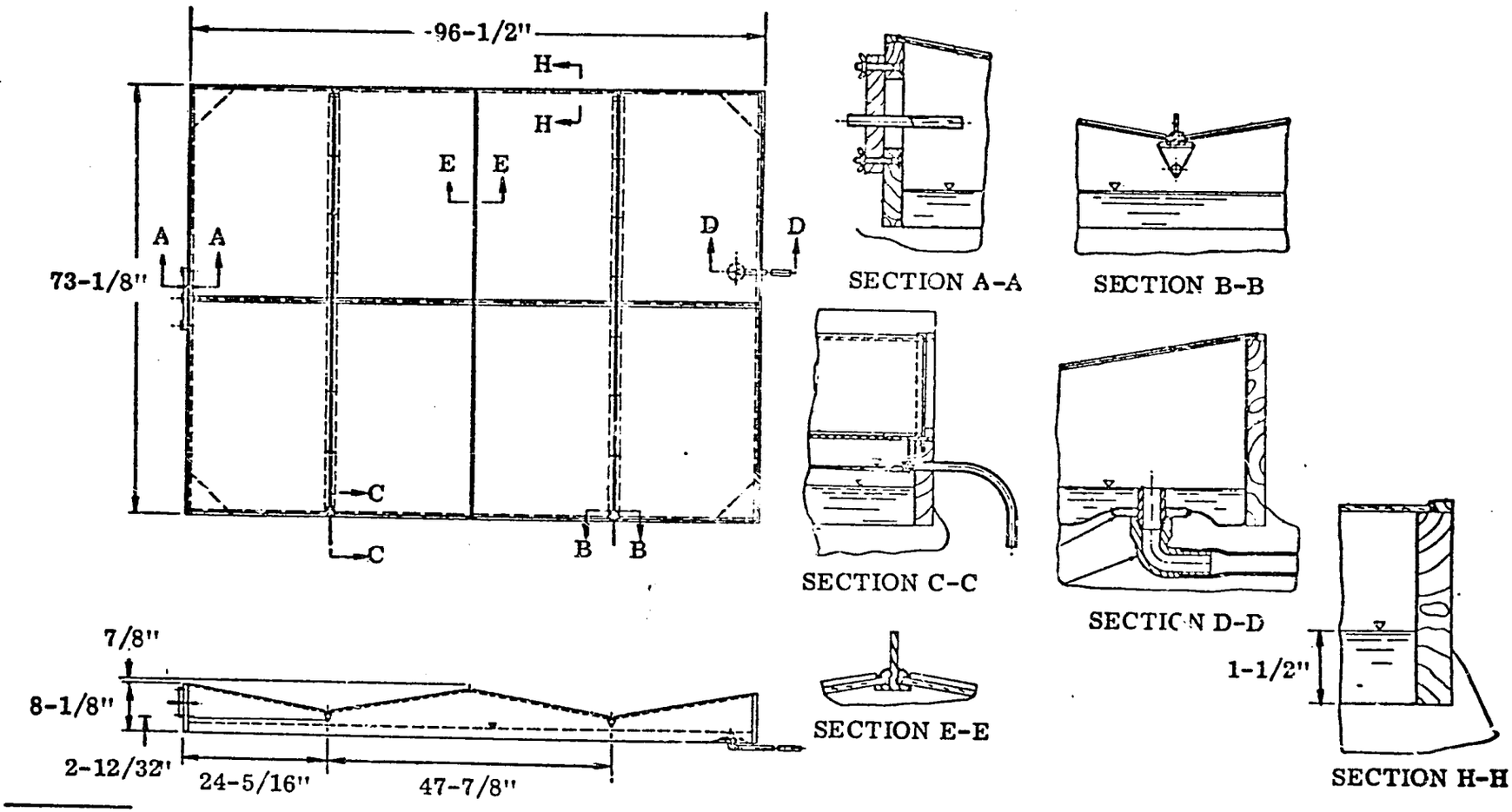


Sources: Battelle Memorial Institute, Second Two Years, Progress on Study and Field Evaluation of Solar Sea Water Stills, Office of Saline Water Research and Development Progress Report No. 147 (Washington, United States Department of the Interior, 1965); A.A. Delyannis and E. Piperoglou, "Solar distillation in Greece", Proceedings of the First International Symposium on Water Desalination (Washington, United States Department of the Interior, 3-9 October 1965), vol. 2, pp. 627-640.

Key:

1. Concrete frame
2. Sand layer for levelling and insulation
3. Butyl rubber sheeting
4. Distillate collection gutters
5. Aluminium frame
6. Glass covers

Figure 10. Schematic design for demonstration unit, small-scale basin-type solar still, for use on Pacific Islands



Sources: G. Nebbia, Researches in the University of Bari (Italy), Coopération Mediterranéen pour L'Energie Solaire Bulletin No. 5 (Marseilles, France, 1963); E.D. Howe, B.W. Tleimat and A.D.K. Laird, Solar Distillation, Sea Water Conversion Laboratory Report 67-2 (Berkeley, University of California, 1967).

Figure 11. Schematic sections of plastic-covered basin-type solar stills

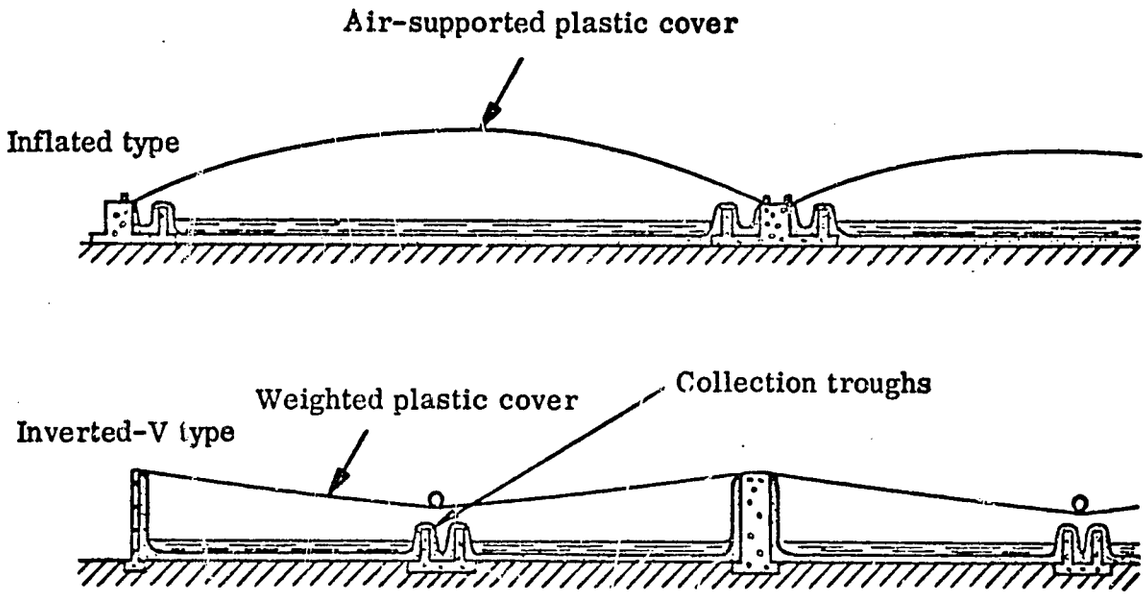
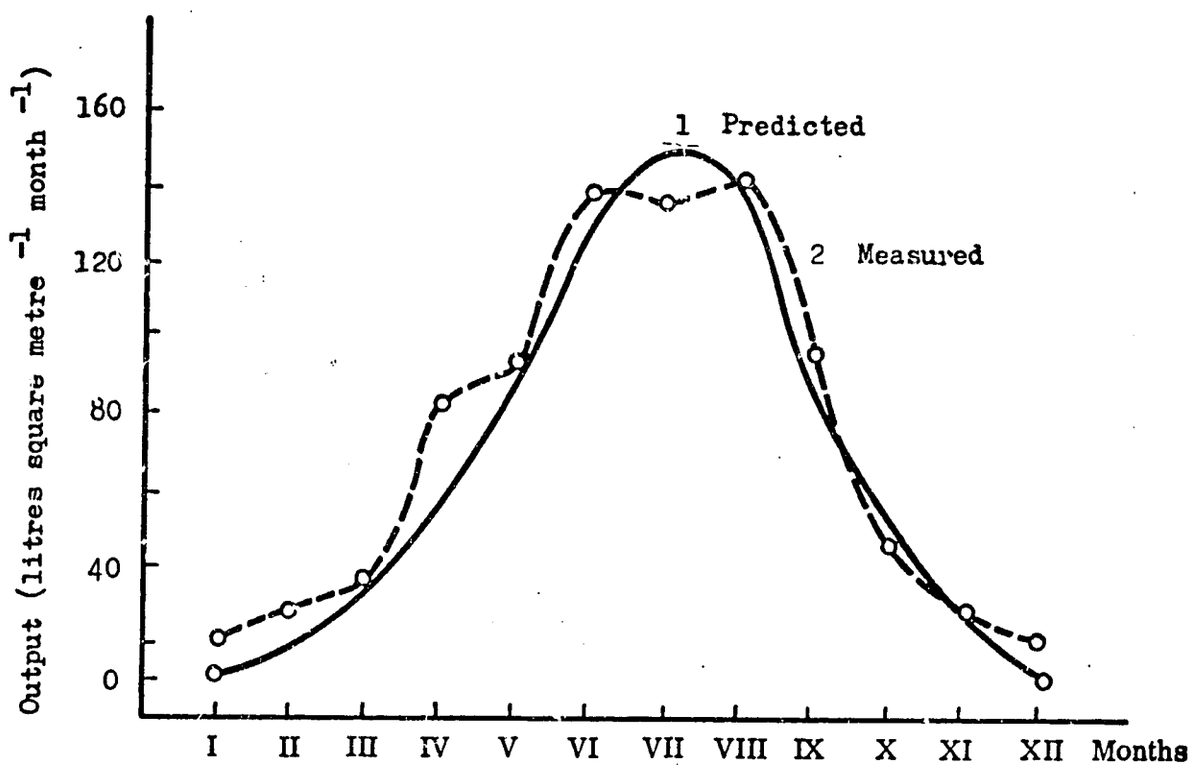


Figure 16. Comparison of results of extended tests of capacity of basin-type solar stills with results obtained from calculations



Note: Curve 1 - results of tests
Curve 2 - results obtained from calculations

Figure 18. Compression-distillation unit using electric energy from solar power plant

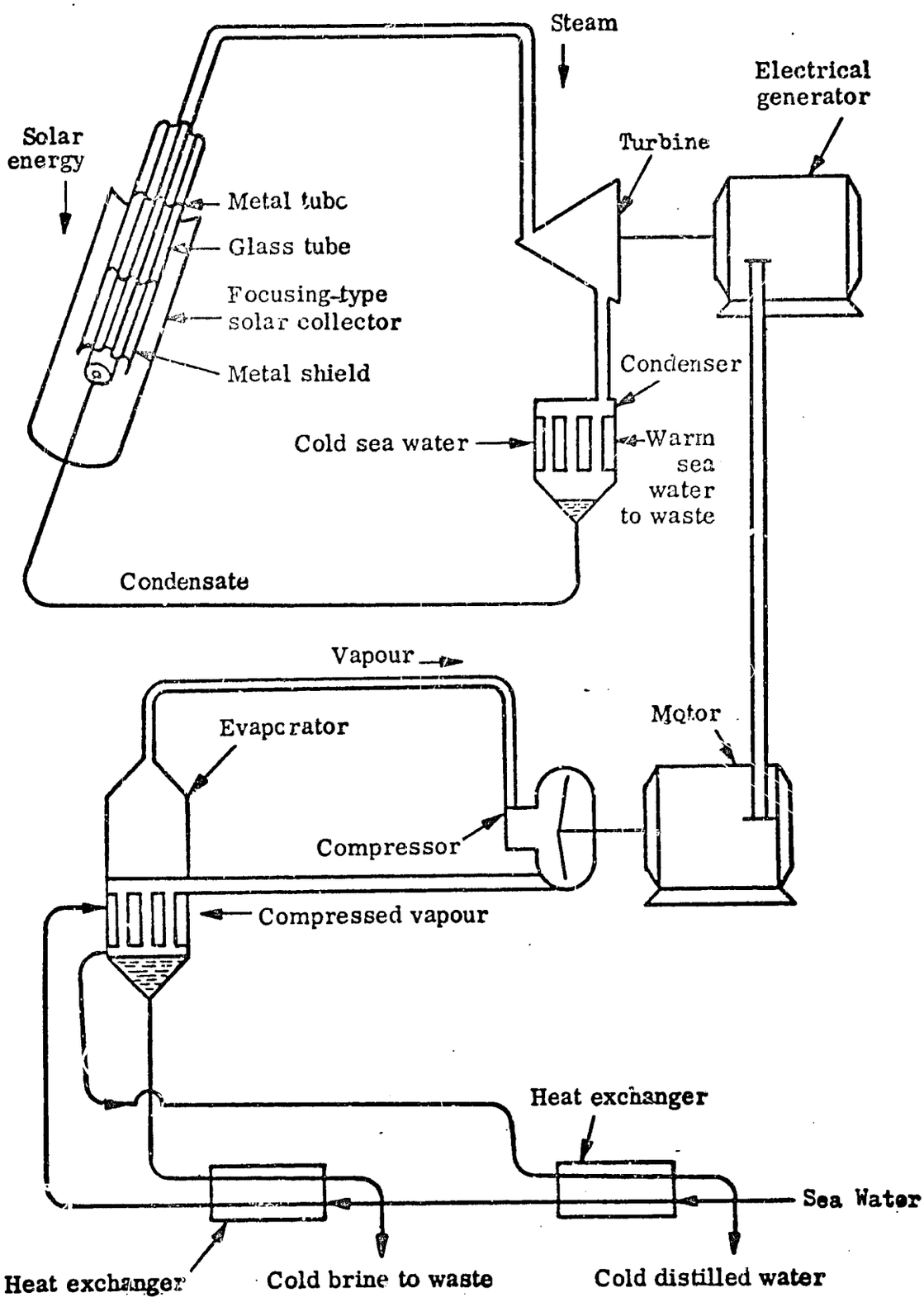
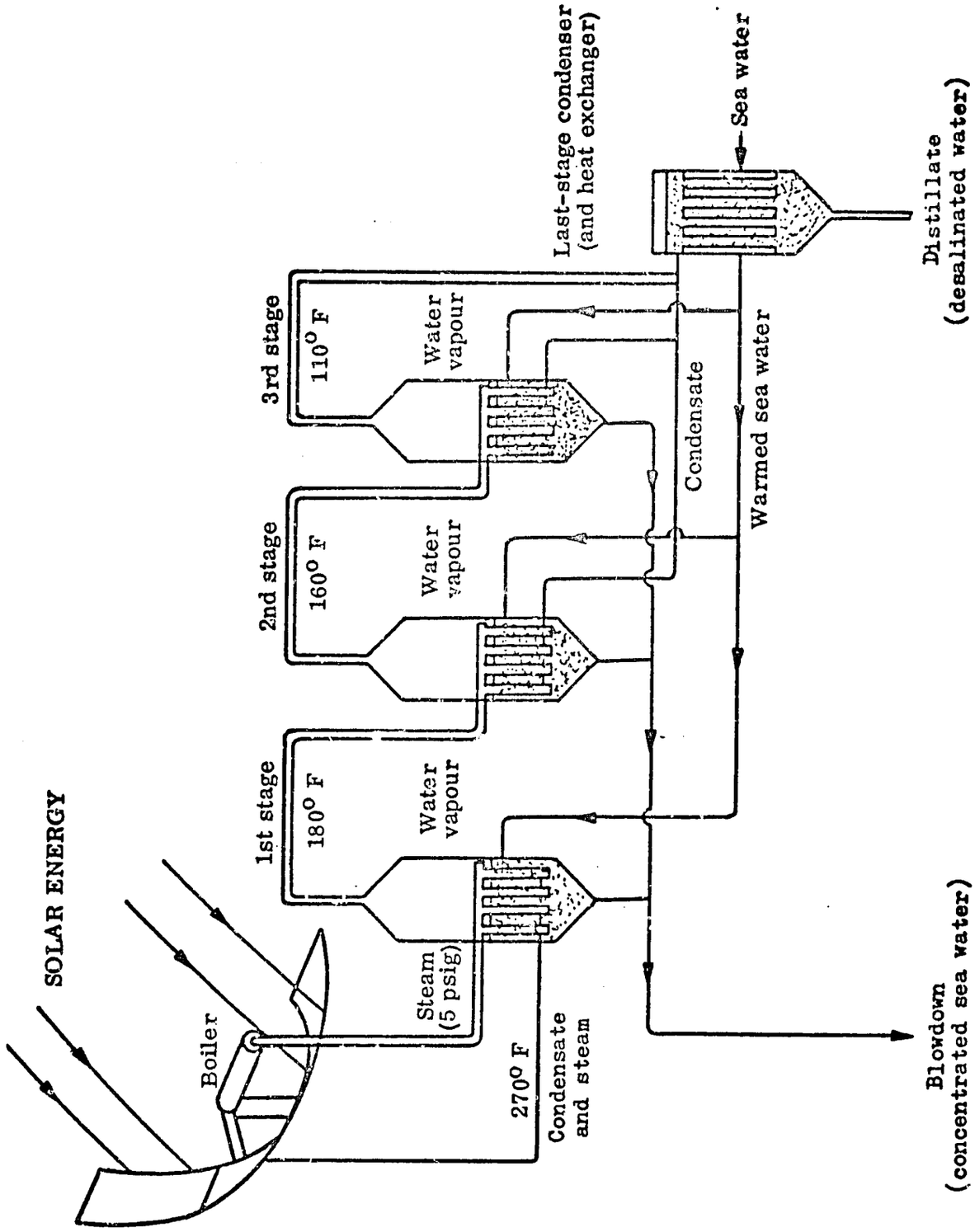


Figure 19. Multiple-effect evaporator heated by steam from focusing solar collector



Source: J.W. Bloemer et al., "A practical basin-type solar still", Solar Energy (United States of America), No. 9, 1965, p. 197.

Figure 20. Multiple-effect evaporator heated by steam from flat-plate collector

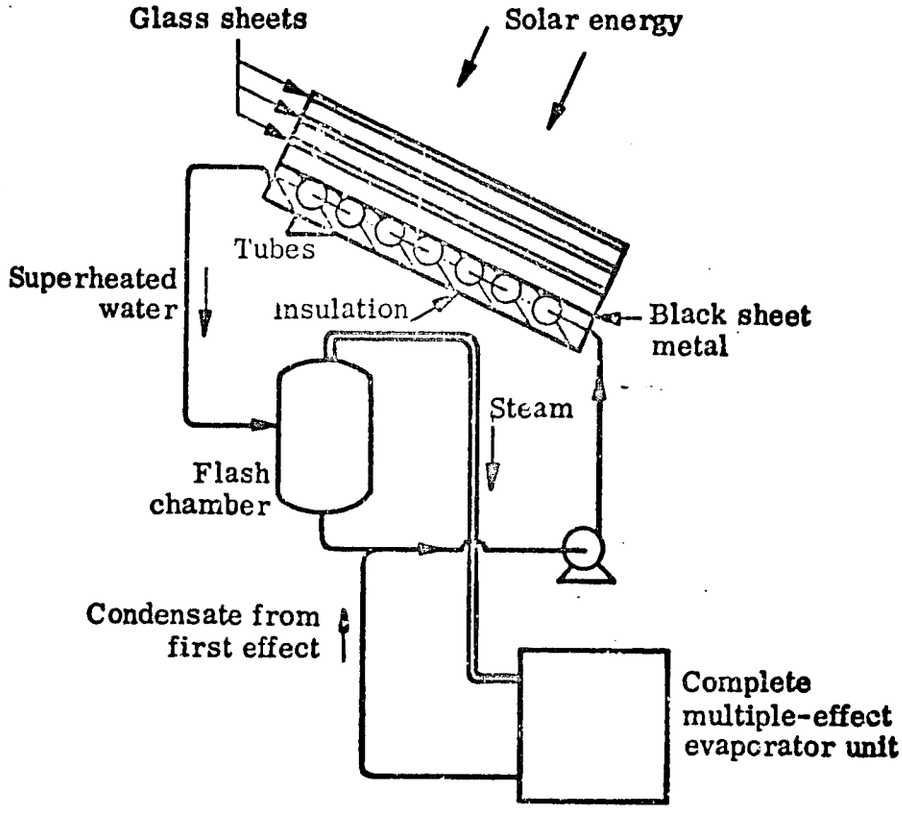


Figure 21. Multiple-effect solar still employing glass covers and copper condenser-evaporator plates

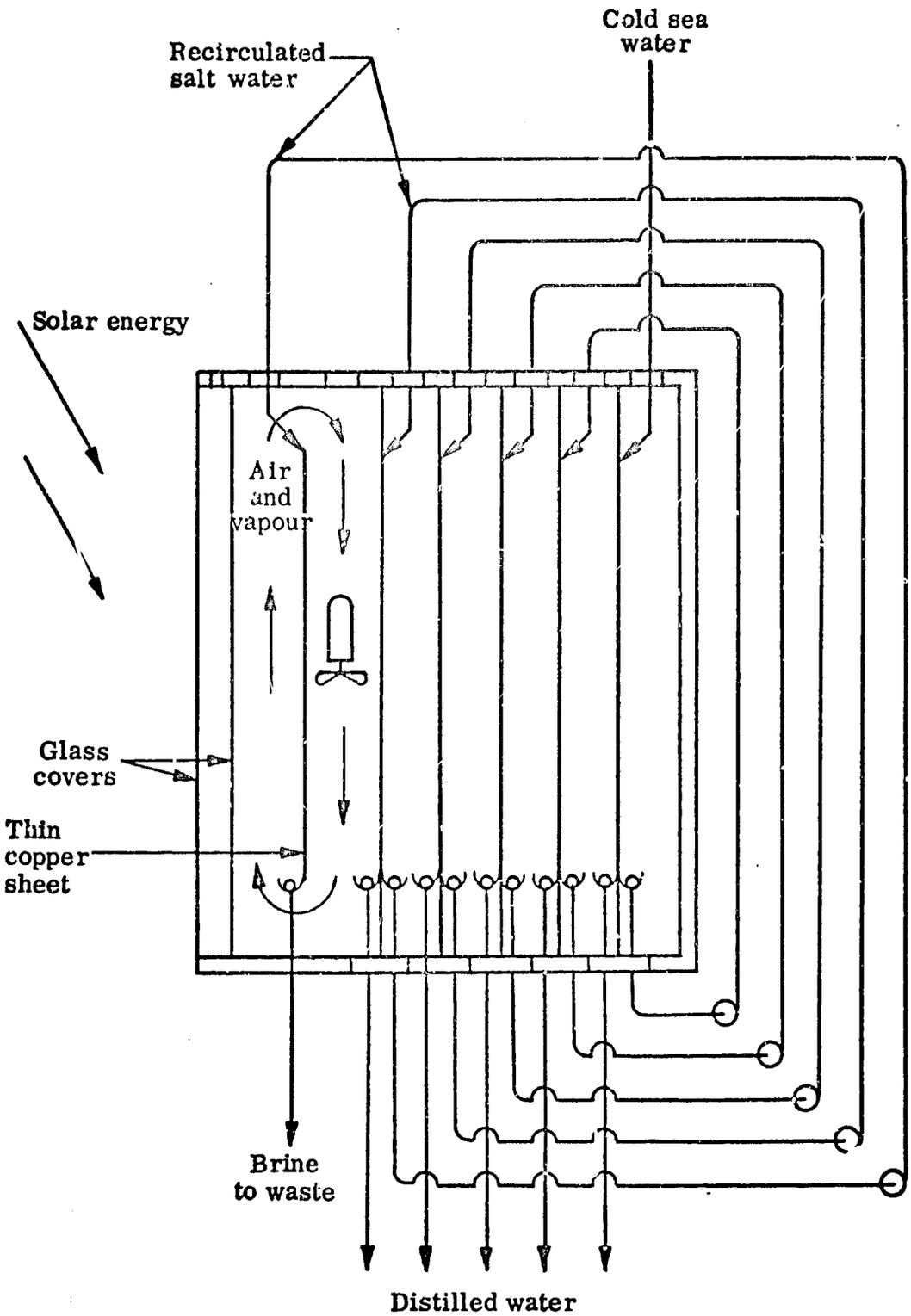


Figure 22. Glass-covered evaporating pan with reflecting surfaces

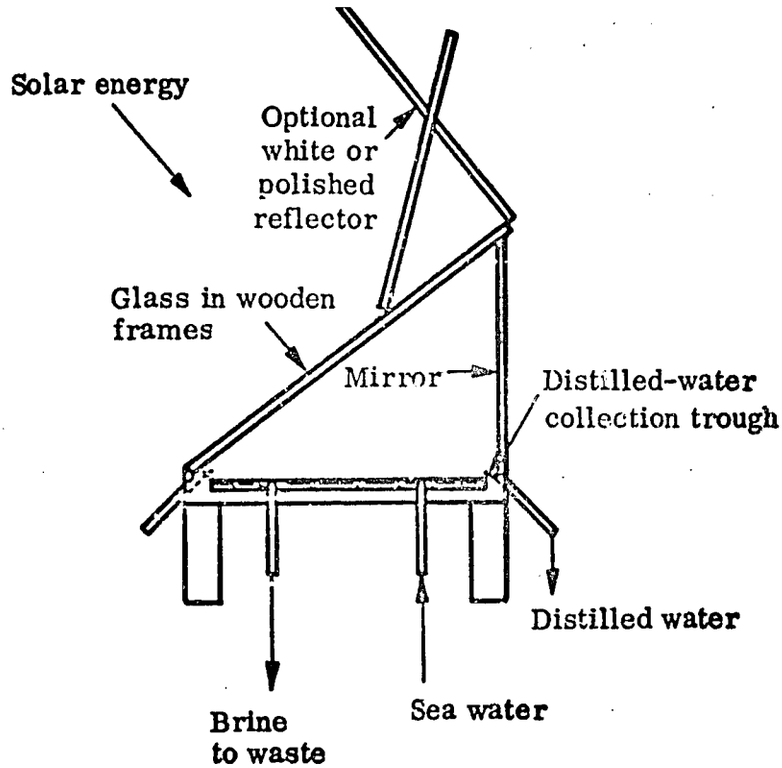


Figure 23. Extruded plastic still with blackwick for evaporation and cooling

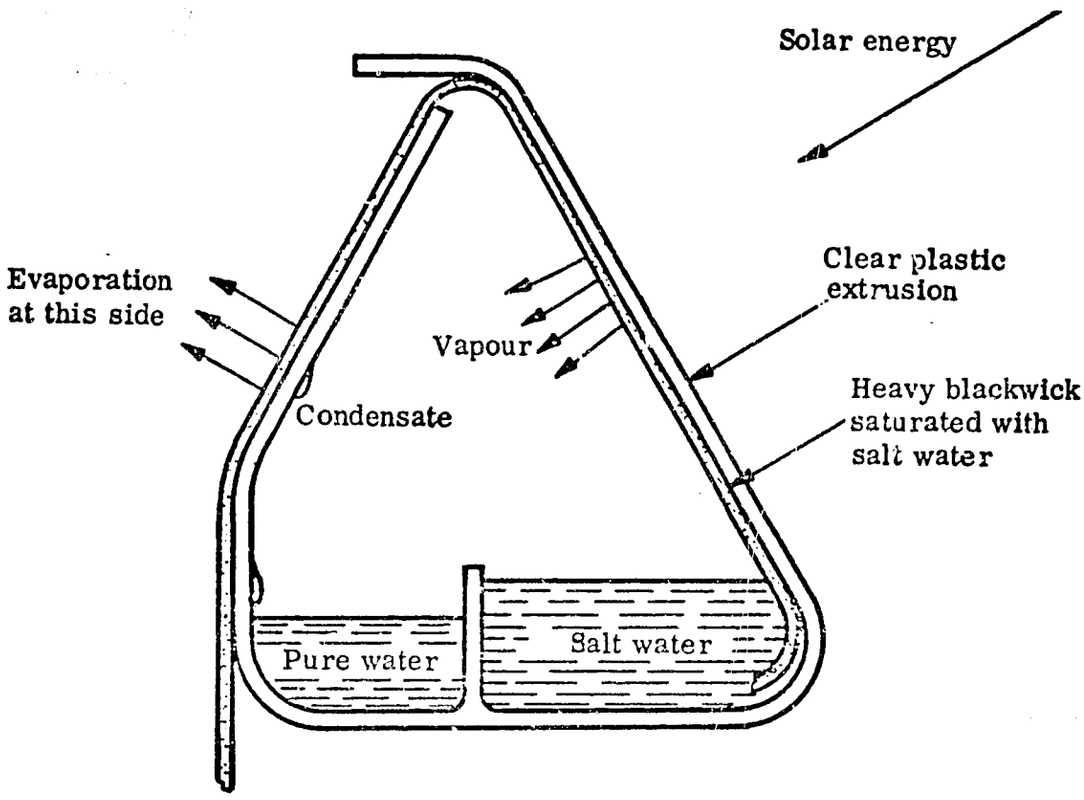
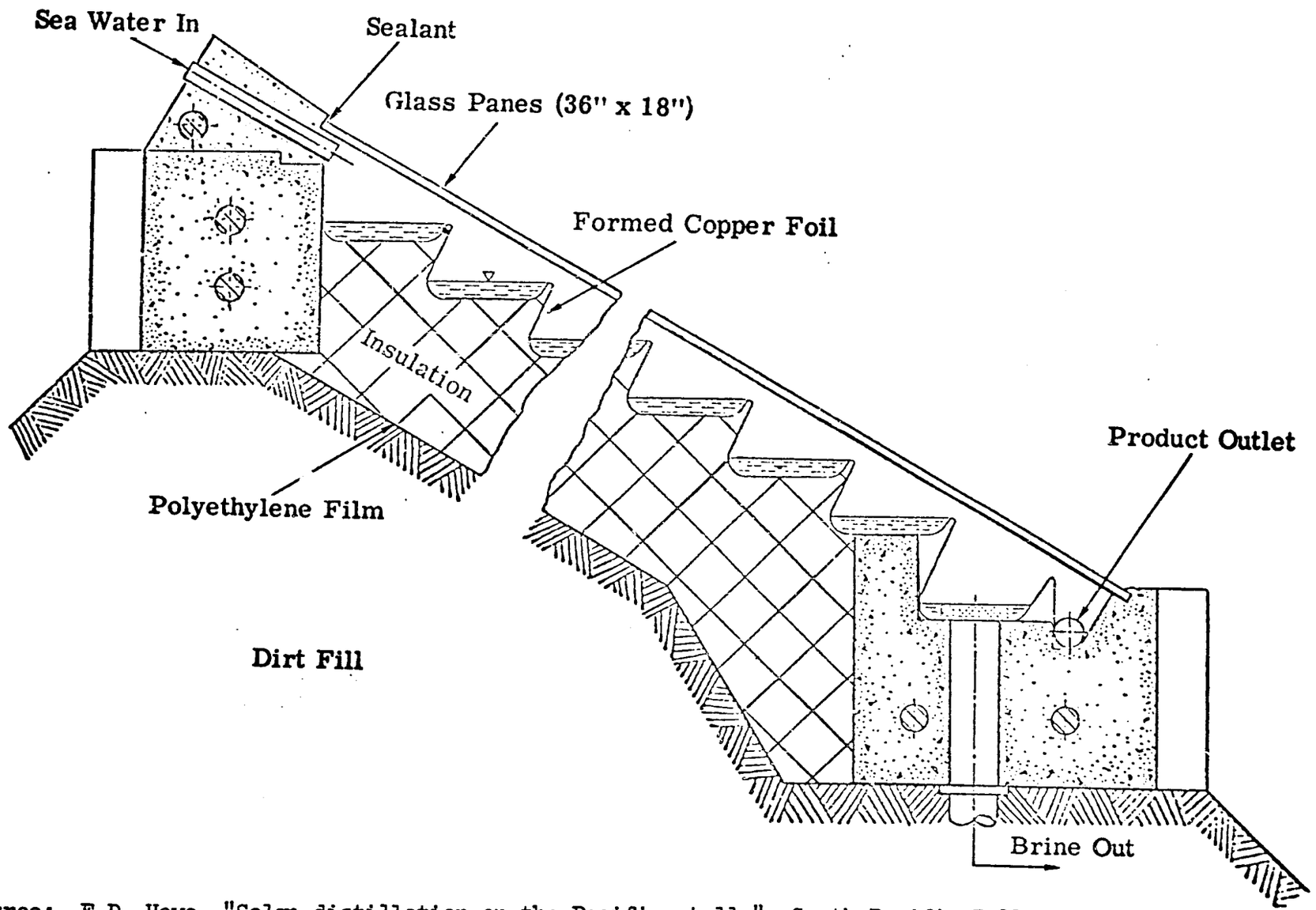
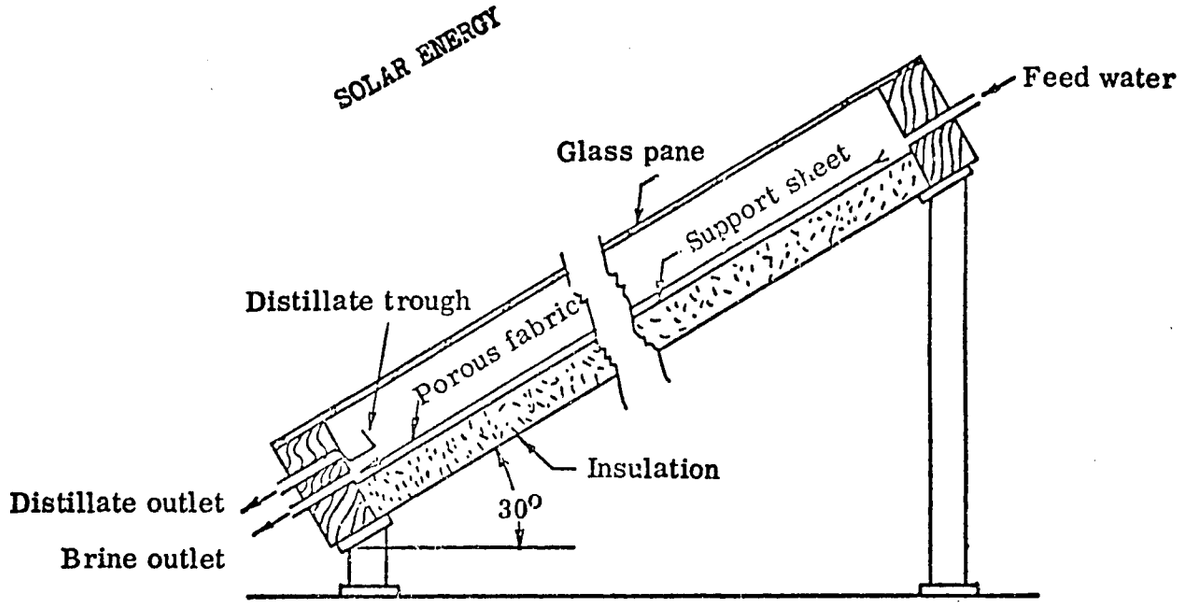


Figure 24. Tilted-tray solar still



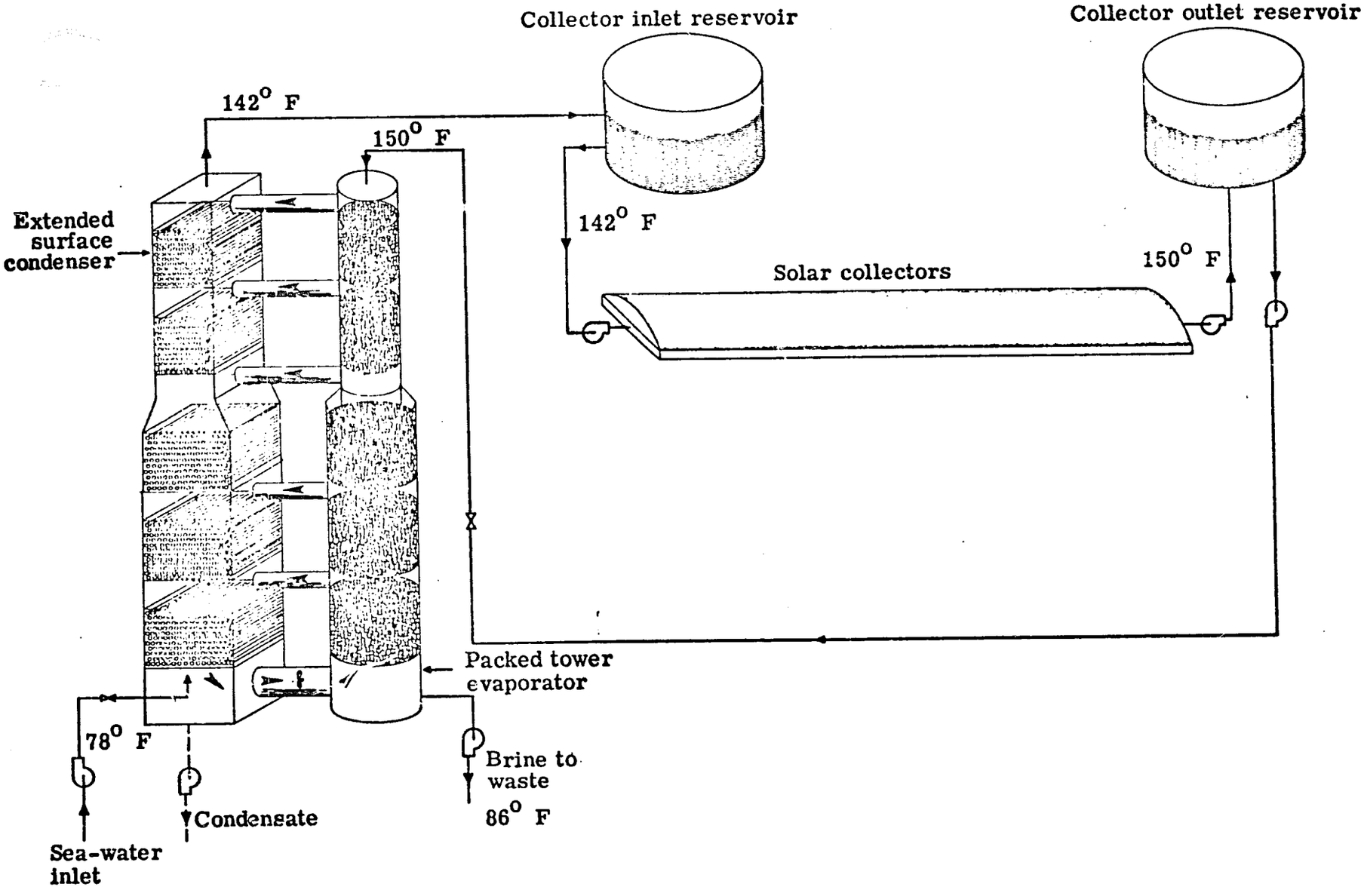
Source: E.D. Howe, "Solar distillation on the Pacific atolls", South Pacific Bulletin (Sydney, Australia), April 1964.

Figure 25. Tilted wick-type solar still



Source: M. Telkes, "Flat tilted solar stills", Proceedings of the International Seminar on Solar and Aeolian Energy, Sunion, Greece, 1961 (New York, Plenum Press, 1964).

Figure 26. Experimental multiple-stage flash solar distiller, Puerto Penasco, Sonora, Mexico



Source: C.N. Hodges et al., Solar Distillation Using Multiple-Effect Humidification, Office of Saline Water Research and Development Progress Report 194 (Washington, United States Department of the Interior, 1966).

Wastes collection and disposal

Human excreta

The conservancy system

In communities without a sewerage system, bucket privies or other types of conservancy latrine are common but are notoriously insanitary. A sanitary survey should indentify the defects and deficiencies in the daily operations involved in the conservancy systems so that they can be promptly remedied. Fig. 25 shows a bucket latrine with a list of the major points to be checked at the dwelling. The following list of points to be considered is more complete:

(1) in a house latrine, the bucket chamber should always have a rear door in good repair, which should be kept closed except during removal and replacement of the bucket;

(2) the bucket-chamber floor should be swept clean every time the bucket is removed;

(3) the seat hole over the bucket should have a flyproof cover with a long handle; the cover should be replaced in position when the seat is not in use;

(4) the bucket chamber should be kept dark as flies avoid dark places; the latrine should also be provided with a well-fitting front door that is easily closed;

(5) the houseowner should be advised to keep the latrine free from flies by cleaning and spraying the surrounding area;

(6) urine and liquid washings should drain into a soakpit to the rear of the latrine for absorption into the ground; in no case should the liquid be allowed to foul the soil surface;

(7) the bucket should be placed between guide blocks so that it receives all the excreta without the sides, the handle, or the rim becoming smeared;

(8) a pair of buckets marked with distinctive colours should be provided for each unit so that they can be used alternately; a cleaned bucket should be left in place when removing the filled bucket; the emptied bucket should be washed and cleaned with a disinfectant before it is returned for service;

(9) broken buckets should be promptly repaired or replaced;

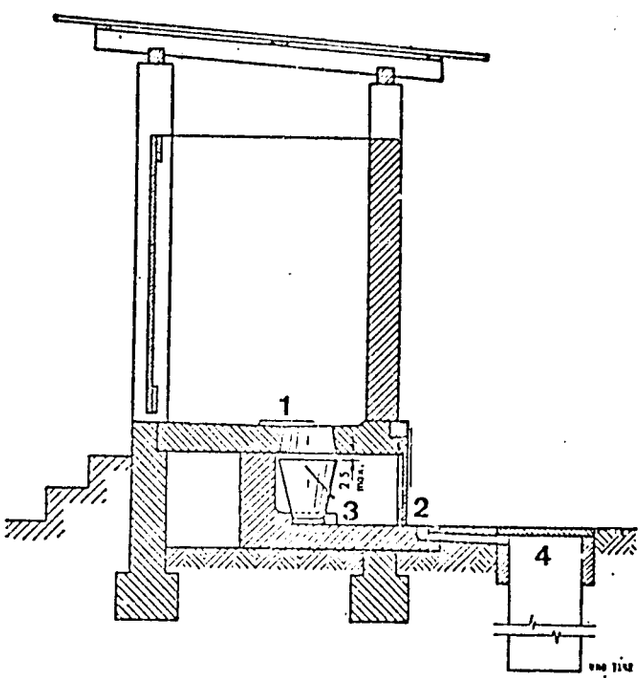
(10) removal, emptying, and replacement operations should not result in any spillage of the contents;

(11) intermediate depots for storage of nightsoil prior to transport, should be avoided if possible; the double handling involved, and the storage of foul matter in populated localities give rise to additional health hazards; if distances and logistic limitations necessitate intermediate depots, it is better to empty the drums into a watertight underground holding chamber from which the nightsoil can be pumped into transport trucks (with a suction pump);

(12) the transport of nightsoil along the town roads to the disposal site should not result in spillage, overflow, or leakage along the route;

(13) at the disposal site, trenching operations should be carried out in a hygienic manner and there should be sanitary protection for the workers; nightsoil should always be completely covered with soil; liquid overflows should be led to a soakpit;

FIG. 25. BUCKET LATRINE *



The measurement shown is in centimetres.

* Reproduced from Wagner & Lanoix (1958).

Check list

1. Is a latrine seat cover provided ?
2. Is the chamber door self-closing and flytight ?
3. Do the guides position the bucket correctly ?
4. Are a drain and a soakpit provided for wash wastes ?

(14) water should be provided at the disposal site for the workmen to wash their hands and feet with a mild solution of a disinfectant at the close of each operation;

(15) at the close of the day's work, all vehicles, drums, tanks, and containers, and the trenching tools, should be washed clean for the next day's work, and all washwater should be collected at a suitable point for treatment in a small oxidation pond prior to subsurface dispersion into the soil, depending on the quantity involved;

(16) staff or vehicles employed by engineering departments in the collection and disposal of nightsoil should not be shared by the water department;

(17) in places where nightsoil is deposited into the sea near a city, it is advisable to interpose an oxidation pond and to discharge the effluent into the sea. The excreta can first be discharged into a collecting well and mixed with water, the liquid then being passed through the oxidation pond for preliminary treatment to reduce the pollutional load on the beach;

(18) composting is not recommended as a means of disposal during an emergency as the risks involved outweigh the possible advantages of obtaining a supply of composted manure.

"*Self-service*" *latrines*

The conservancy service will need to be replaced, sooner or later, by the more satisfactory "self-service" type latrine. Where it is expected that a public sewer system will eventually be installed, waterborne sanitary privies can be connected to a household septic tank as an interim measure, the effluent being disposed of by soil absorption.

This may be possible in urban areas with water supply systems and where individual houses have enough room for a septic tank and for effluent disposal. Under certain conditions, even pit-type latrines or borehole latrines may provide suitable alternatives to the conservancy latrine. The provision of such latrines by the householder should be encouraged wherever it is feasible in areas without sewers to reduce the scope and extent of the conservancy service. Such a plan can pay dividends, particularly in improving the defences against epidemics, in areas covered by a conservancy system.

Public latrines

Public latrines have not been satisfactory especially in rural areas. They call for collective responsibility for proper use and maintenance; unfortunately collective responsibility often degenerates into irresponsibility and the latrines fall into misuse. Public latrines are useful where they form an adjunct to specific institutions such as markets, railway stations, schools, hospitals, bus terminals, extended family groups, municipal parks, etc., when full-time maintenance is provided by the institution.

Public latrines at institutions should be of a permanent character, well located, well conceived, well built and well maintained. They help the itinerant users to appreciate the potential benefits of sanitary privies. The service latrine is therefore the least suitable type for such places. Either an aqua privy or a septic tank latrine would be more suitable if water is available and if the effluent can be disposed of by subsurface absorption or other suitable means. A pit latrine can also serve the purpose as a temporary expedient as long as there is adequate protection against flies. Borehole latrines are not suitable for such installations because of capacity limitations.

Household privies

With sanitary household privies it is essential that the excreta should be disposed of on the site without contamination of either surface water or ground water in the vicinity, that the privies are not exposed to flies or accessible to animals, that they are not smelly or unsightly, and that they are simple and inexpensive. For emergency and interim measures in rural areas, a house latrine can be either a pit privy or a borehole latrine; these types are simple and comparatively cheap and can be constructed on a large scale as a permanent sanitary measure that will yield enduring benefits in the control of enteric diseases among the rural population.

Pit privy. Pit privies can be built anywhere without special tools; the family members themselves can construct the latrine with guidance from the public health authorities. They can have a greater cubic capacity than borehole latrines and consequently a longer useful life. Precautions are necessary, however, against collapse of the pit; and there is a greater need for fly control. Fig. 26 shows the details of the superstructures and slabs, and Fig. 27 the pit lining details.

Borehole latrine. A borehole latrine is a hole (20–30 cm diameter) bored into the ground with an earth auger, with a squatting slab on top (Fig. 28). In soft soils and with a low water table (at least 4–5 metres below the surface) the borehole latrine can be satisfactory as a family latrine. A "water-seal plate" can be used instead of the ordinary seat over the borehole, for a slight extra cost. The excreta can then be flushed away with as little as 1½ litres of water. The latrine is clean and the excrement is completely out of view and inaccessible to flies.

The following points should be examined during a sanitary survey of pit latrine and borehole latrine installations:

(1) size of the pit or hole in relation to the number of users;

(2) local subsidence that might indicate caving in;

(3) precautions against surface flooding;

(4) cleanliness of seat; use of hole covers;

(5) absence of foul smells;

(6) presence of flies;

Cinemas

(*a*) The safety of the drinking-water available to the public should be assured at all times.

(*b*) In unsewered areas where piped water is available, sanitary privies should be of the aqua-privy or septic tank type. Latrine seats may be provided at the rate of 1 for every 100 persons. Urinals should be adequate for the peak demand (about 1 for 30–50 persons) and washing facilities should be available on the spot. Frequent disinfection of the area during the day is a necessary precaution.

(*c*) Fly-control operations (by spraying insecticide) in and around cinemas may be carried out during an epidemic to help in arresting its course, but must not be relied upon as a long-term measure.

Markets

(*a*) Unsafe water, insanitary latrines, and fly infestations in a crowded market place carry the risk of disease transmission if sanitary precautions are ignored. Safe water must be available because vegetables and meat washed with contaminated water can transmit pathogenic organisms.

(*b*) Sanitary latrines are essential. Aqua-privies are suitable, but if pit latrines are provided they should be deep and well protected from flies. This can be achieved by covering the holes, spraying with insecticides, and disinfecting the pit contents frequently.

(*c*) The collection and disposal of refuse at frequent intervals is essential since putrescible organic matter will support breeding of flies and add to the health hazards. The refuse container shown in Fig. 33 is suitable for market places.

(*d*) The disinfection of insanitary places as a routine measure is a necessary precaution. Markets should be cleaned more frequently during an emergency and additional hygiene squads should be employed to cover these and other public places where infections might be transmitted.

Parks

(*a*) A safe water supply from public standpipes or drinking-water fountains should be provided in parks frequented by large numbers of people. Unsafe wells should either be closed or effectively chlorinated; unsafe sources of water, such as lakes, ponds, canals, natural swimming pools, and similar bodies, should be marked with a clear warning that the water is not safe to drink.

(*b*) Latrines of the aqua-privy type should be provided in unsewered areas. Pit-type latrines are not suitable for use in parks.

(*c*) A close watch should be kept on litter and refuse deposited in the area and the park should be kept tidy in order to prevent insanitary conditions and the breeding of flies.

Abattoirs

(*a*) The need to provide an adequate safe water supply must be emphasized on account of the hazards of meat becoming contaminated from polluted water. Washing and cleaning facilities should be robust and simple to operate. A piped supply is desirable, drawn either from the municipal system or a suitable local source with effective disinfection.

(*b*) The discharge from abattoirs of liquid wastes that have a high biological oxygen demand (BOD), must be carefully controlled. In unsewered areas, initial treatment of wastes in a settling tank of adequate capacity can be followed by storage in a stabilization pond, if feasible. Fig. 36 shows layout details of a rural abattoir.

(*c*) The maintenance of sanitary conditions and the application of fly-control measures are essential.

(*d*) The examination of food handlers is especially important in areas where food is processed.

Ice and drinks factories

The full details of sanitary precautions are discussed elsewhere; however, the use of bacteriologically safe water in these premises is of special importance. Refrigeration helps the survival of pathogens if they succeed in gaining entry at any stage. Not only should the provisions for a safe water supply be foolproof but the sanitary facilities for the employed staff should be designed to prevent faecal contamination resulting from defective types of toilet, the absence of adequate washing facilities, or imperfect personal hygiene. For obvious reasons, only water carriage latrines should be provided in such institutions. The employees should be given a medical examination regularly.

Long-distance bus stations

(*a*) The water supply at bus stations should be easily accessible, adequate, and safe. If obtained from a municipal system or an independent source, the supply should be locally piped and carry free residual chlorine. Separate provision should be made for drinking-water fountains, washing and for bathing facilities.

(*b*) Toilet facilities should be of the aqua-privy type since pit privies may be misused and rendered insanitary by itinerant members of the public; a liberal provision of separate urinals is desirable. Liquid wastes can be disposed of by dispersion into the soil.

(*c*) Refuse disposal and fly control are essential sanitary measures in these busy places. The vending of fruit, beverages, and other food should be under sanitary control. Frequent disinfection of insanitary places, insecticidal spraying, sanitary surveillance of eating places,

and the licensing of food vendors should be enforced.

(*d*) Long-distance buses should carry a supply of safe water on board, using chlorine dispensers for disinfection, the consumer's supply being drawn through taps from a hygienic storage vessel.

Railway services

(*a*) Water supply and sanitary latrine provisions at railway stations should serve as model facilities for the travelling public. There is an element of risk in filling water tanks in individual carriages via connecting hoses from sluice valves located near track level because the valves are often housed in chambers liable to pollution by spill water. Water supply reservoirs within each carriage should be filled from sanitary feed points supplied from the pressure main, and drinking water should be drawn from hygienic containers through taps. Disinfection of water by chlorine from chlorine dispensers is an essential precaution, particularly in an emergency.

(*b*) Latrine provisions in the stations in unsewered areas are often of the service type. There must be efficient supervision of the servicing of such latrines, both as a routine and particularly during an emergency. The latrines should be disinfected daily. Washing facilities are essential adjuncts to such latrines.

(*c*) The use of the railroad track for the disposal of faeces is dangerous and the precaution should be taken of collecting, disinfecting, and disposing of such excreta. Inspection of the track is necessary where it traverses inhabited localities and crowded communities in order to find, cleanse, and disinfect insanitary spots. The cleansing crew must be provided with the necessary implements and disinfectants for this purpose. These measures are of special importance during emergencies.

(*d*) The entire premises of each railroad station should be kept in a sanitary state as a major contribution to protecting the travelling public from environmental health hazards. Cleaning, insecticide spraying, and disinfecting operations should be carried out systematically to ensure the sanitary upkeep and maintenance of the carriages and station premises. The sale of fruit, beverages, and other food in the carriages and on the platform should be subject to strict sanitary control and surveillance, and rigid licensing should be enforced.

(*e*) During emergencies, case detection squads should keep a strict watch on bus and railroad traffic since they are potential channels for the spread of infection by isolated carriers.

Ship sanitation

Shipping traffic on inland water routes and international sea routes provides an important channel for the spread of infection from carriers to new hosts, sometimes in distant areas separated by land and sea. Insanitary conditions on board ship may result in minor or major epidemics of enteric disease, particularly cholera, and ship sanitation therefore assumes a special importance in connexion with the containment and prevention of enteric diseases. The environmental health measures necessary to secure this objective are set out in the *Guide to ship sanitation* (Lamoureux, 1967). The measures are of equal importance in international seaports to cover basic sanitation, the surveillance of drinking-water and food, and the control of insect and rodent vectors of disease.

Hygiene and sanitation in aircraft

Sanitation in airports and aircraft is now of very great importance: since speed is the motivation and saving time the major objective, air travel facilities must include special precautions against all health hazards incidental to such rapid travel. The facts that toilets are often situated adjacent to galleys, that food, food refuse, and human waste (including vomitus) are stored in close proximity, and that limited space is available for toilet and washing facilities all necessitate the most stringent sanitary control measures and safety precautions. The details are given in the *Guide to hygiene and sanitation in aviation* (World Health Organization, 1960). The precautions are equally relevant to airport sanitation.

Camp sanitation

The vulnerability of camps

Camps, fairs, and festivals attract large numbers of people, some of them possibly from regions where enteric diseases are endemic. Sanitary deficiencies in the environmental health facilities provided in these temporary gathering places may expose the participants to health hazards during their short stay, and the transmission of disease from carriers to the susceptible hosts is a constant threat, involving any of the vehicles of transmission. If infections are contracted at these camps, those infected may act as foci and spread the disease in minor or major epidemics when they return home. The duration of such gatherings is of less significance than the intensity of crowding and the tendency to neglect sanitary discipline on account of preoccupation with the primary purpose of the gathering. Camps and religious fairs have been repeatedly shown to be the origin of epidemics initiated by returning participants.

Health education is vital in camps, fairs, and festivals. To a large extent it must be used to supplement the environmental health measures by creating public awareness of the risks and by stimulating cooperation in the observance of personal hygiene and sanitary discipline.

Camp water supplies

For camp sites that are used regularly it is prudent to provide a permanent water supply. The use of mobile water treatment plants should be reserved for camps occupied only casually and infrequently. Camp water supplies should be adequate to cover all essential needs, easily accessible to preclude the need to resort to any unsafe local supplies, and safe in quality at all times, with an optimum level of free residual chlorine. The water should be piped if possible and be drawn from suitably located public standpipes. Any of the alternative methods already described for developing water sources and distributing water may be adapted to suit the local conditions and requirements.

Sanitary collection and disposal of excreta in camps

The following factors must be considered.

Shallow trench latrines are the least suitable type for undisciplined and irresponsible groups living in big camps. Such latrines are liable to gross misuse and are to be avoided.

Service latrines are better than shallow trenches if adequate conservancy staff are available. Even so, human failure may reduce the conservancy service to a low level of efficiency and defeat its purpose.

Straddle trench latrines. These are better than shallow trench latrines and may be suitable in certain locations as a purely emergency measure. A straddle trench is a ditch some 25 cm wide, 75 cm deep, and of a convenient length based on the probable number of users, at a rate of about 75 cm per user. Generally, two trenches each about 5 m long can together serve about 100 people for a few days. No seats are provided with this type of latrine, but boards should be placed along each side of the trench to provide a sure footing and to prevent the sides from caving in. Privacy can be provided with inexpensive screens of locally available material. The excavated earth is piled near the trench, with a scoop or shovel placed near each pile. Each person covers up his excreta with a shovelful of earth to keep away flies and reduce odours. Toilet paper and ablution water should be placed near to hand. Hand-washing facilities must be provided separately. The trench latrine should be closed when it is filled to within 50 cm of ground level. The earth should be replaced in the trench and tightly packed down, and the site marked with a sign. Fig. 37 and 38 show the general features of a trench urinal and of a straddle trench latrine.

Well-type pit latrines. Well-type pit latrines are more satisfactory in camps. The wells may be about 2 m in diameter and about 5-6 m deep, or about 1 metre above the subsoil water level. The wells or pits may be lined to the minimum extent necessary to prevent the sides from caving in. Four latrine seats can be placed over each

FIG. 37. TRENCH URINAL

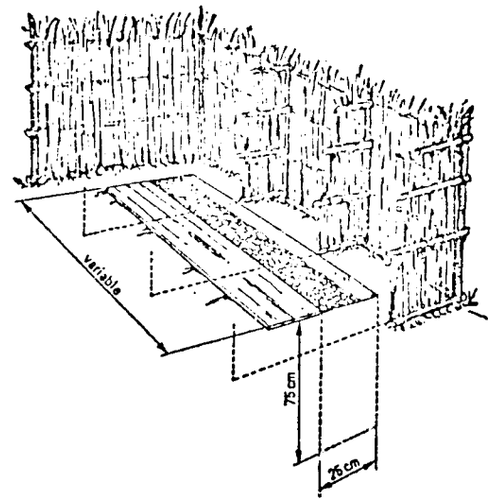
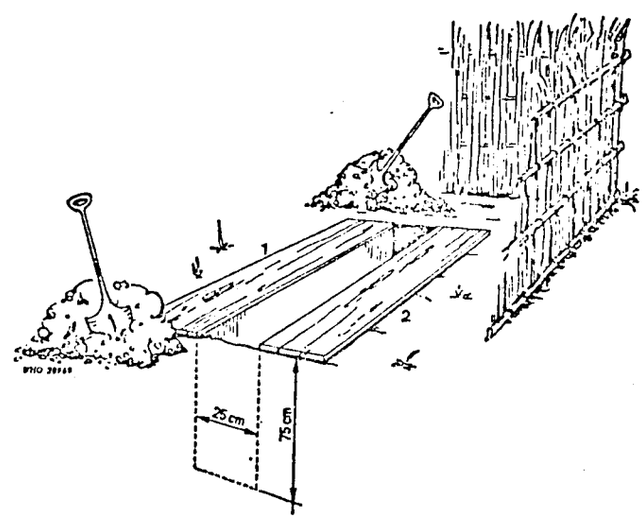


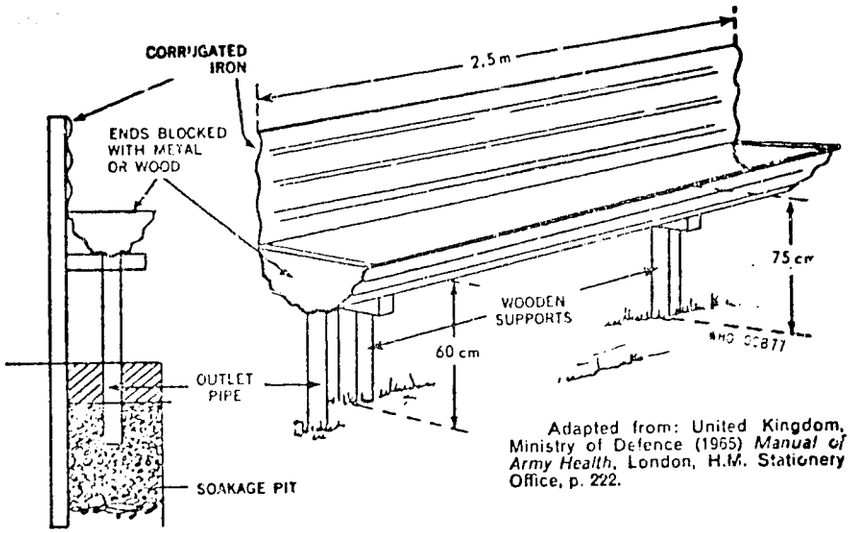
FIG. 38. STRADDLE TRENCH LATRINE



Check list

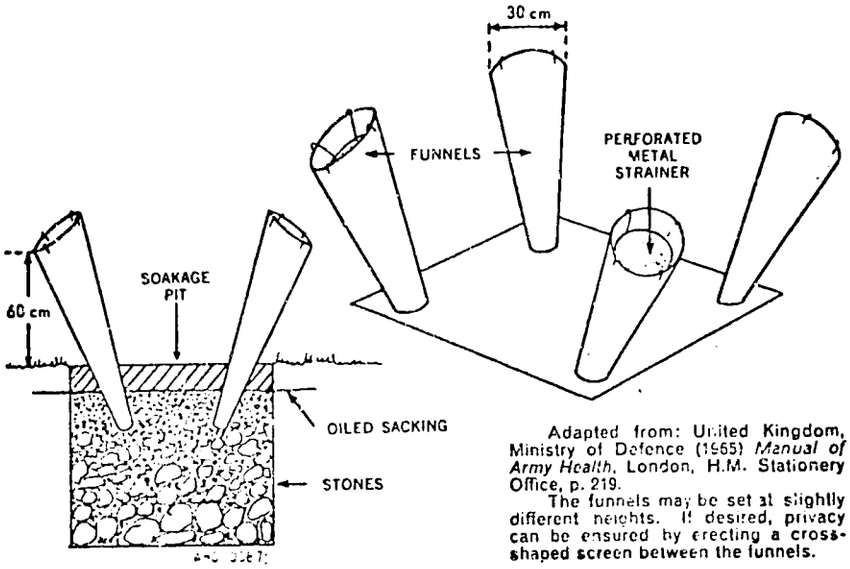
1. Are boards provided for safe footing ?
2. Is about 3 m of trench/day/100 persons provided ?

FIG. 23. TROUGH URINAL



Adapted from: United Kingdom, Ministry of Defence (1965) *Manual of Army Health*, London, H.M. Stationery Office, p. 222.

FIG. 24. FOUR-FUNNEL URINAL

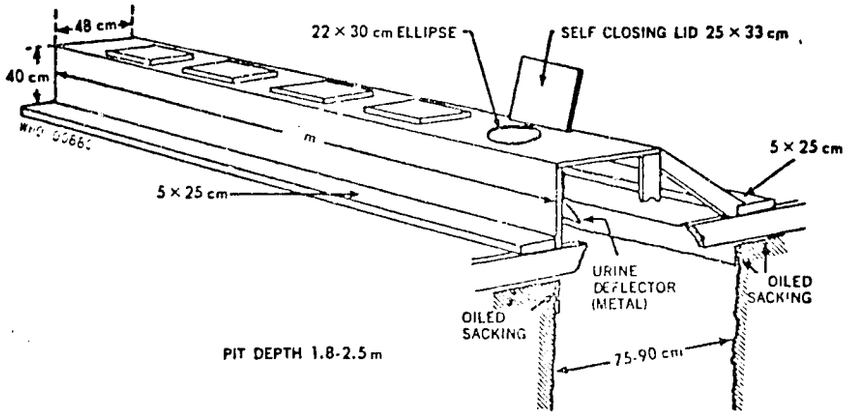


Adapted from: United Kingdom, Ministry of Defence (1965) *Manual of Army Health*, London, H.M. Stationery Office, p. 219.

The funnels may be set at slightly different heights. If desired, privacy can be ensured by erecting a cross-shaped screen between the funnels.

ENVIRONMENTAL HEALTH MEASURES

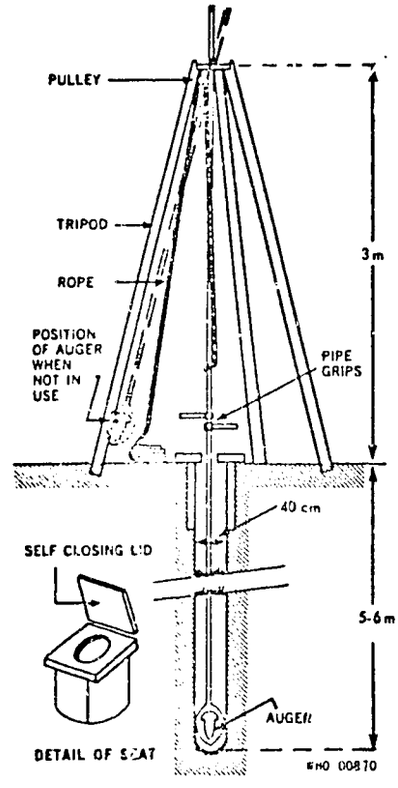
FIG. 21. DEEP TRENCH LATRINE



Adapted from: Canada, Department of National Health and Welfare (1967) *Environmental health in disaster*, Ottawa, p. 85.

Trench revetted at sides. Anti-fly oiled sacking laid down for width of 1.25 m all round trench; wooden fly-proof cover of tongued and grooved wood on strong base.

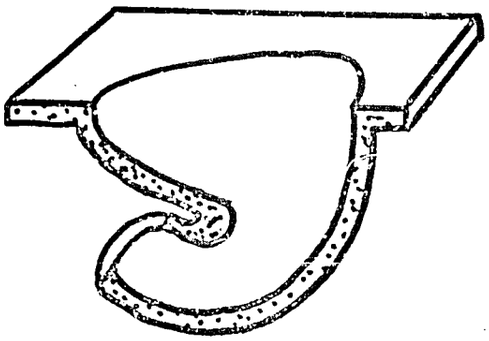
FIG. 22. BORE-HOLE LATRINE



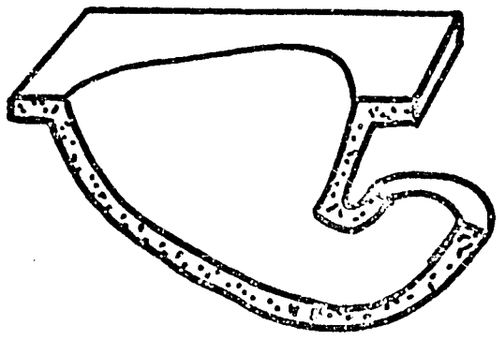
Adapted from: Canada, Department of National Health and Welfare (1957) *Environmental health in disaster*, Ottawa, p. 86.

The bore-hole latrine is a vertical boring usually 40 cm in diameter and anything up to 6 m deep. A fly-proof seat superstructure should be provided. The boring is made by a special hand-operated auger, the shaft of which is made in sections for easy transport and to allow lengths to be added as the work proceeds. Shear legs are erected over the site of the boring to act as a guide for the upper end of the shaft and to provide a support for the pulley block used in withdrawing the auger from the ground. The auger is rotated by hand turning applied to a detachable cross-T handle which can be adjusted in the shaft as the boring deepens. If the bore reaches water, this is of great assistance in the digestion of the sewage. When ground water is not reached, a concrete skin covering the base of the bore and extending for 50 cm up the sides will hold water poured in from the top for some time. This type of latrine should be provided with adequate hard standings and drainage around it and a centrally placed seat over the bore to ensure that the edges are not fouled. Such latrines will last for years and are a most satisfactory form of sewage disposal in the field.

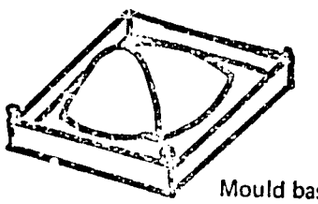
Fig. 26. THE WATER SEAL CLOSET OR POUR FLUSH BOWL



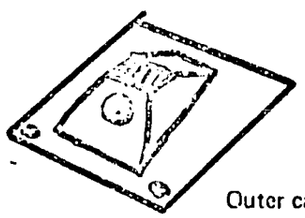
S.E. Asian type with forward facing trap



Ceylon type with rear facing trap

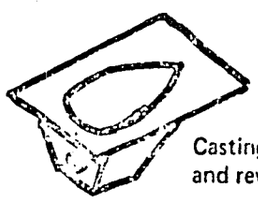


Mould base

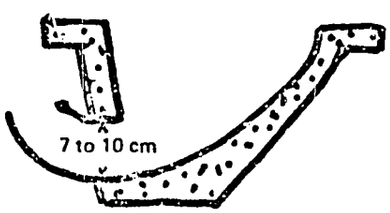


Outer case

plug



Casting removed and reversed



Section of completed closet bowl

A method of casting closets in concrete

The mould is made in three parts, *the base* consisting of a shallow wooden tray fitted with a core which can be moulded in concrete, and two locating pegs. Fitting over the base is *the outer case* made from wood, there is a gap 3 to 4 cm between the base and the outer case, which is fitted with *the plug* which forms the hole for the outlet pipe. All inside surfaces of the mould are greased before casting.
Concrete made from 2½ parts sand and 1 part cement is rammed into the mould through the filling hole and allowed to set for 24 hours. The plug and the case can then be removed, and after a further 24 hours the bowl can be carefully lifted from the base and allowed to harden for about 4 or 5 days. The bowl is completed by cementing a standard pipe elbow of the correct size into the hole left by the plug.

Fig. 25. THE PIT PRIVY

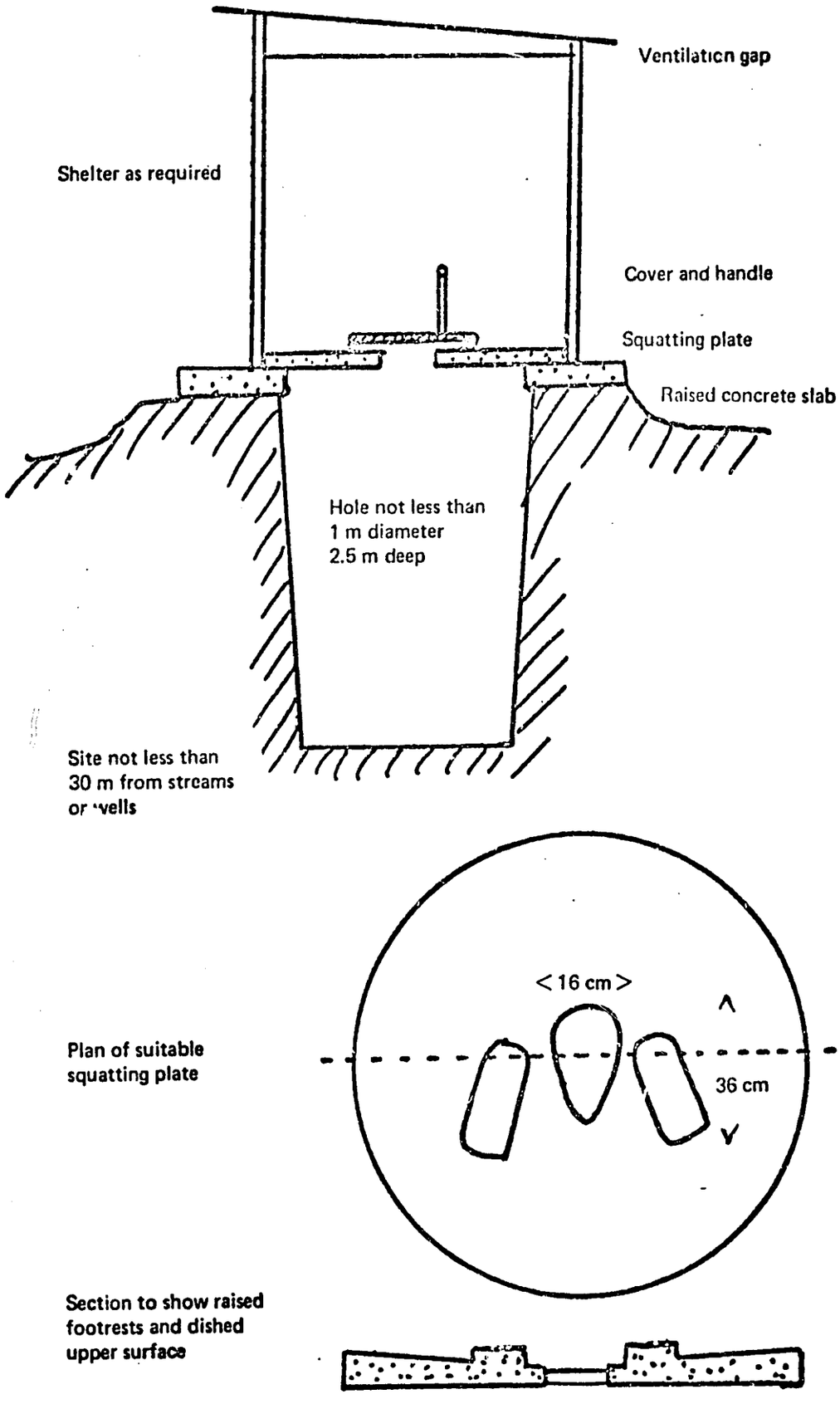
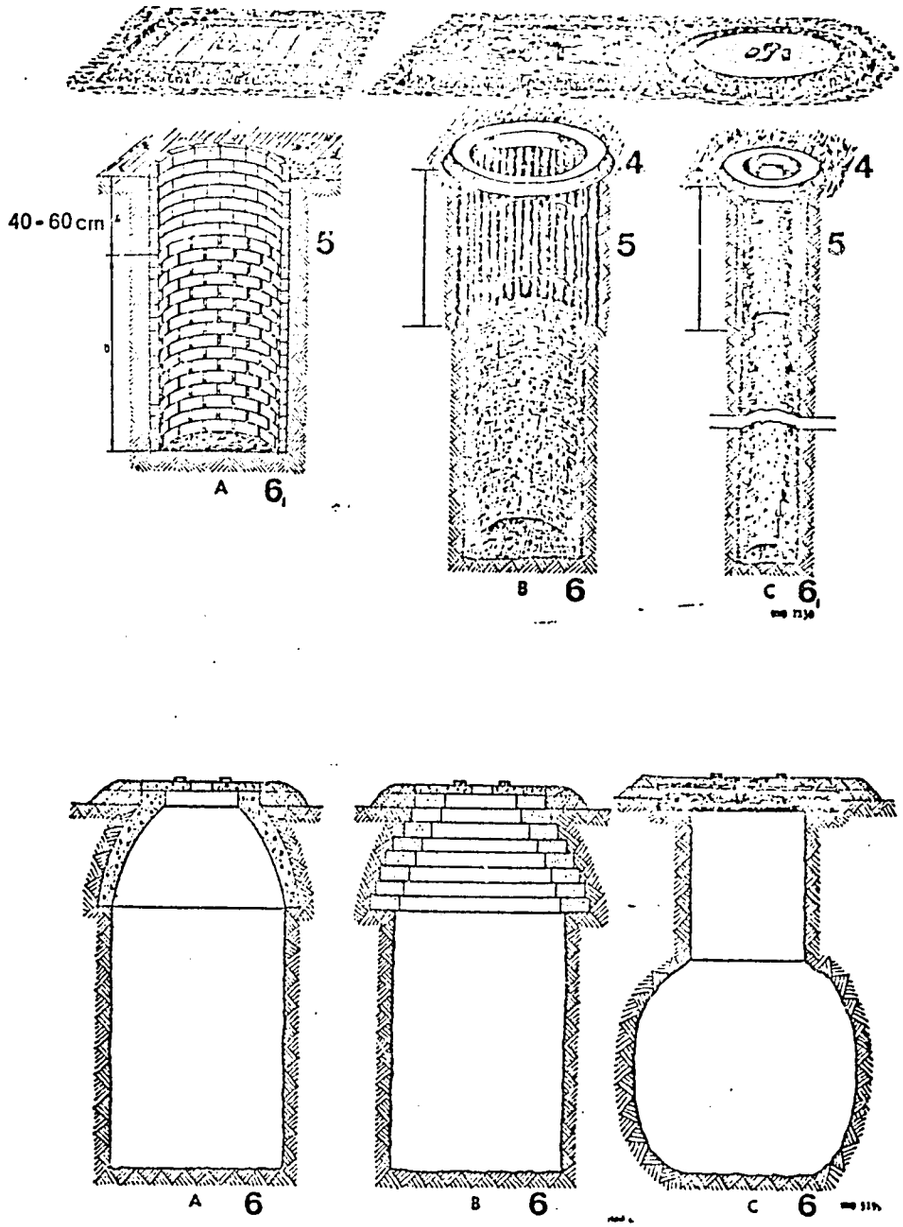


FIG. 27. PIT PRIVY – PIT LINING DETAILS *



* Reproduced from Wagner & Lanoix (1958).

VARIOUS COMBINATIONS OF DIFFERENT TYPES OF PIT, PIT LINING, BASE, AND FLOOR

a = Open joints

b = Joints laid with mortar

A = Square pit with brick lining and base and wooden floor

B = Round pit with partial lining of cut tree limbs, soil-cement base, and built-up floor

C = Bored pit with concrete lining, base, and floor

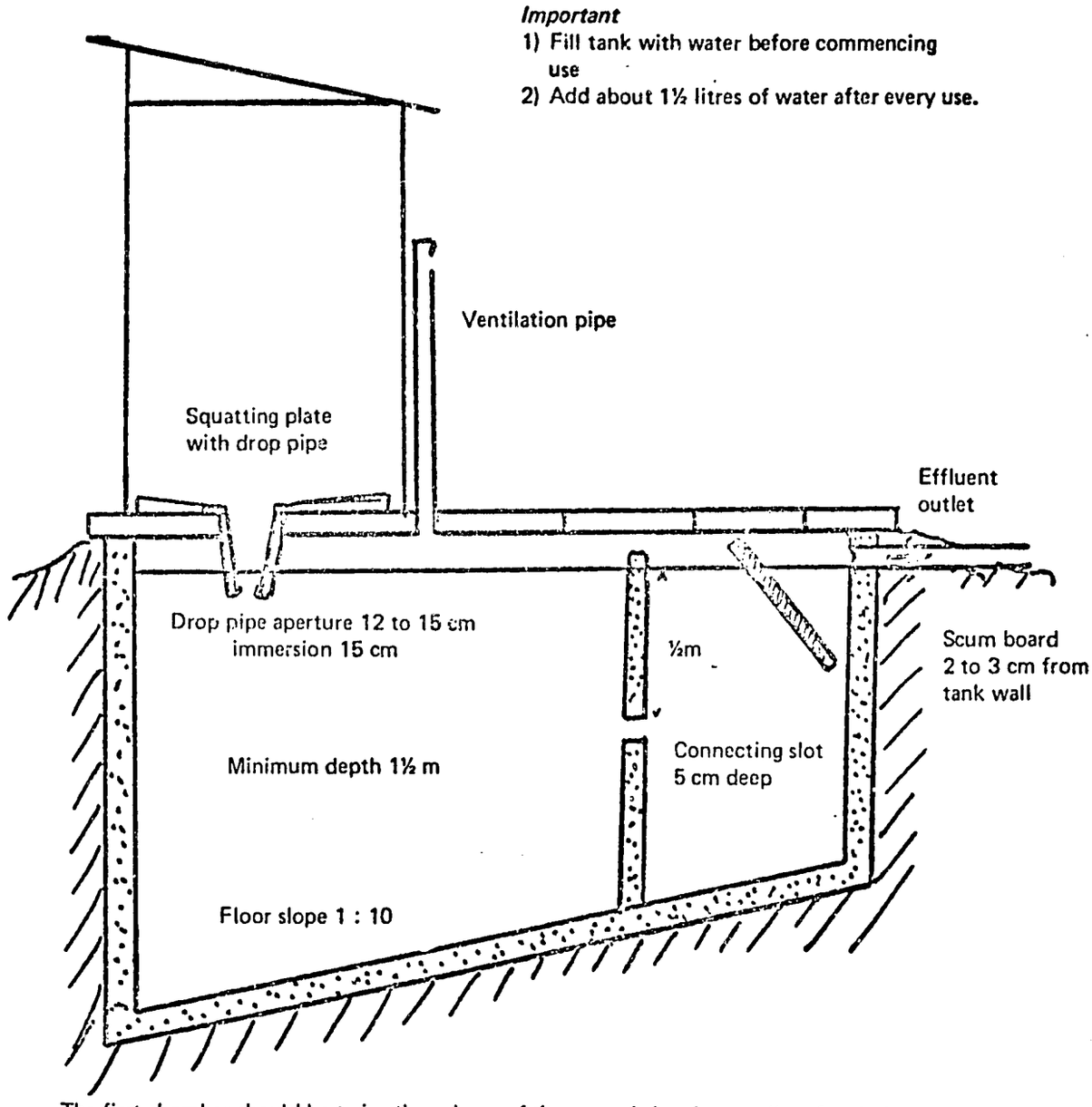
LARGE-VOLUME PITS WITH SMALL FLOORS AND SUPERSTRUCTURES

A = Large diameter or square pit with soil-cement cone at top to reduce size of opening and accommodate small floor (Cone may be of any material that will provide the strenth to support the weight on top.)

B = Similar to A, but with brick

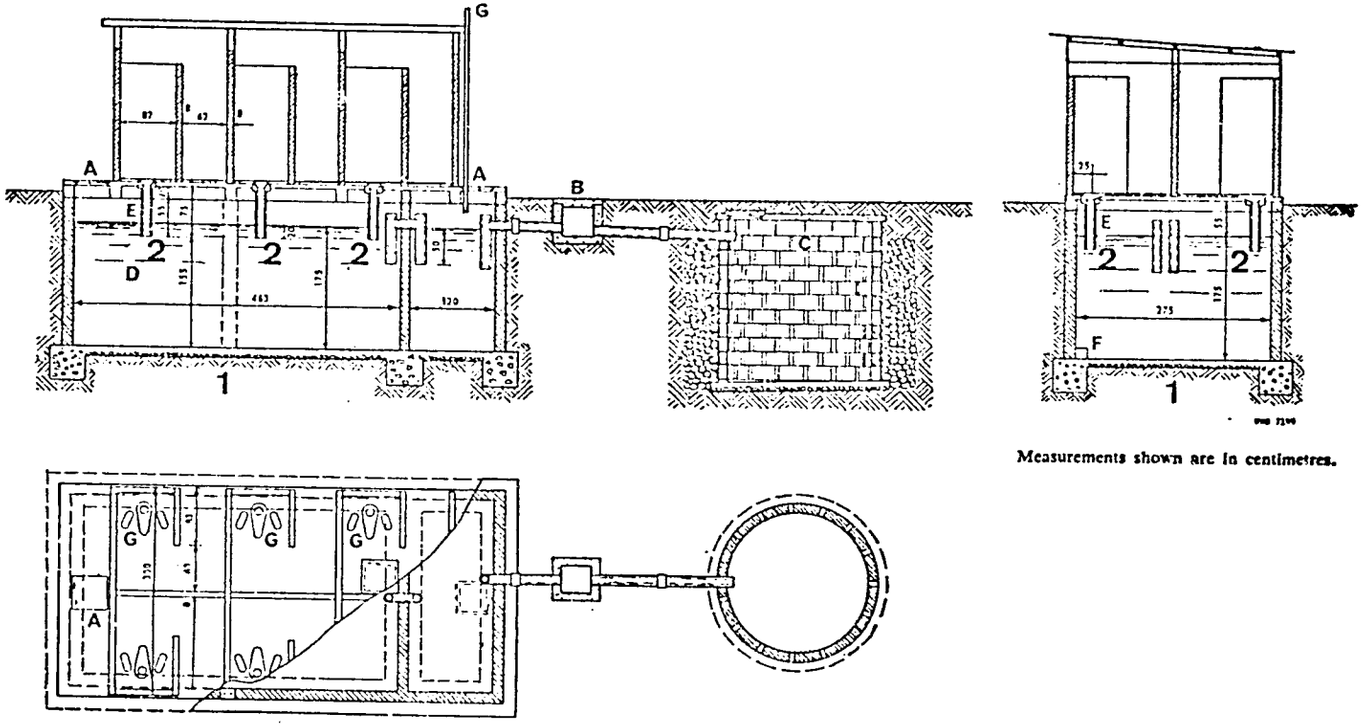
C = Pit showing enlarged lower portion to provide increased volume; practicable only in very stable soil.

Fig. 27. THE AQUA PRIVY



The first chamber should be twice the volume of the second chamber to allow for sludge storage.

FIG. 30. INSTITUTIONAL-TYPE AQUA PRIVY •



Measurements shown are in centimetres.

• Reproduced by permission of the United Nations Relief and Works Agency for Palestine Refugees in the Near East.

Check list

1. Is the concrete tank of watertight construction ?
2. Do the drop pipes extend below water outlet level ?

A = Inspection manholes, 40 × 40 cm
B = Inspection box, 40 × 40 cm
C = Soakage pit or soakage trench
D = Capacity of tank : 22.3 m^3
E = Drop pipe 10.5 cm in diameter
F = Opening 15 × 15 cm in partition wall
G = Ventilator pipe

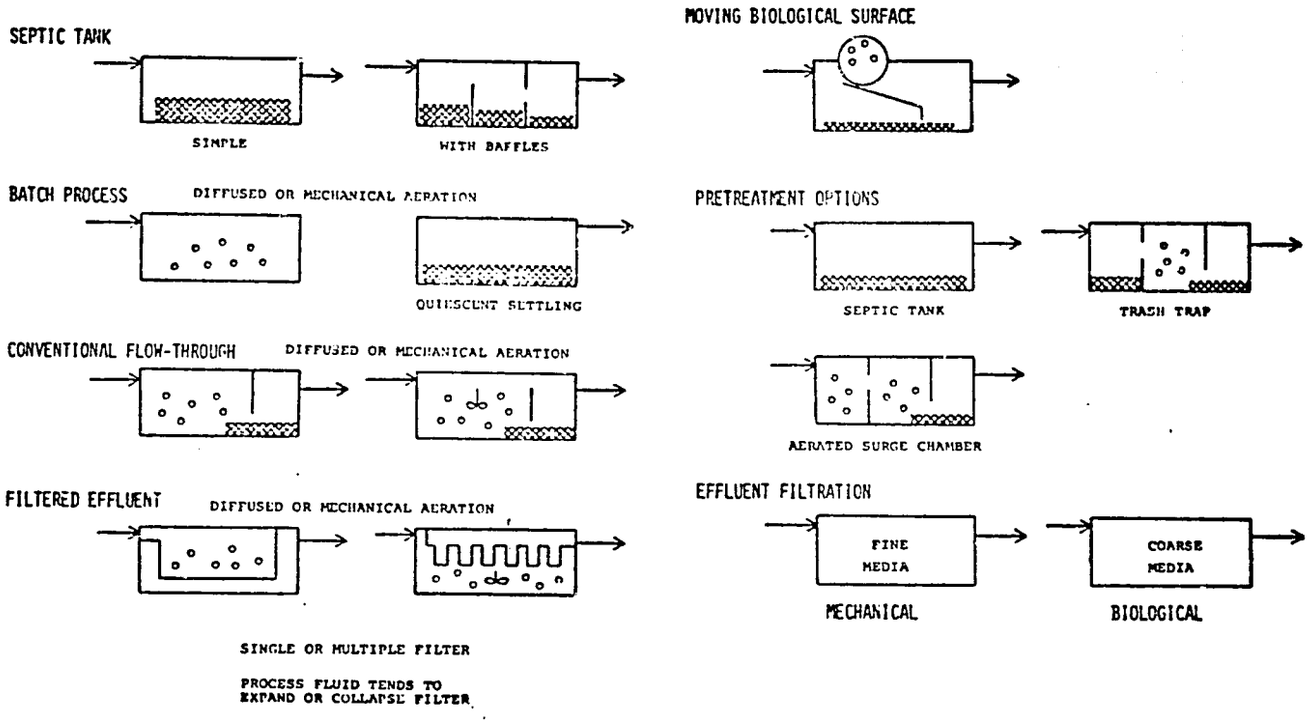


Fig. 1 Waste treatment systems designs.

HOUSEHOLD SEPTIC TANK EFFLUENT

— VARIABLE —

ITEM	RANGE
FLOW	0 - 40 GAL/HR
pH	7.1 - 8.3
D.O.	0
T. COLI.	$10^6 - 10^8$ /100 ml
TEMP. (@ -27°C AIR)	6° - 13° C
BOD	90 - 384 mg/l
COD	150 - 720
SS (98% 0.5μ - 5.0μ)	40 - 350
VSS	80% SS
TS	820 ±
T. ORG. CARBON	129 ±
TN	25 - 36 ±
ORG N	30% TN
FREE NH_3	30% TN
PO_4	35 - 100
CHLORIDES	75 - 95 ±
ALKALINITY	400 ±

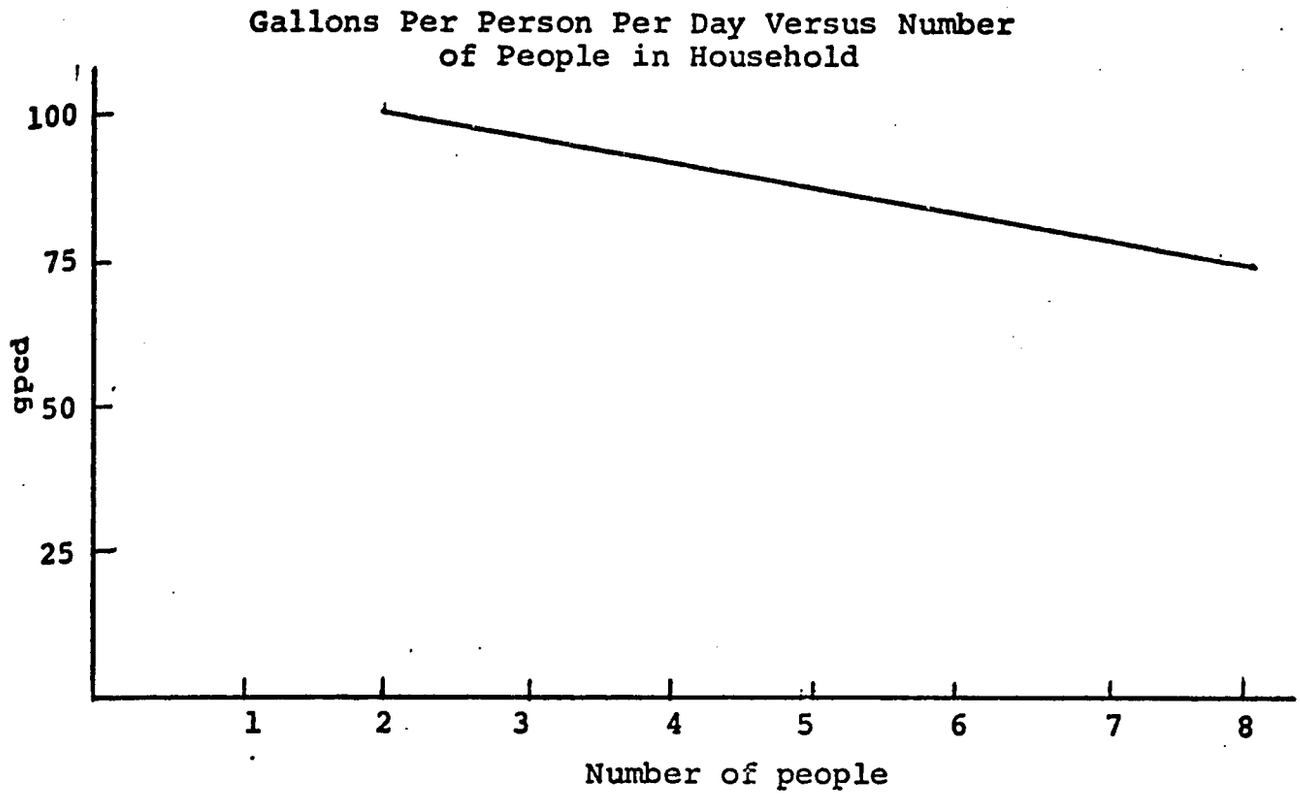


FIGURE 1a

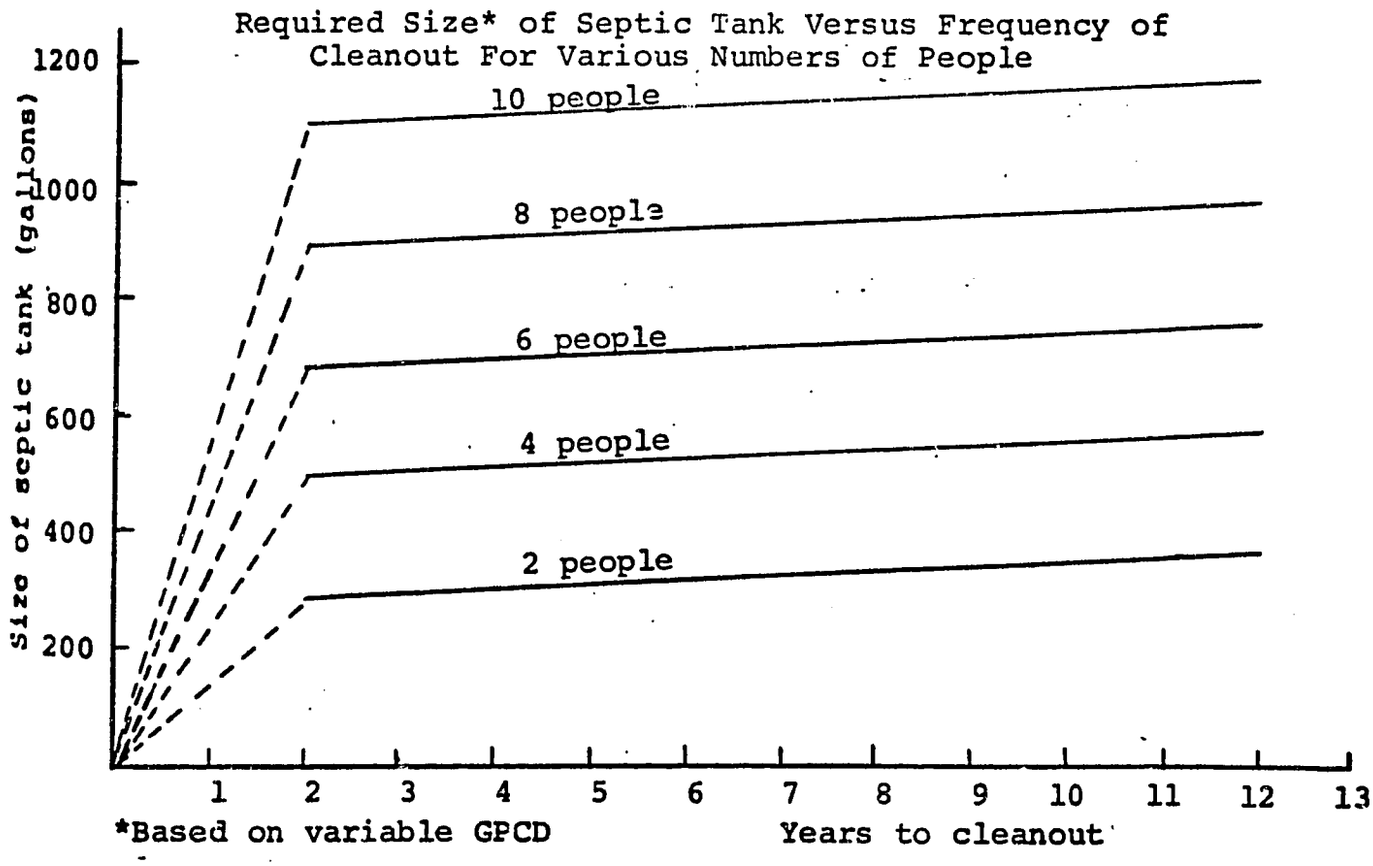


FIGURE 2a

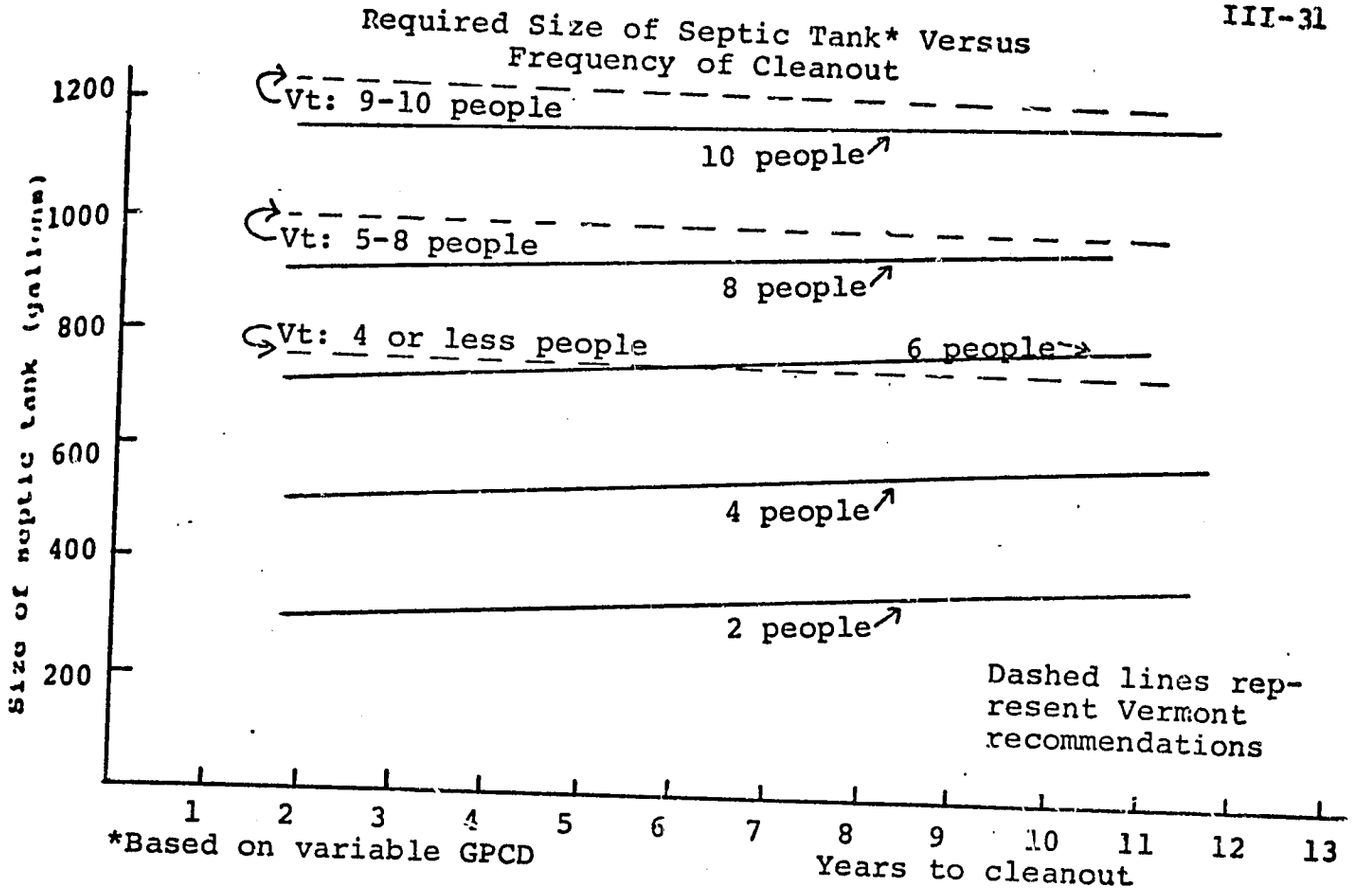


FIGURE 3a

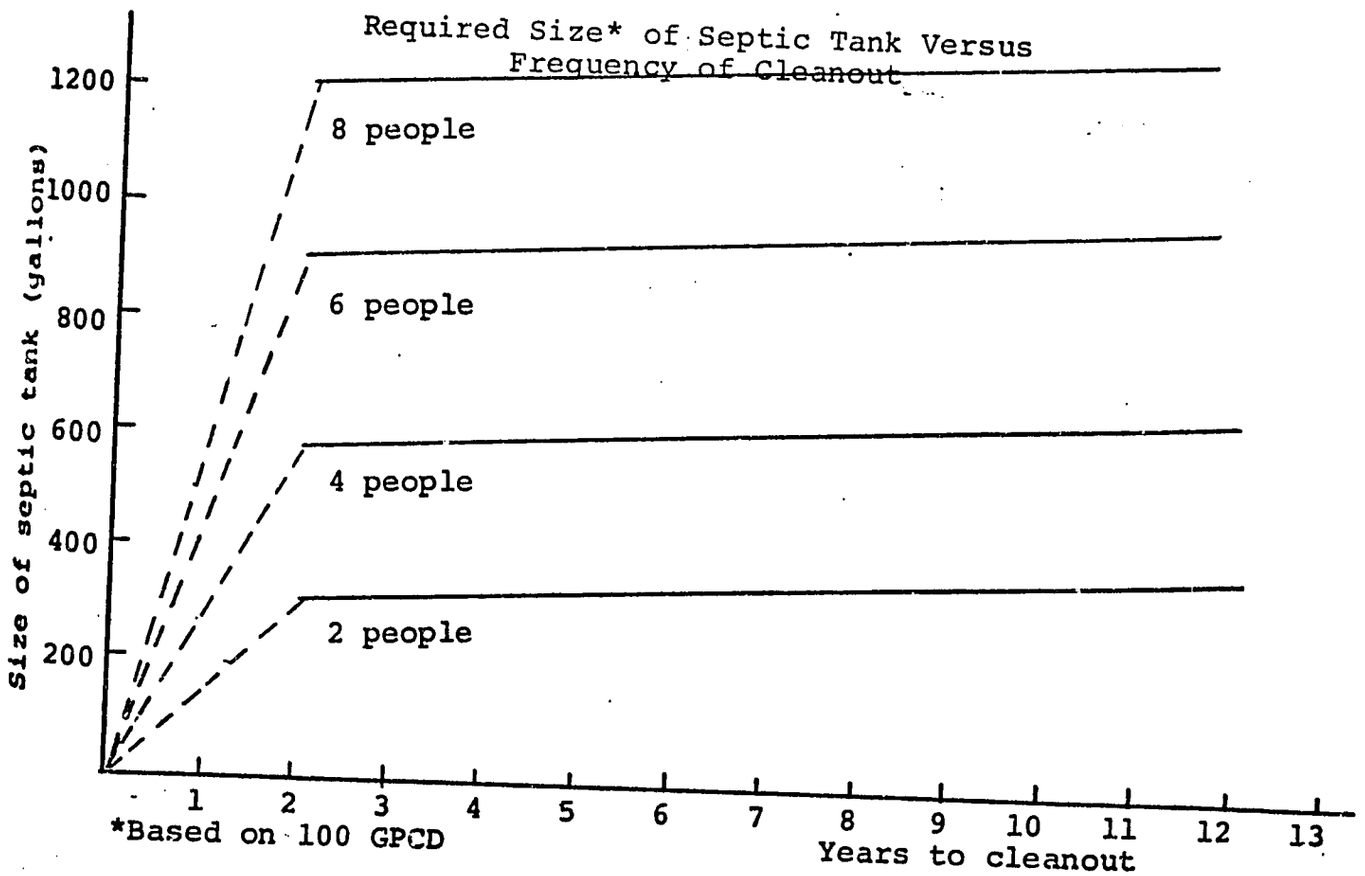


FIGURE 4a

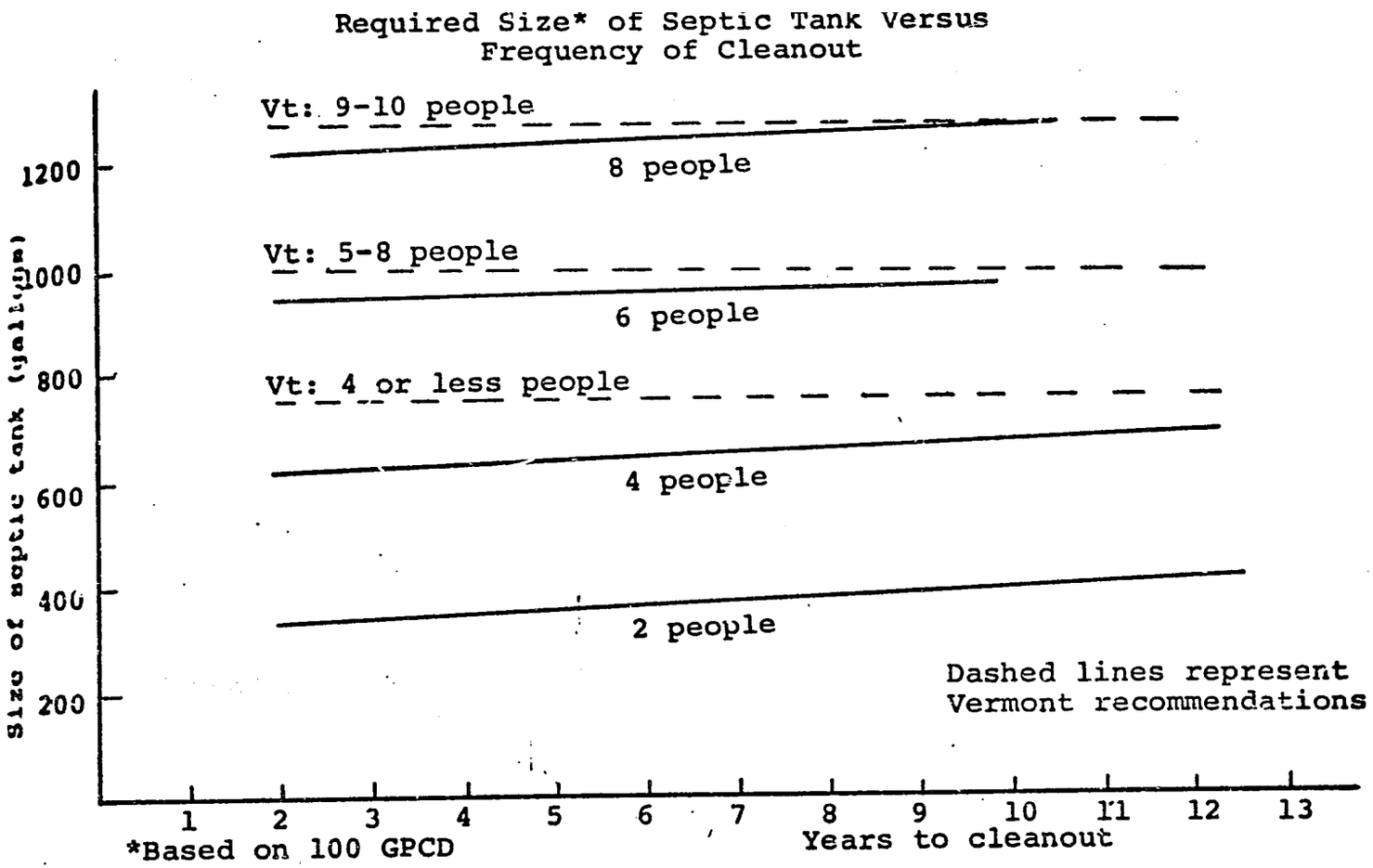

Required Size* of Septic Tank Versus
Frequency of Cleanout
Vt: 9-10 people
8 people
Vt: 5-8 people
6 people
Vt: 4 or less people
4 people
2 people
Dashed lines represent
Vermont recommendations
Size of septic tank (gallons)
1200
1000
800
600
400
200
1
2
3
4
5
6
7
8
9
10
11
12
13
*Based on 100 GPCD
Years to cleanout

FIGURE 5a

Square Feet of Absorption Area As Required by the Septic Tank Manual

Two curves are shown in the Septic Tank Manual:

1) square feet per bedroom versus percolation rate,
2) loading (gal. per sq.ft. per day) = Q versus percolation rate (t) where $Q = 5/\sqrt{t}$

Assuming that each bedroom contains 1.5 people and sewage flow is 100 gpcd, the flow per bedroom is 150 gpd since:

$$Q = \frac{\text{gallons per day}}{\text{square feet}}$$

$$1/Q \frac{\text{(gallons per day)}}{\text{bedroom}} = \frac{\text{square feet}}{\text{bedroom}}$$

or $$1/Q(150) = \frac{\text{square feet}}{\text{bedroom}} \quad \text{where } Q = 5/\sqrt{t}$$

Using the above formulation with the gallons per bedroom equal to 150 gpd and 200 gpd the results are compared to the values given by the Septic Tank Manual on page 9 (see Table 1a and Figure 6a).

TABLE 1a

Percolation Rate	By Formula @150 gal.per Bedroom per day	By Formula @200 gal.per Bedroom per day	Recommended
1 or less	30	40	70
2	43	57	85
3	52	69	100
4	60	80	115
5	68	91	125
10	94	125	165
15	115	154	190
30	167	222	250
45	187 (214)*	250 (286)*	300
60	250	334	330

*Using Q = .7 instead of .8 in an attempt to straighten the curve.

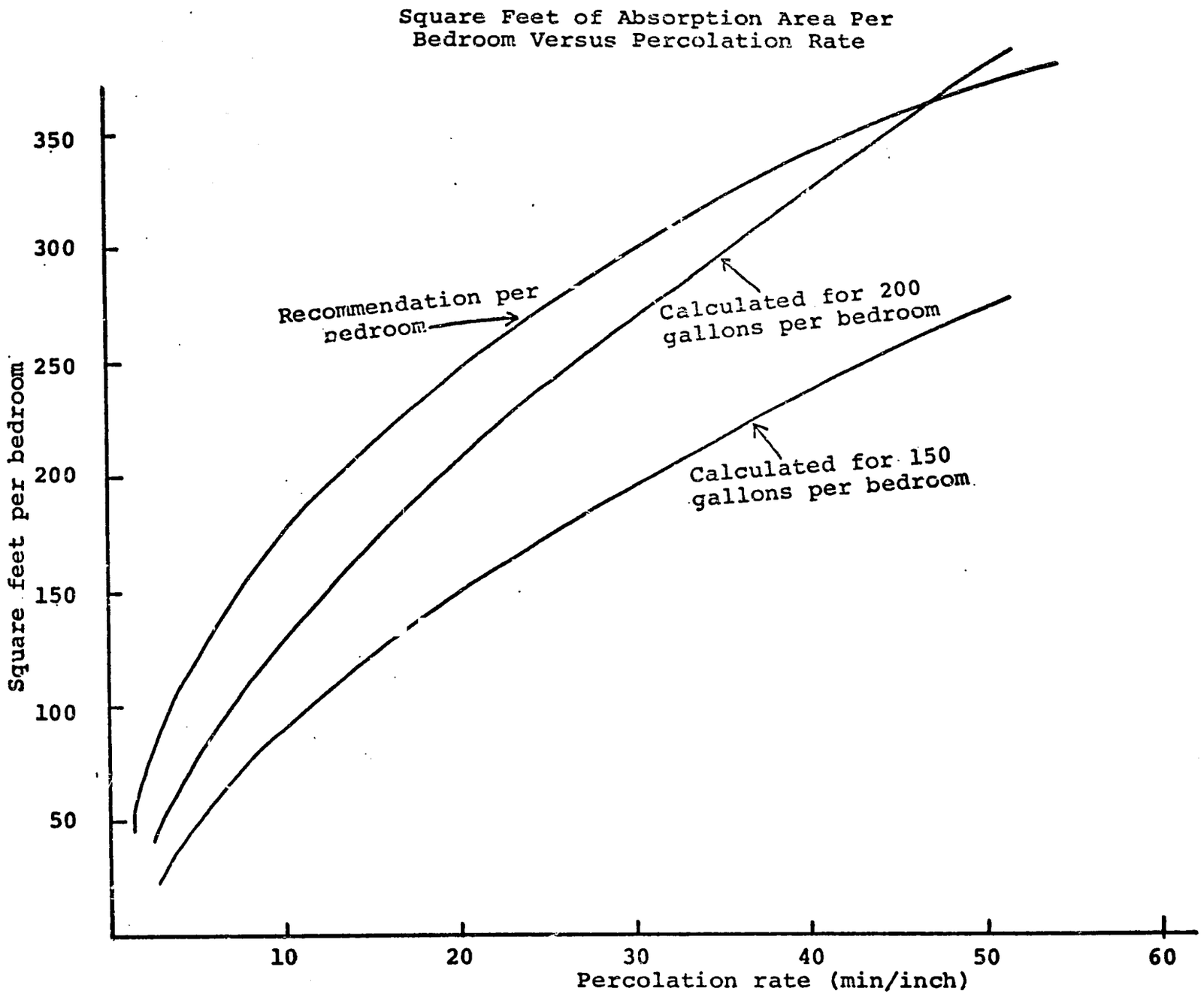

Square Feet of Absorption Area Per
Bedroom Versus Percolation Rate
Square feet per bedroom
350
300
250
200
150
100
50
10
20
30
40
50
60
Percolation rate (min/inch)
Recommendation per bedroom
Calculated for 200 gallons per bedroom
Calculated for 150 gallons per bedroom

FIGURE 6a

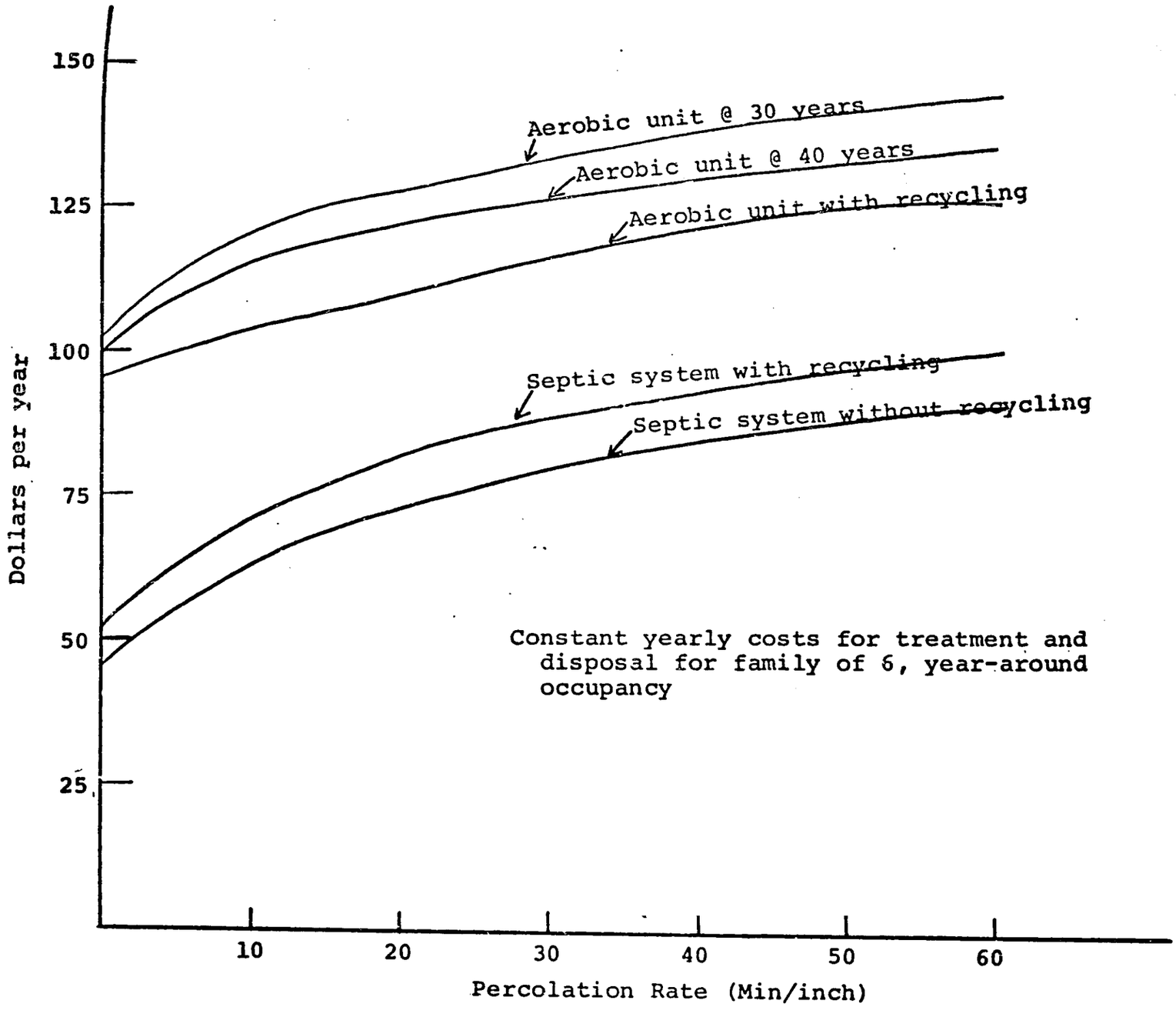

150
125
100
75
50
25
Dollars per year
Aerobic unit @ 30 years
Aerobic unit @ 40 years
Aerobic unit with recycling
Septic system with recycling
Septic system without recycling
Constant yearly costs for treatment and disposal for family of 6, year-around occupancy
10
20
30
40
50
60
Percolation Rate (Min/inch)

FIGURE 13

Table 3
Treatment Cost—Septic Tank System for 20 Year Life, Cost of Tank = $770

Soil Permeability	*Ft^2 Absorption Area Required 4 Bedroom*	*Absorption Field Costs*	*Total Annual Cost*	*Total Annual Cost/ 1000 gal.*
Good	280	$ 300-450	$ 80	$0.90
Fair	500	$ 500-750	$100	$1.15
Poor	1330	$1330-2000	$200	$2.20

Cleaning cost $15/year.
Capital recovery at 20 yr. and 7½% interest rate.

SEPTIC TANK - SOIL ABSORPTION SYSTEM

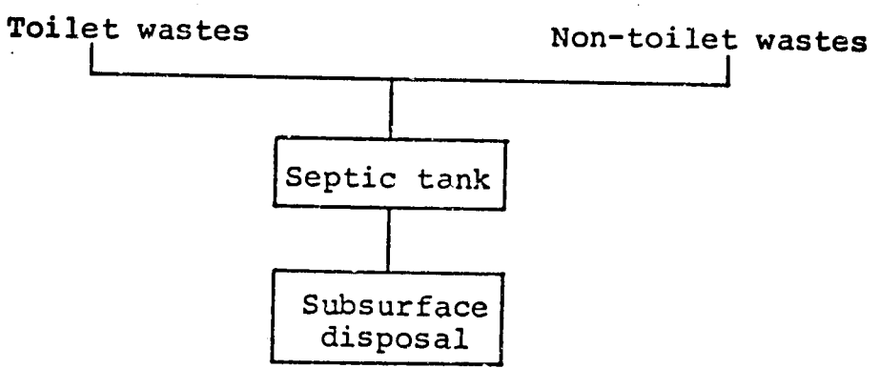


FIGURE 3

HOUSEHOLD AEROBIC TREATMENT UNIT

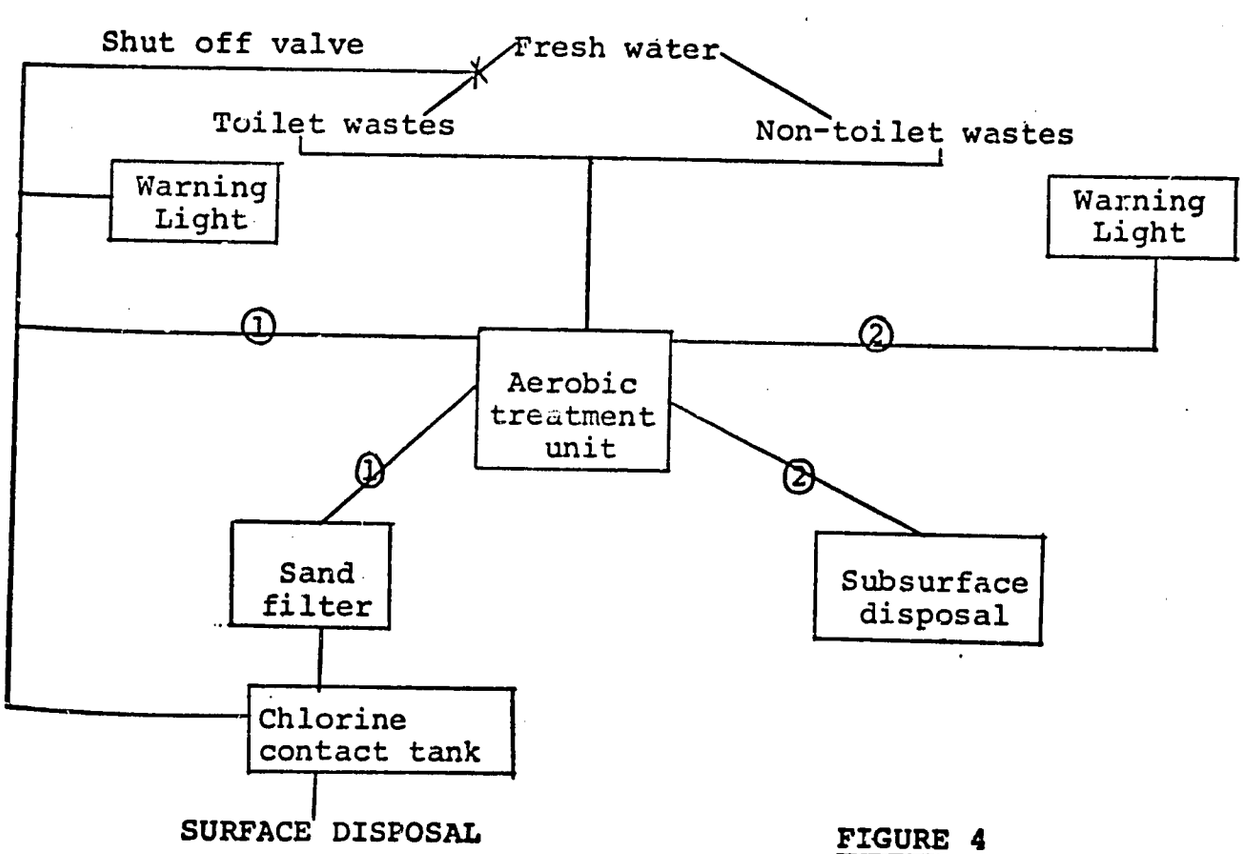
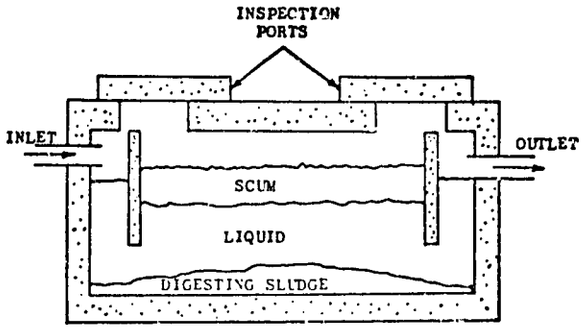
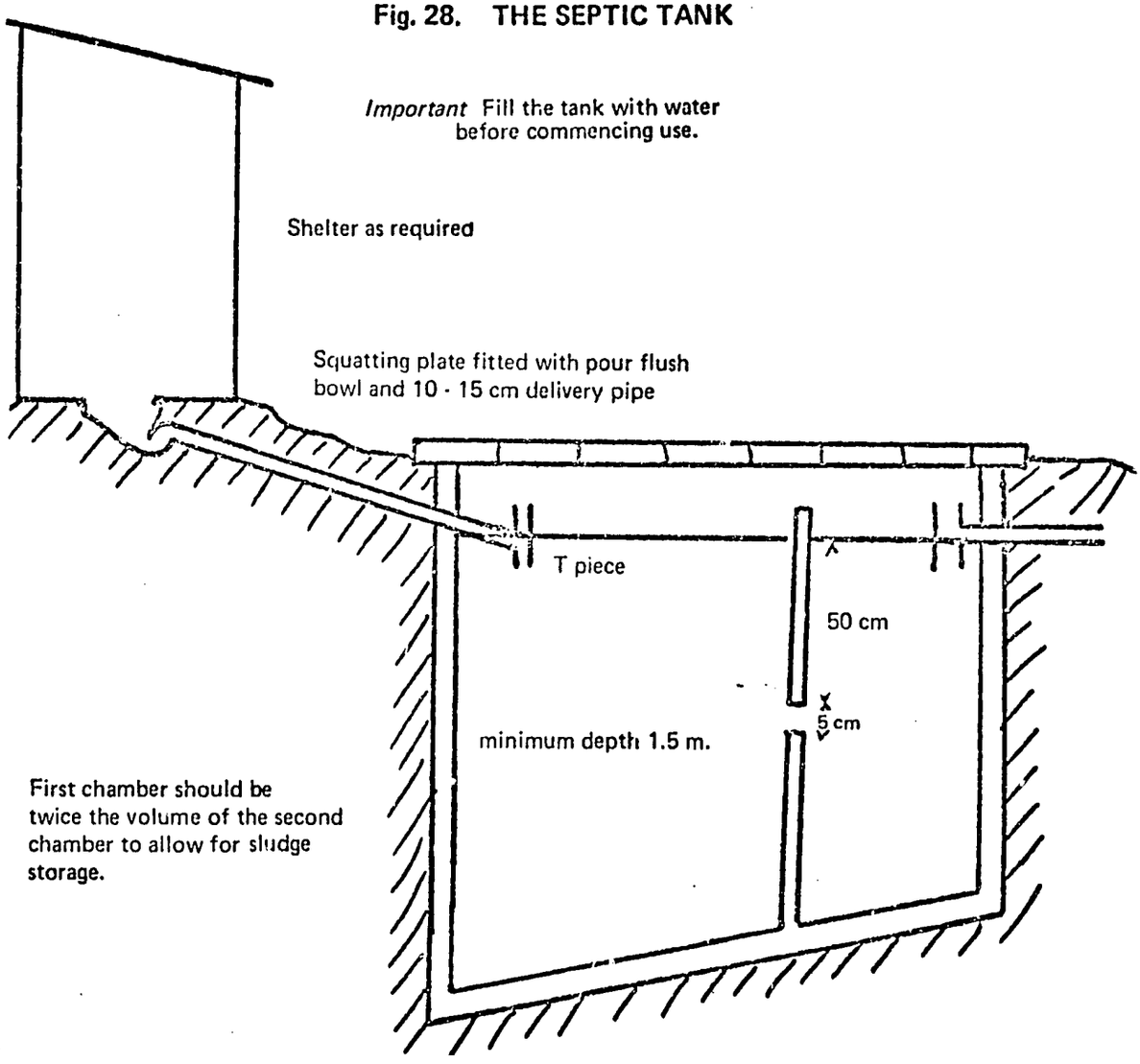


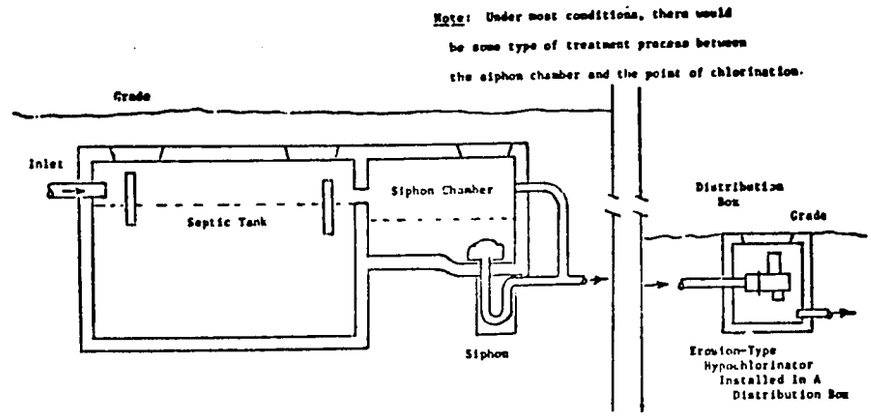
FIGURE 4



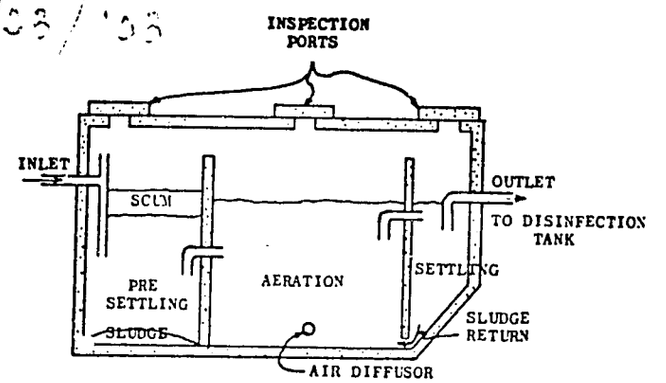
5. Septic tank.

Fig. 28. THE SEPTIC TANK





9. Cross-sectional sketch of a septic tank and a siphon chamber with a split-flow type erosion hypochlorinator installed in distribution box for final disinfection of the treated wastewater.



8. Typical aerobic unit.

HOLD TANK

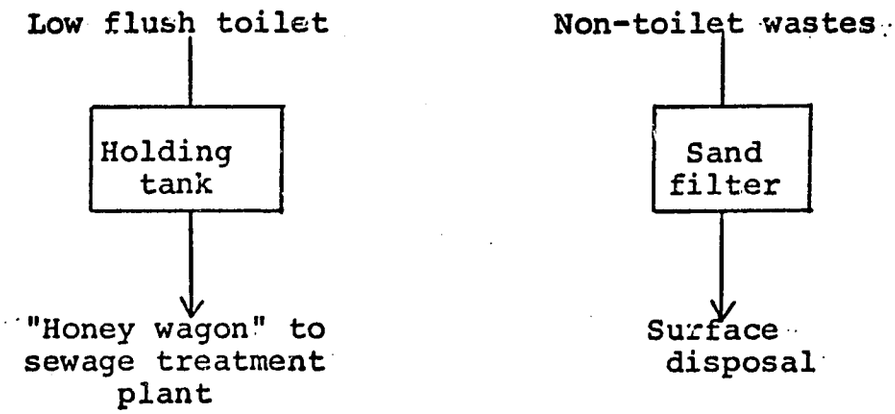


FIGURE 7

GRINDER PUMP TO REMOTE DISPOSAL AREA

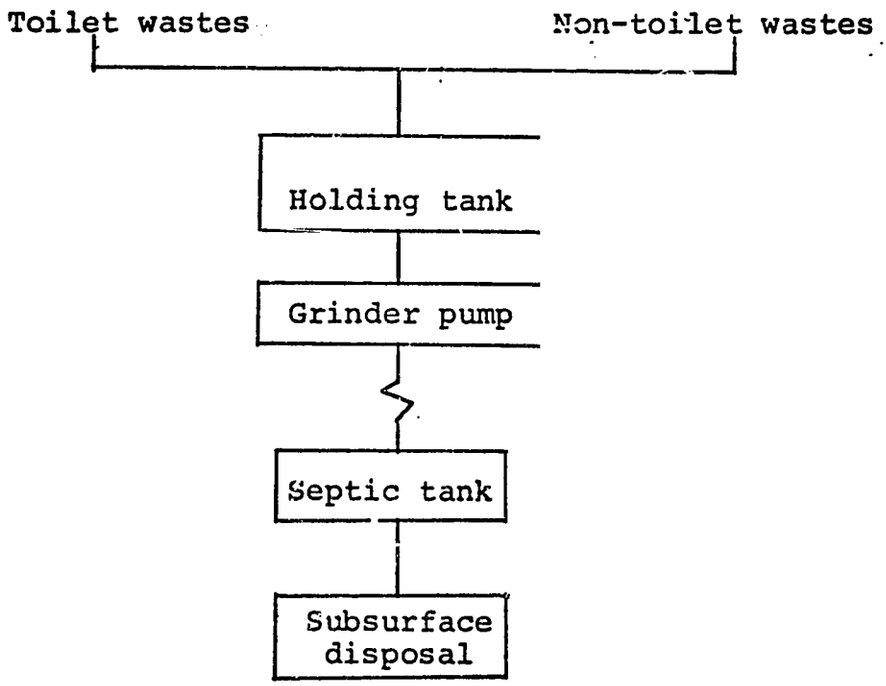


FIGURE 8

E. Sub-surface Systems

Six systems comprised of septic tanks and sub-surface disposal have been constructed, one is presently under construction, and two are scheduled for construction in the near future. These include sand filters and sand trenches with daylight outlets and drain fields dependent upon the absorptive capacity of the soil.

The sand filters are similar in design to those previously mentioned in connection with the aeration units, being constructed of concrete blocks and having an area of 48 square feet.

The sand trenches were designed for a loading factor of 30 gpcd and a transfer surface area of 2 sq. ft./gal. Parallel trenches were constructed, and flow control was provided at one installation in order to permit a comparison between continuous and intermittent loading.

The trench is 2½ feet wide and 3½ feet deep, with a 12 inch layer of sand in the bottom. Sand was also placed along the sides of the trench, leaving a core 14 inches wide and 18 inches deep to be filled with No. 9 washed stone. The effective area of the sidewall transfer surface is therefore 18" x 2, or 3 sq. ft. per lineal foot of trench. The distribution pipe is placed above the system in a layer of No. 6 stone. Twelve inches of backfill is provided.

A typical installation, serving two people, consists of a flow control device and two 20-foot trenches, followed by three feet of sand, five feet of No. 9 stone, and five feet of No. 6 stone, to daylight. Total cost of the system excluding housing improvements is estimated at $600.

One homesite has been provided with a "narrow-deep trench" disposal system as described by McGauhey and Winneberger.[3] The system serves a family of two, and consists of a septic tank, flow control, and two parallel trenches, each 50 feet in length. The cost of the system was about $700 plus $220 for housing improvements. The cross-sectional area of the trench is described as follows:

1. Total trench dimensions: 36" deep x 18" wide
2. A 4" layer of No. 9 stone in bottom
3. Sixteen inches of No. 9 stone along trench walls
4. A 16" x 6" core of No. 6 stone
5. Eight inches of No. 6 stone on top, with distribution pipe at centerline
6. Eight inches of backfill

The effective area of the absorption field in 2 x 16", or 2 2/3 square feet per lineal foot of trench.

Four inches in trench depth can be eliminated by use of a trapezoidal trench. One such prototype has been constructed, and a second one will be completed in the near future. In the installation already completed, total

trench depth is 32 inches. Top width is 30 inches, and bottom width 6 inches. A four-inch layer of No. 9 stone was placed in the trench bottom and along the side walls to a depth of 24 inches. The V-shaped core was filled with No. 6 stone with the distribution pipe placed two inches below the surface, at center-line. Eight inches of backfill was provided.

The area of the inter-face below the bottom of the tile is approximately 2 2/3 square feet per lineal foot. However, since this surface is inclined, the effective area can be considered to be equal to the vertical component or 2 1/3 square feet per foot.

The existing installation, which serves six people, consists of a 300 gallon septic tank and two 50-foot trenches. Therefore, only about 1 1/3 square feet of effective surface area per gallon of sewage has been provided. The limited space available prevented the installation of the additional 50 to 60 feet of trench required to conform with the 2 square feet per gallon design criteria. The cost of this installation (septic tank and disposal system) is estimated at $650.

IV. Conclusions

Probably the most important contribution of the Prototype Study to date is the acceptance of exclusion from the various treatment systems of all waste except human excreta. Since volume is a critical consideration in the design of sub-surface systems, this action has allowed the installation of systems where compliance with Code design was impossible, by reducing the size requirements of the installation. It has also permitted the use of proprietary devices designed specifically for the treatment of human waste.

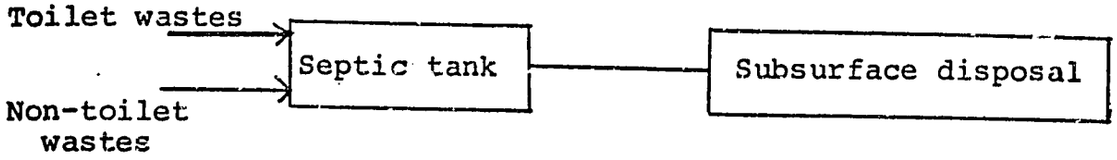
The cost of providing space to house the various units, or that portion which is within the home, varies from case to case. Eliminating these costs from consideration, it can be seen that the initial cost is considerably less for the incinerator toilets than for any of the other systems installed. The monthly operating cost of $2.00 must be considered. However, the costs associated with servicing septic tanks and drainfields are likely to approach, or even exceed, this figure.

Some concern was held regarding the acceptability of the incinerators prior to their installation. This concern appears to have been unfounded. The incinerators, as well as all other prototypes, have experienced excellent acceptability. Only one family has expressed dissatisfaction, and this apparently was an attempt to obtain a larger public assistance payment to compensate for the additional expense.

While the gas unit costs less initially, the electric incinerator appears to have a better maintenance record. Operating costs are about the same. The maintenance problems encountered with the gas units have not been serious, but the households associated with the Study usually do not include a person capable of keeping the equipment in operating condition.

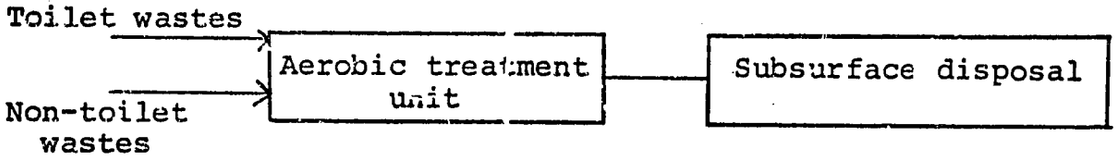
OPTIONS CONSIDERED FOR YEAR-AROUND HOUSES IN GOOD TO POOR SOIL

Septic Tank - Subsurface Disposal



Initial cost	$270 installed	$250 to $830 based on percolation rate
Yearly cost	$ 10 per year	$0
Lifetime	40 years	20 years

Aerobic Treatment Subsurface Disposal



Initial cost	$680 installed	Same as above
Yearly cost	$ 40 per year	Same as above
Lifetime	30 years	30 years; 40 years

FIGURE 11

RECYCLING

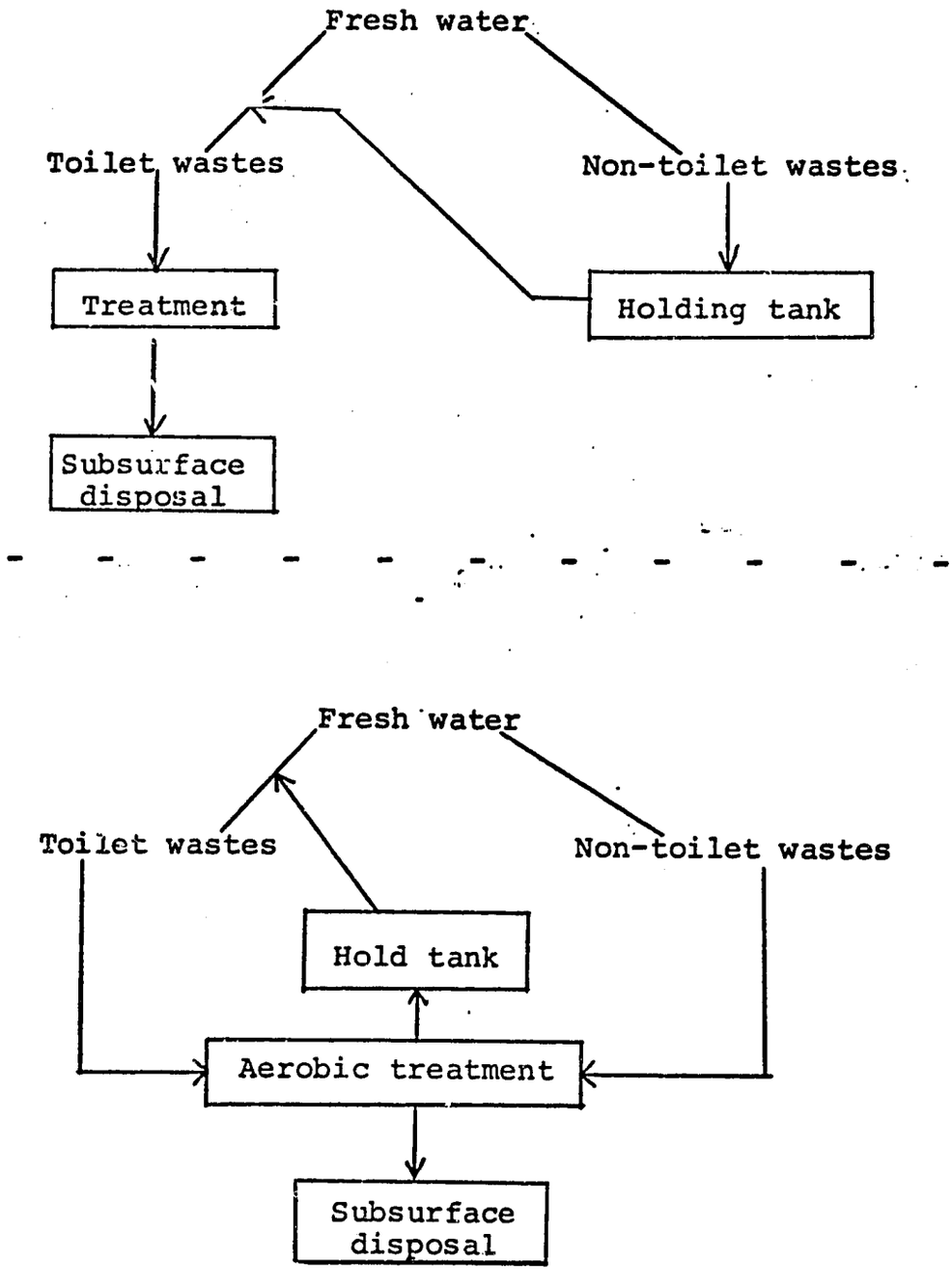
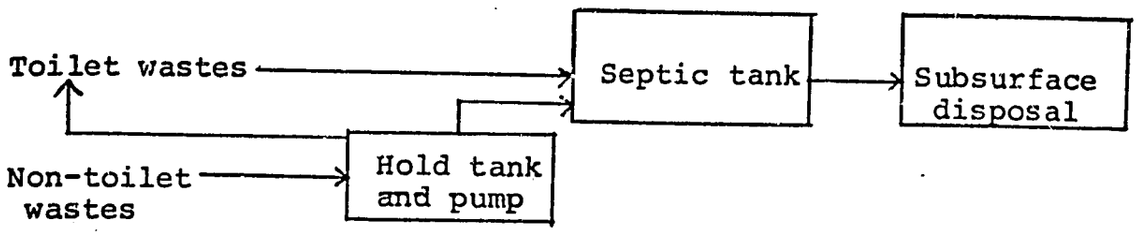


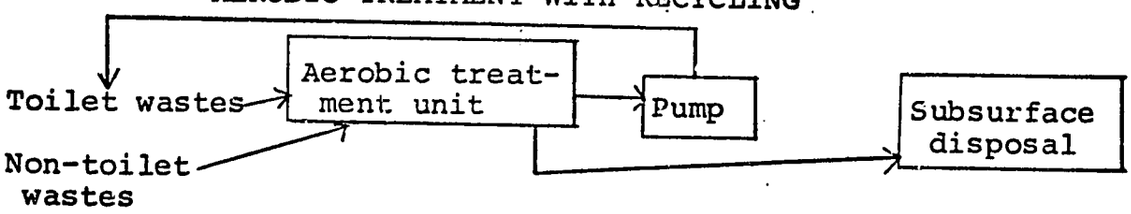
FIGURE 9

SEPTIC TANK - SUBSURFACE DISPOSAL WITH RECYCLING A FLUSHING FLUID



Initial costs	$250 installed	$230 installed	Same as Fig.11
Yearly costs	$ 10 per year	$ 10 per year	Same as Fig.11
Lifetime	20 years	40 years	20 years

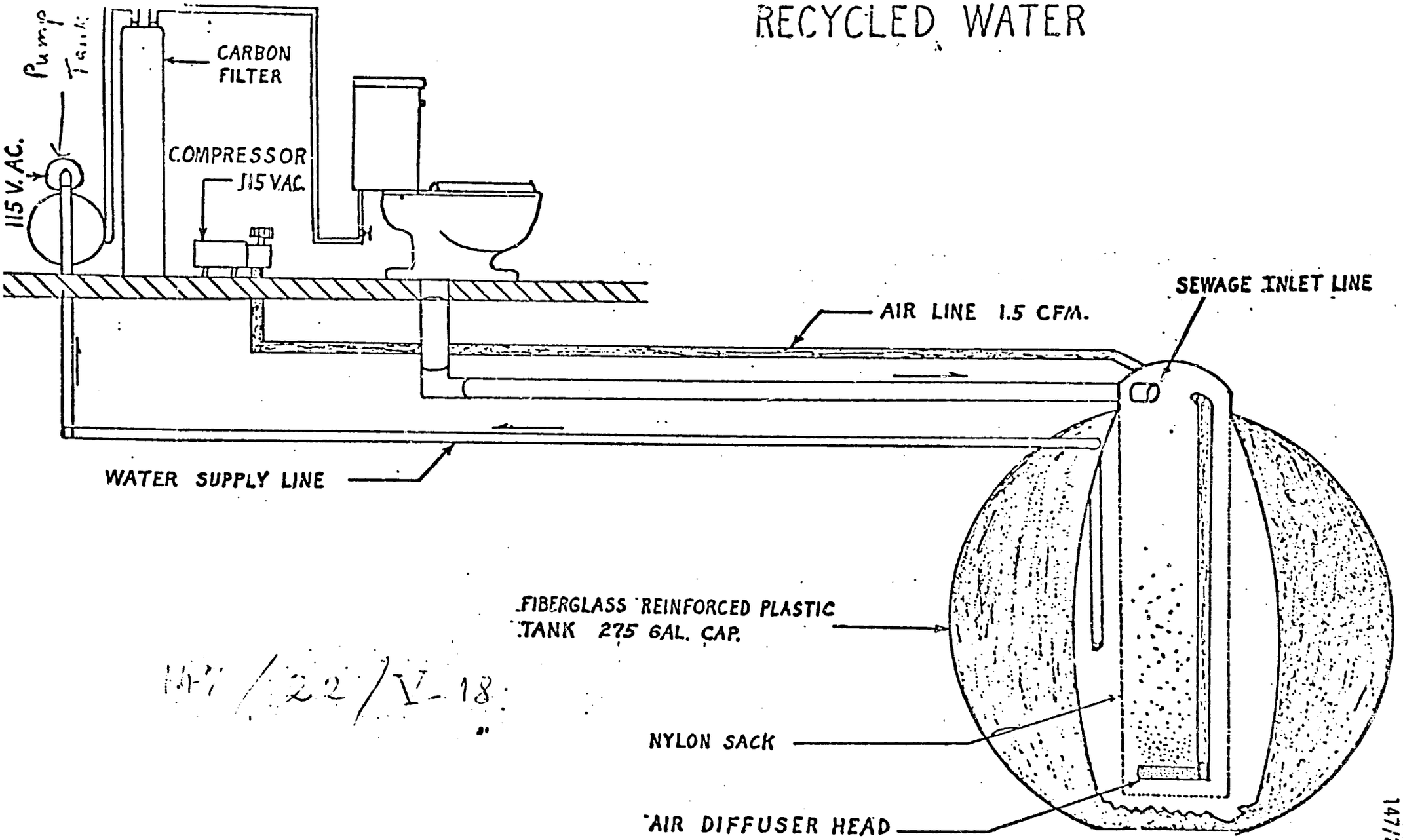
AEROBIC TREATMENT WITH RECYCLING



Initial costs	$680 installed	$100	$165 to $550 based on percolation rate
Yearly costs	$ 40 per year	$ 10/yr	$ 10 per year
Lifetime	30 years	20 years	20 years

FIGURE 12

AEROBIC SEWAGE DISPOSAL UNIT
RECYCLED WATER



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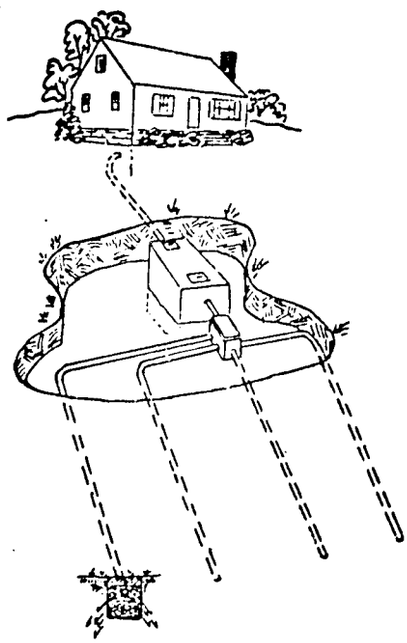
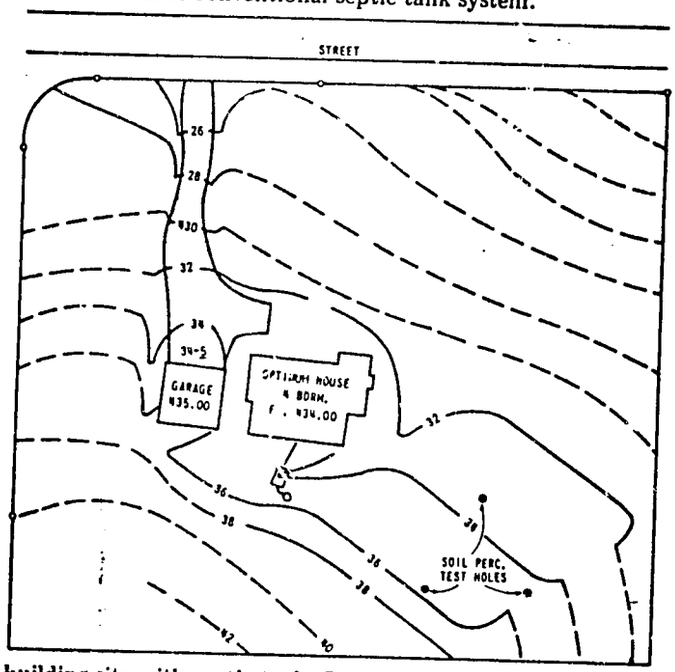
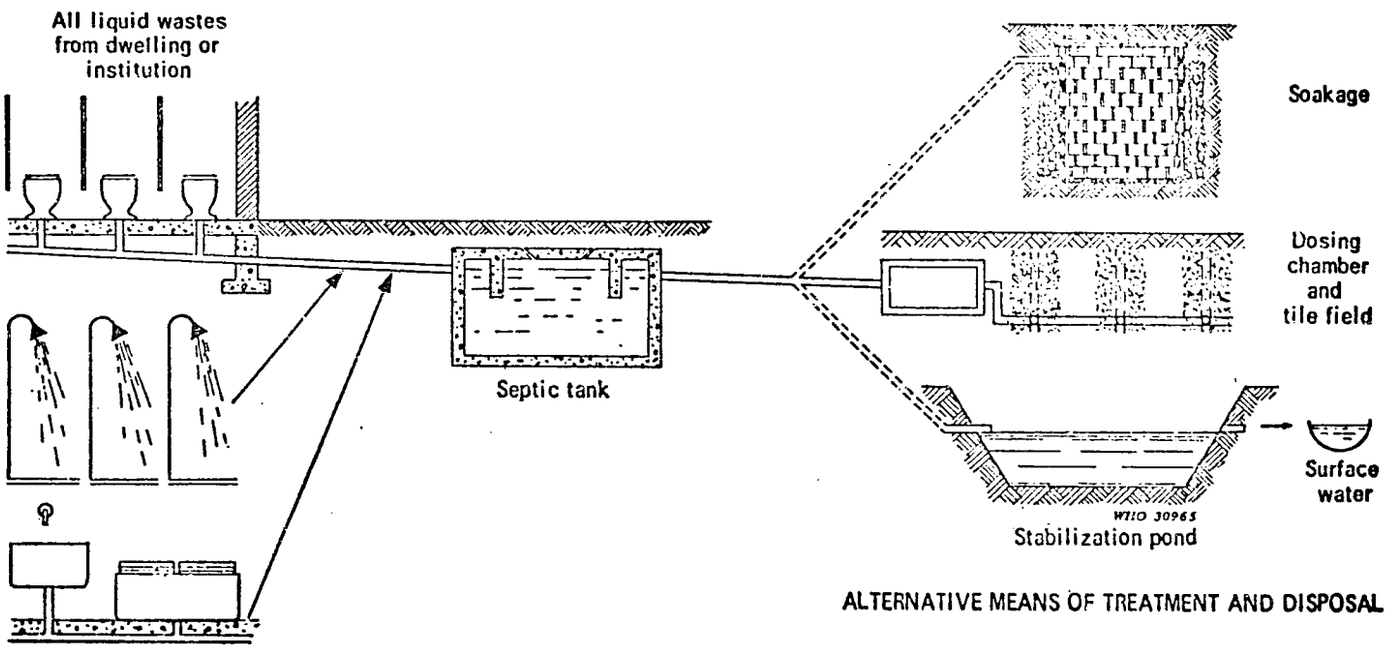


1. A conventional septic tank system.



2. Typical building site with septic tank, flow diversion valve, and split drainfield.

FIG. 32 SEPTIC TANK AND ALTERNATIVE EFFLUENT TREATMENT/DISPOSAL MEASURES



Check list

1. Is a piped water supply available ?
2. Does the septic tank provide 8-12 hours detention time ?
3. Is the septic tank effluent given secondary treatment ?

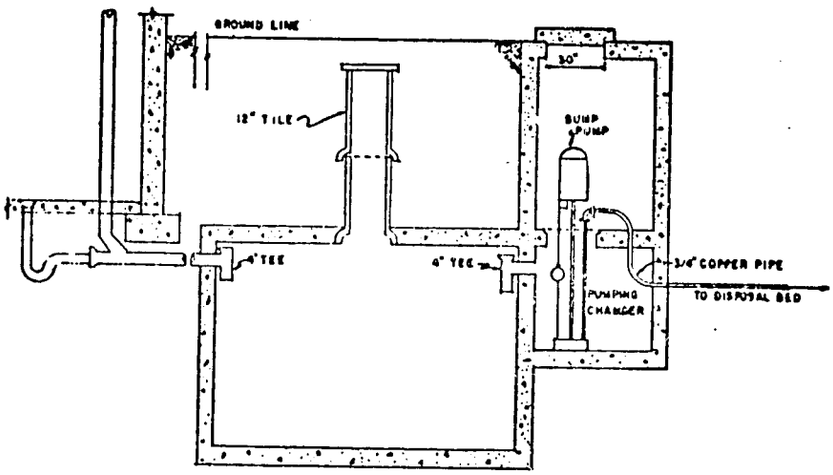


Fig. 1 The septic tank and pumping chamber as installed at the sheep farm house on the NDSU farm campus in 1948.

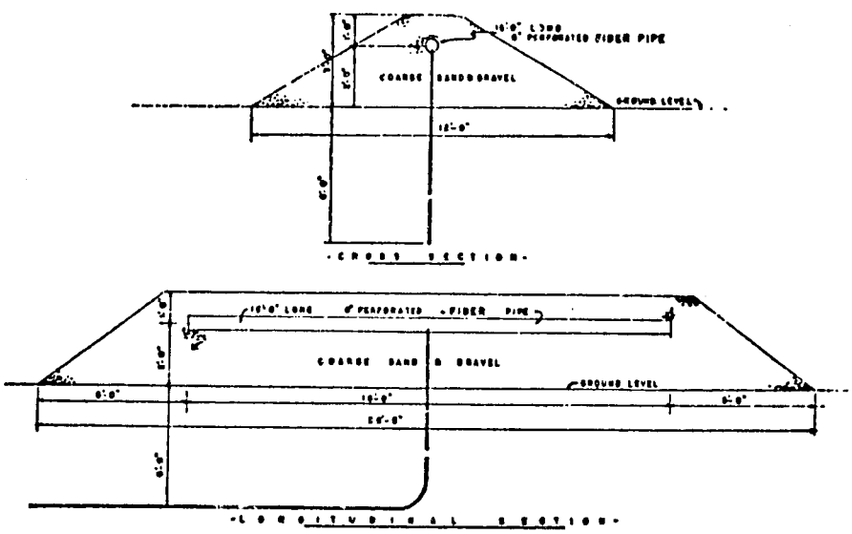


Fig. 2 The drain field as installed on the first Nodak System on the NDSU farm campus.

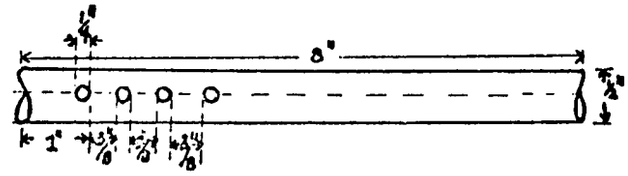


Fig. 1 Schematic diagram of 8 in plexiglas tube showing spacing arrangement of 1/4 in diameter holes (not to scale).

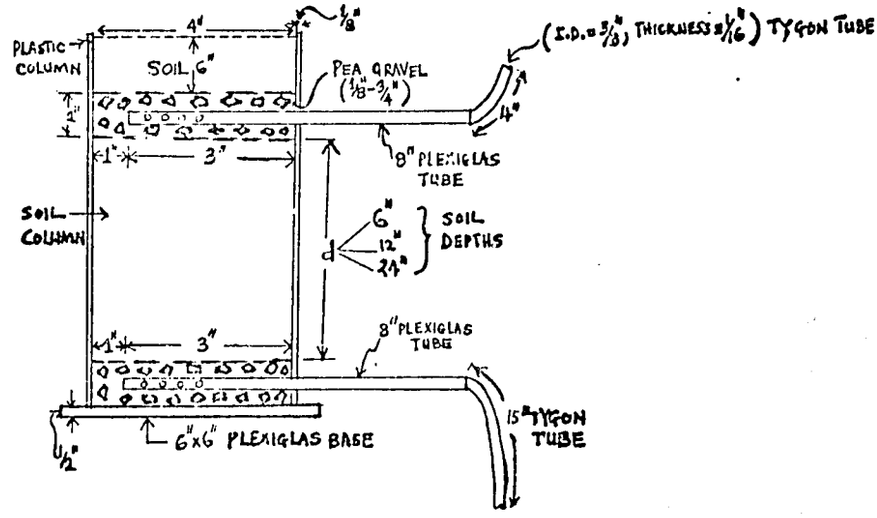


Fig. 2 Shows schematic diagram of soil and gravel arrangement inside columns (not to scale).

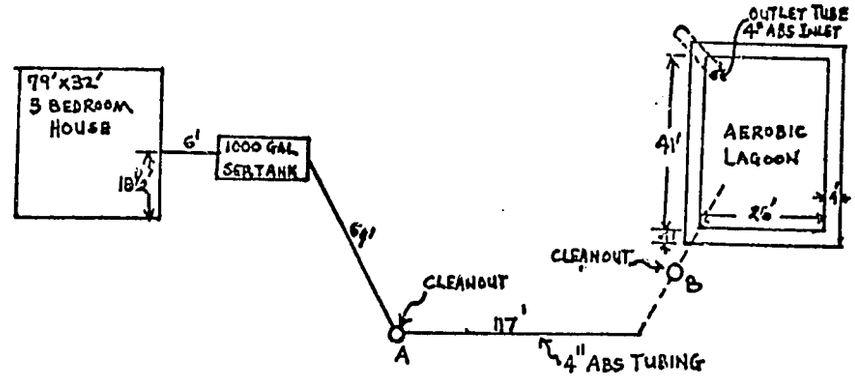


Fig. 3 Schematic diagram showing location of septic tank and aerobic lagoon (not to scale).

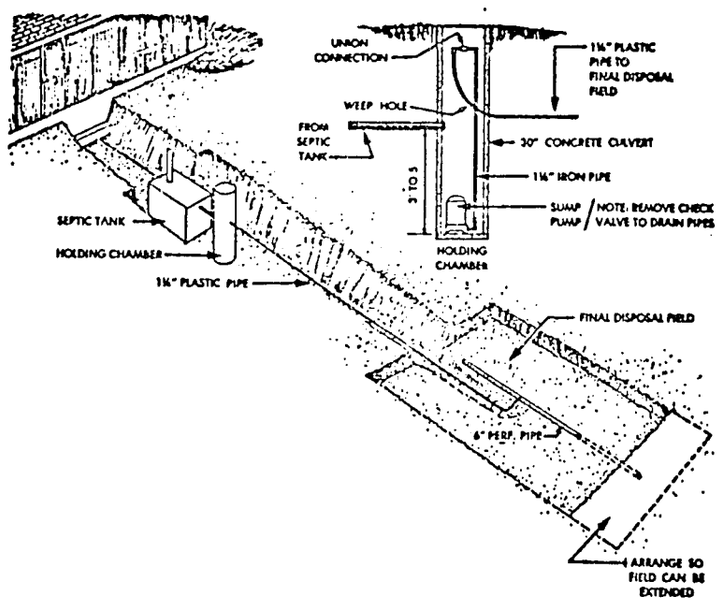


Fig. 3 The Nodak Sewage System as installed on farms today.

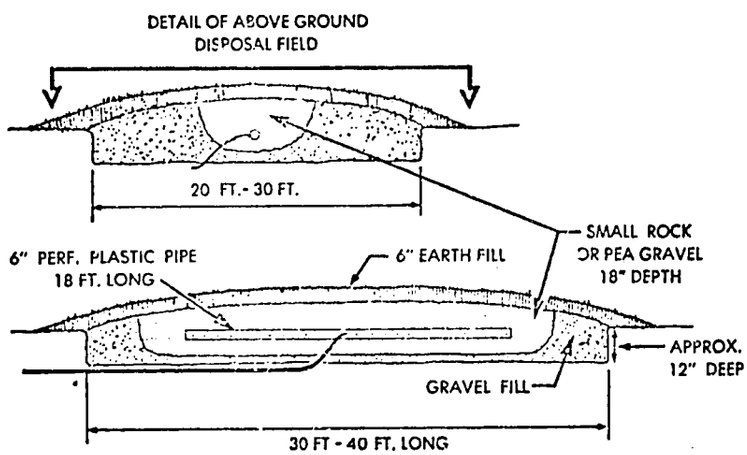
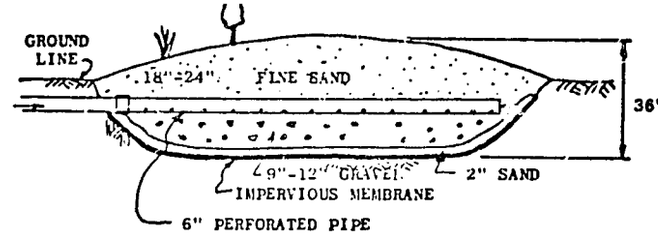


Fig. 4 The final disposal field as used today.



APPLICATION RATES

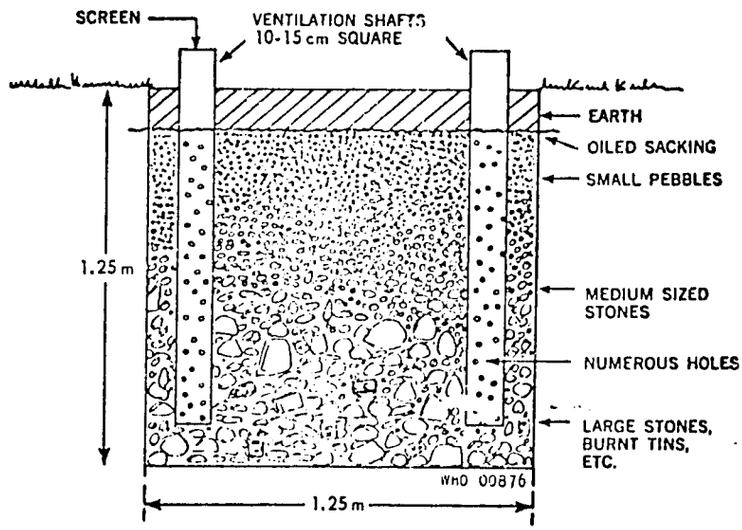
	SEPTIC	AEROBIC
SUMMER	0.1 GPD/FT^2	0.2 GPD/FT^2
WINTER	0.02	0.06

INCREASE 50% FOR FULL VEGETATION

0.1 GPD/FT^2 = 5 FT/YR

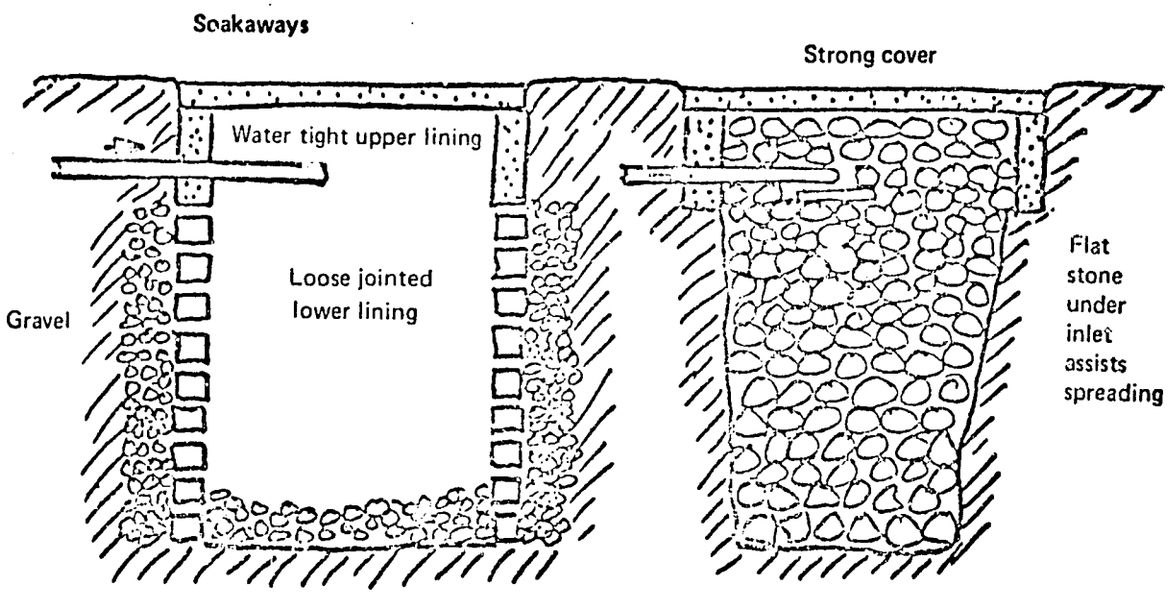
6. Evaporation-transpiration bed.

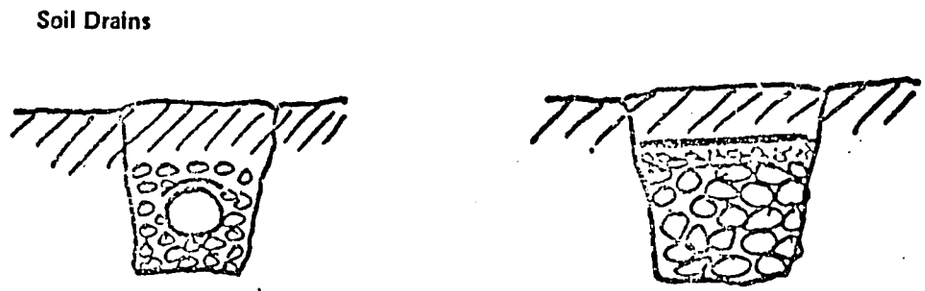
FIG. 25. SOAKAGE PIT

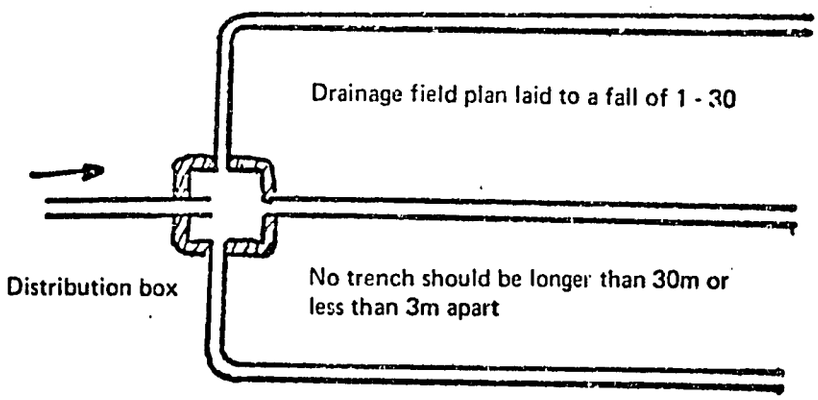


Adapted from: Canada, Department of National Health and Welfare (1967) *Environmental health in disaster*, Ottawa, p. 88.

Fig. 33. SOAKAWAYS AND SOIL DRAINS



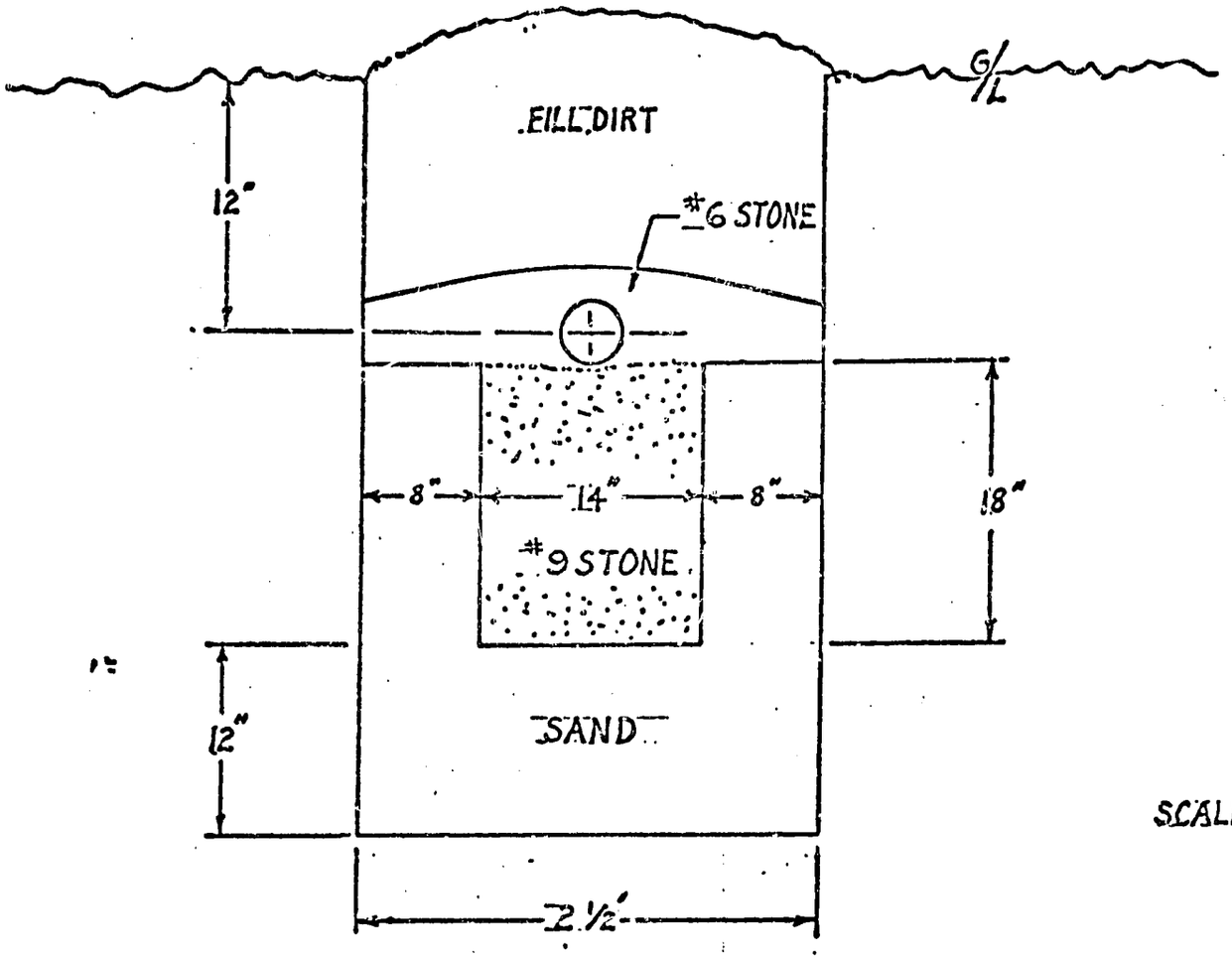




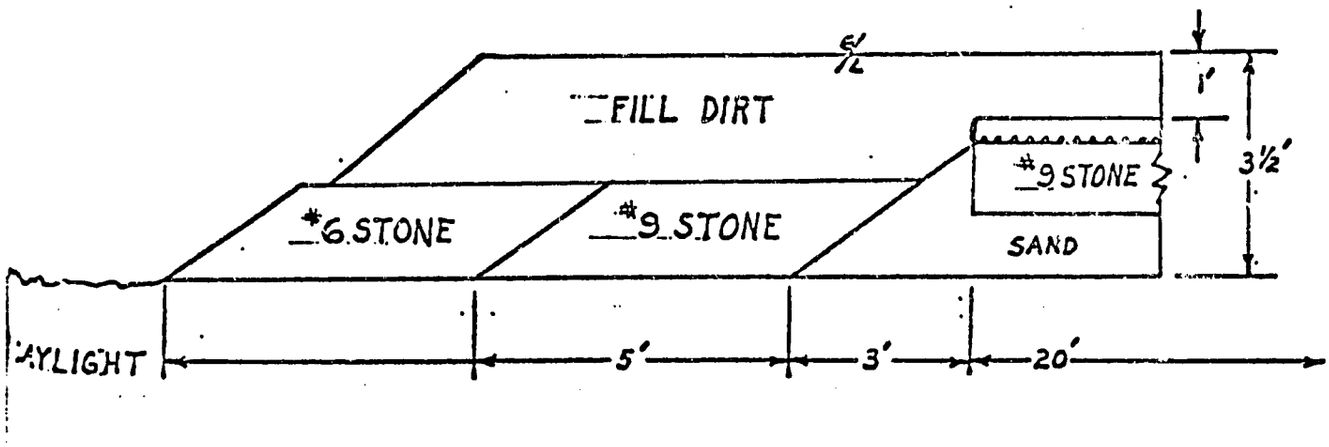
Trenches can curve to follow natural contours.
No trench should be less than 10 m from any large tree.

SAND TRENCH

156/22/V-23

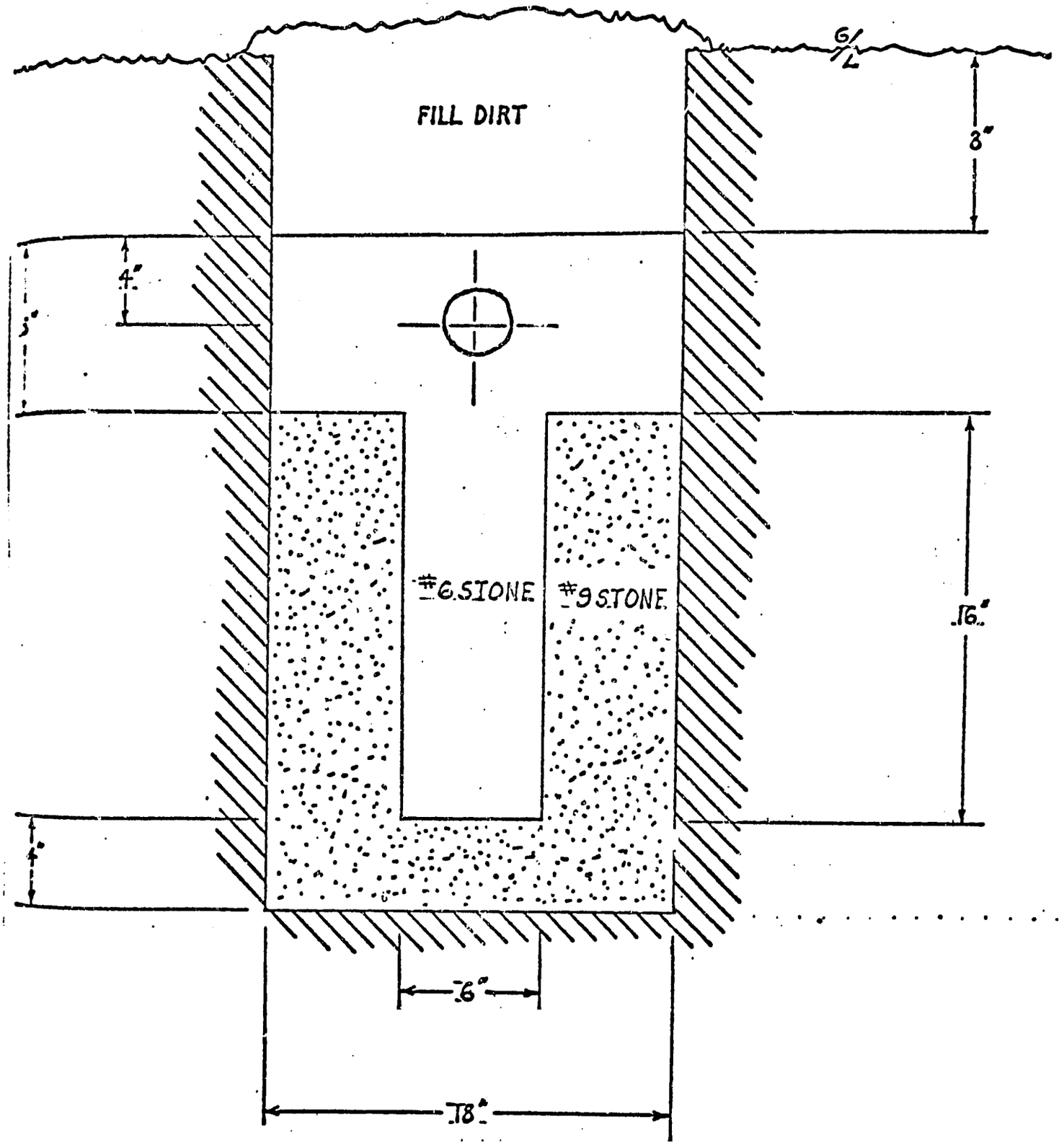


SCALE: 1"-1'0"



by W.C.J

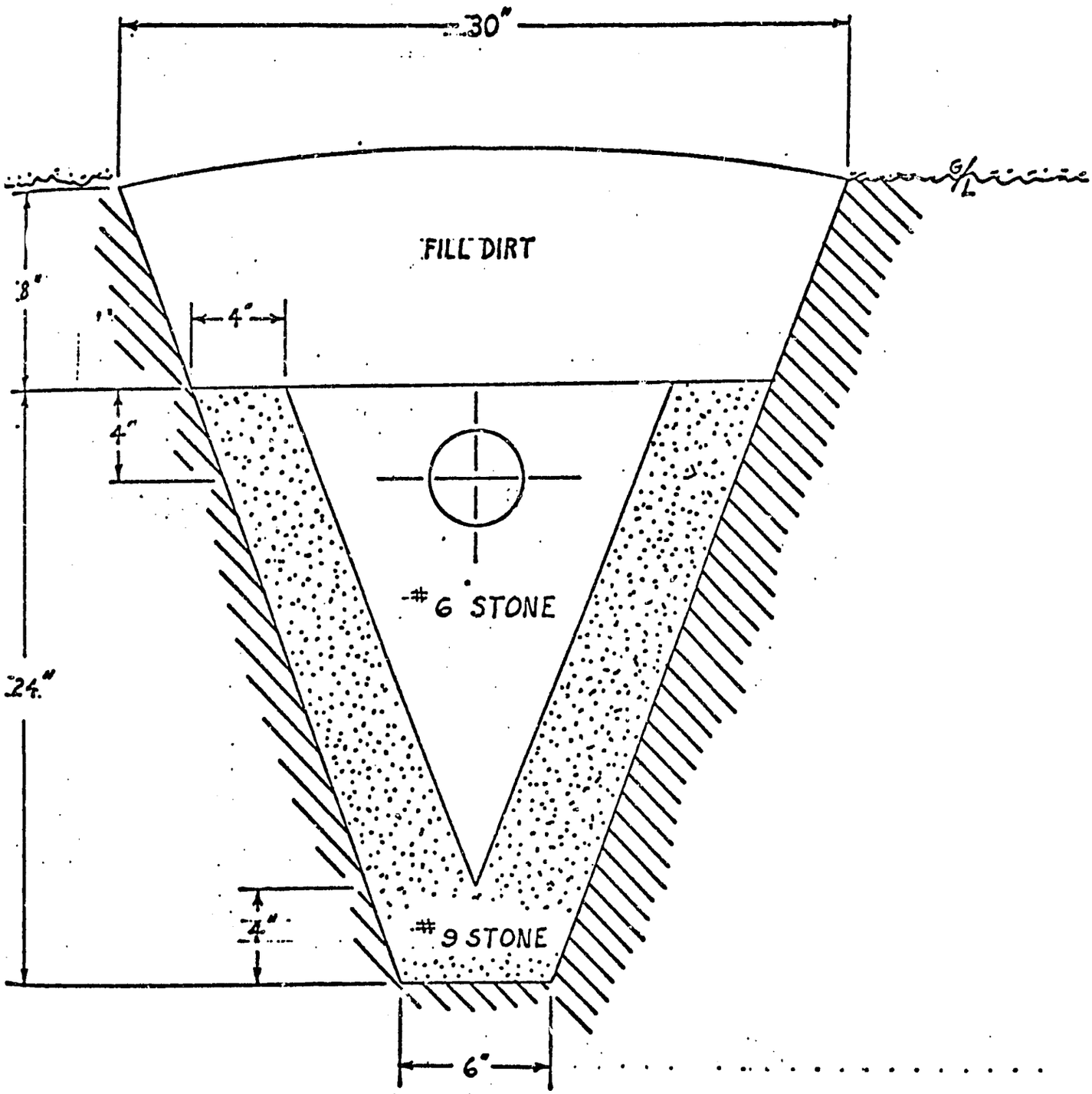
DEEP TRENCH



SCALE 1" = 6"
by W.C.J.

TRAPEZODIAL TRENCH

158/22/V-25



SCALE 1" = 6"
by W.C.J.

Fig. 34. BANKS CLARIFIER INSTALLED IN A FINAL SETTLING TANK

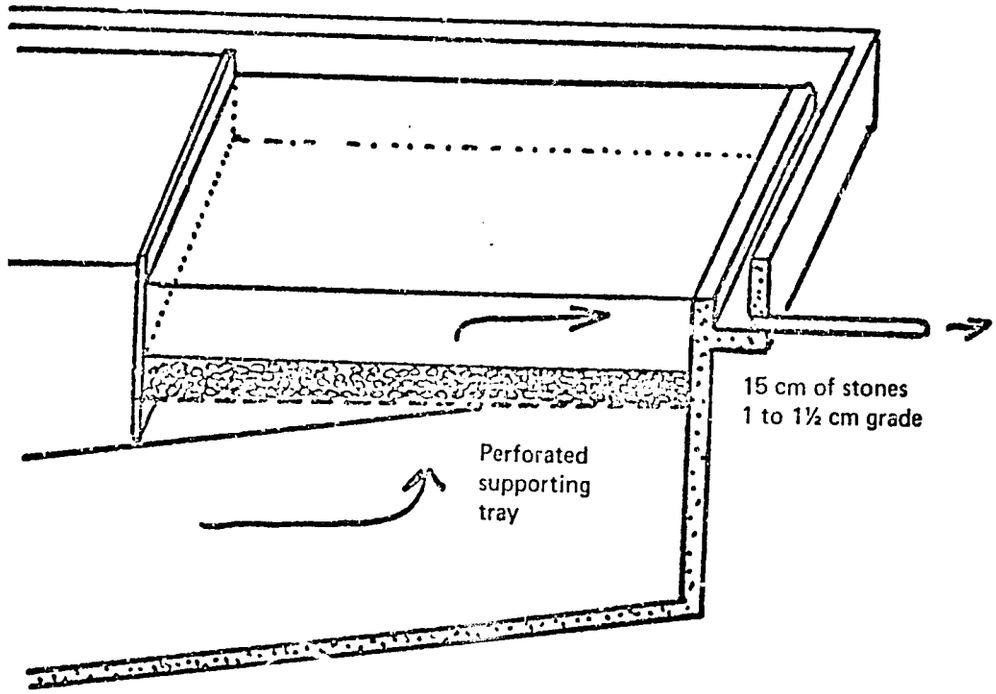
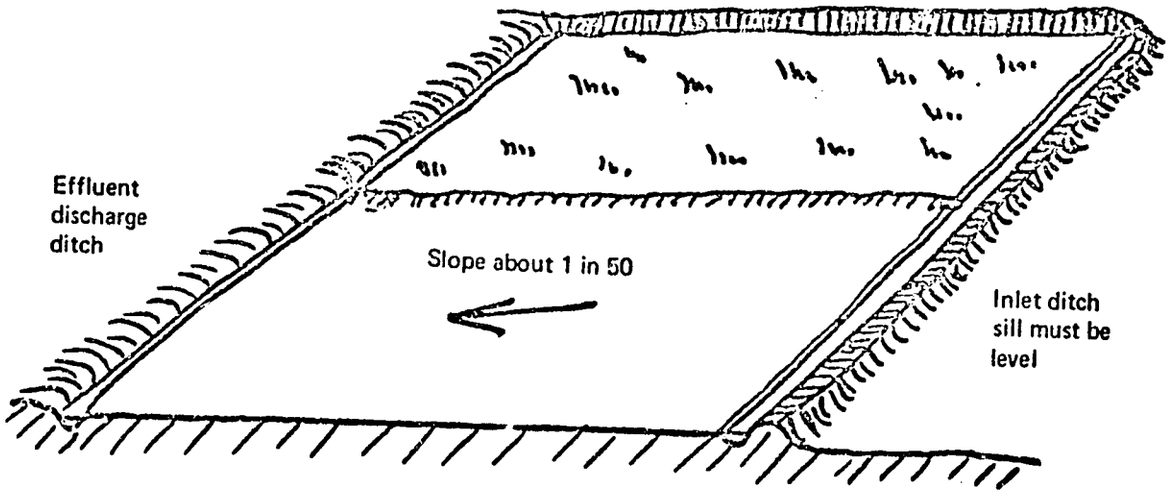
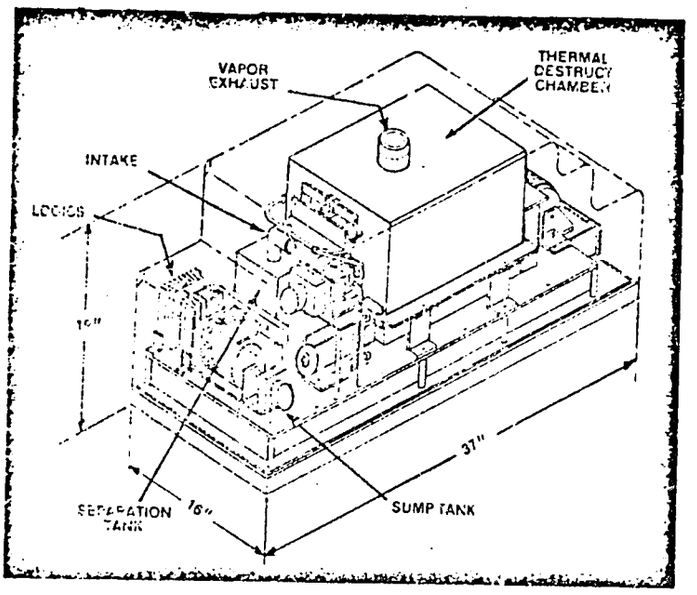
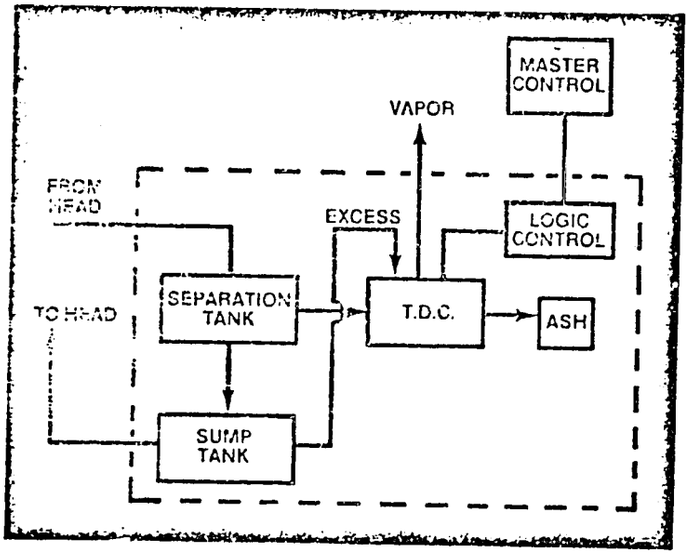


Fig. 35. GRASS PLOTS FOR FINAL EFFLUENT TREATMENT







Xpurgator II is a compact, fully solid-state, completely self-contained unit. Indicator and function controls may be remoted.

OPERATING CHARACTERISTICS

	% Reductions	
	Aerobic Treatment Unit	Septic Tank
BOD_5	70-80%	30-50%
Suspended solids	70-80%	20-40%
Coliform	$>10^6$/100 ml	$>10^7$/100 ml

Bathing → $<10^2$/100 ml

FIGURE 5*

INCINERATOR TOILET

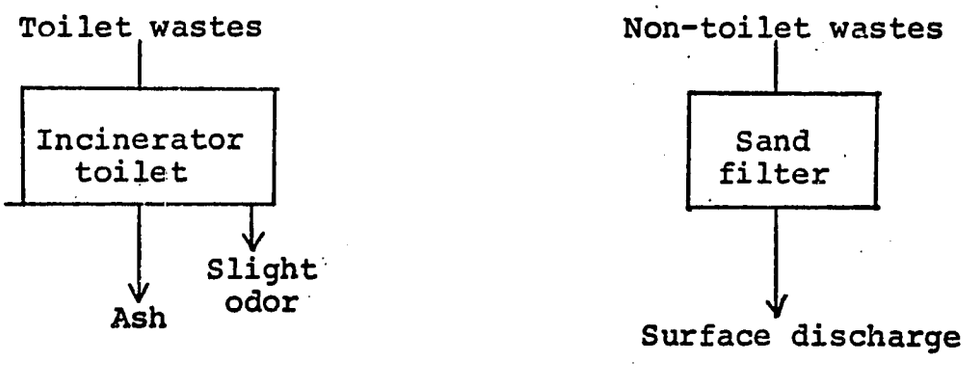
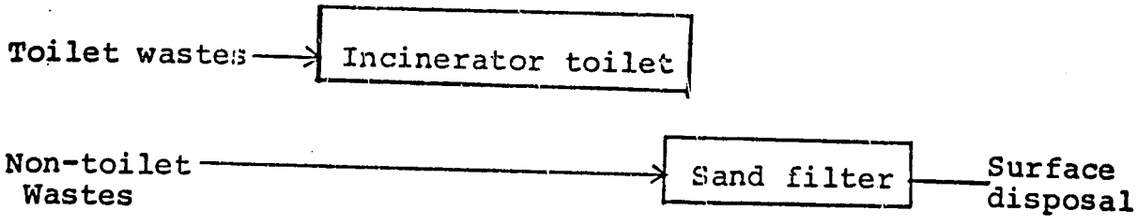


FIGURE 6

*H.A. Thomas et al, "Individual Household Sewage Disposal Systems, Developing Technology, Cost Analysis and Research Needs".

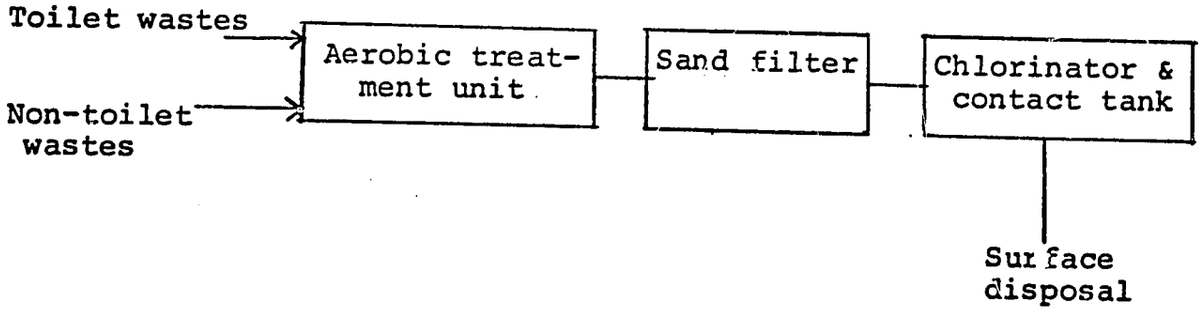
OPTIONS CONSIDERED FOR HOMES IN IMPERVIOUS SOIL

Incinerator Toilets with Sand Filter



Initial costs	$500	$200
Yearly costs	$.025/flush	$0/yr
Lifetime	30 years	30 years

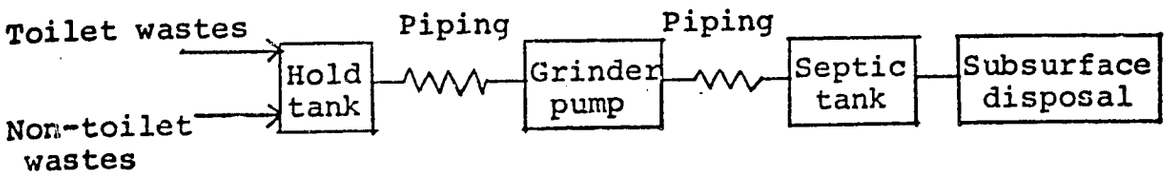
Aerobic Treatment with Same Sand Filter and Past Chlorination



Initial costs	$700	$400	$200
Yearly costs	$ 40	$0	$ 10
Lifetime	30 years	30 years	30 years

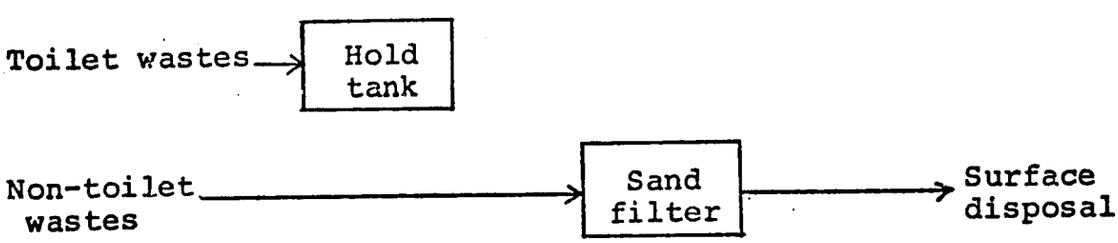
FIGURE 14

Grinder and Pump to Remote Disposal



Initial costs	$100	$200	$500	$4/ft	$400	$1200
Yearly costs	$0	$0	$ 5	$0	$ 10	$0
Lifetime	40 yrs	40 yrs	20 yrs	40 yrs	40 yrs	20 yrs

Hold Tank and Sand Filter

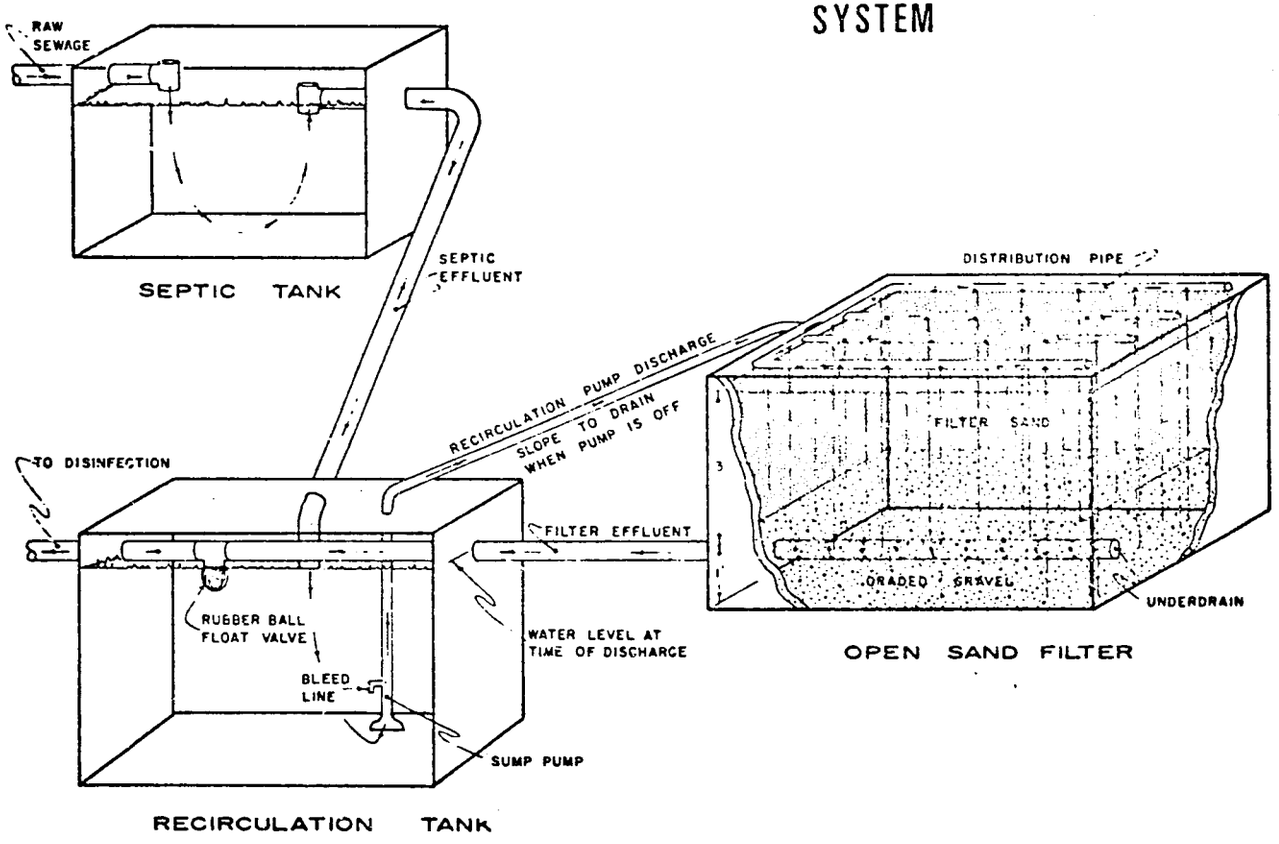


Initial costs	$225-500 based on required size	$200
Yearly costs	$ 30/cleanout	$0
Lifetime	40 years	30 years

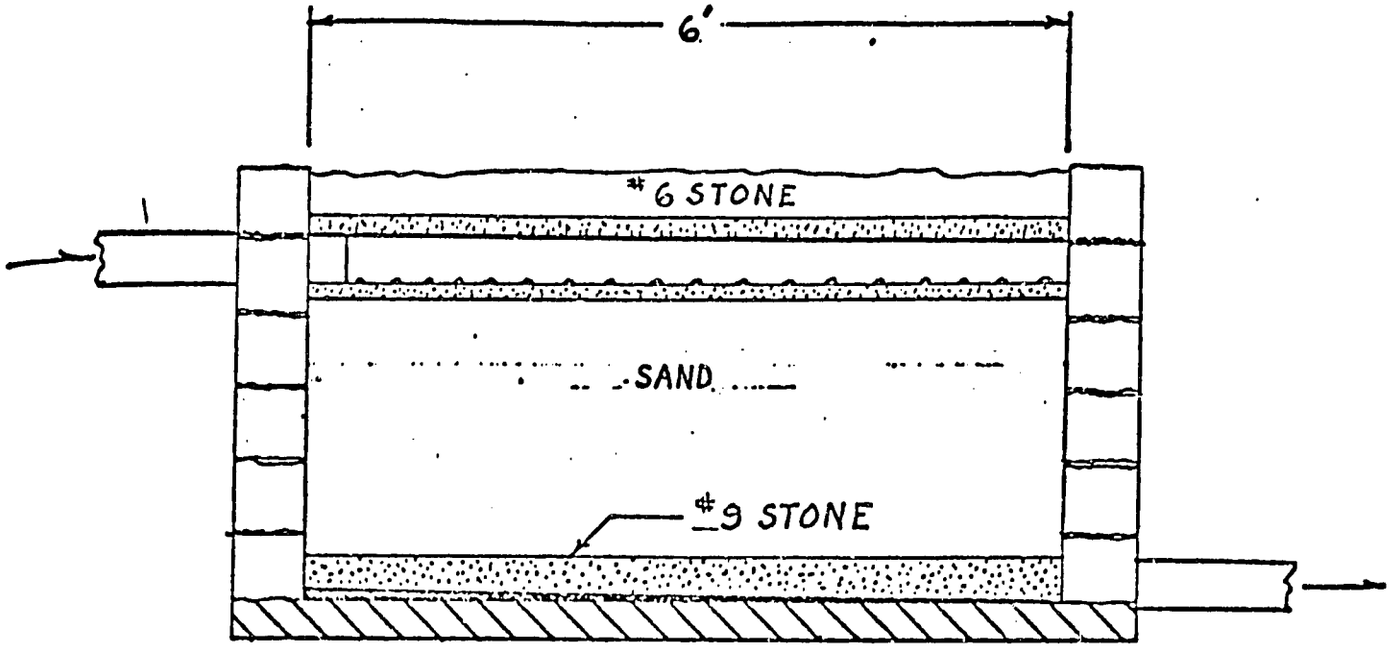
FIGURE 15

Figure 1

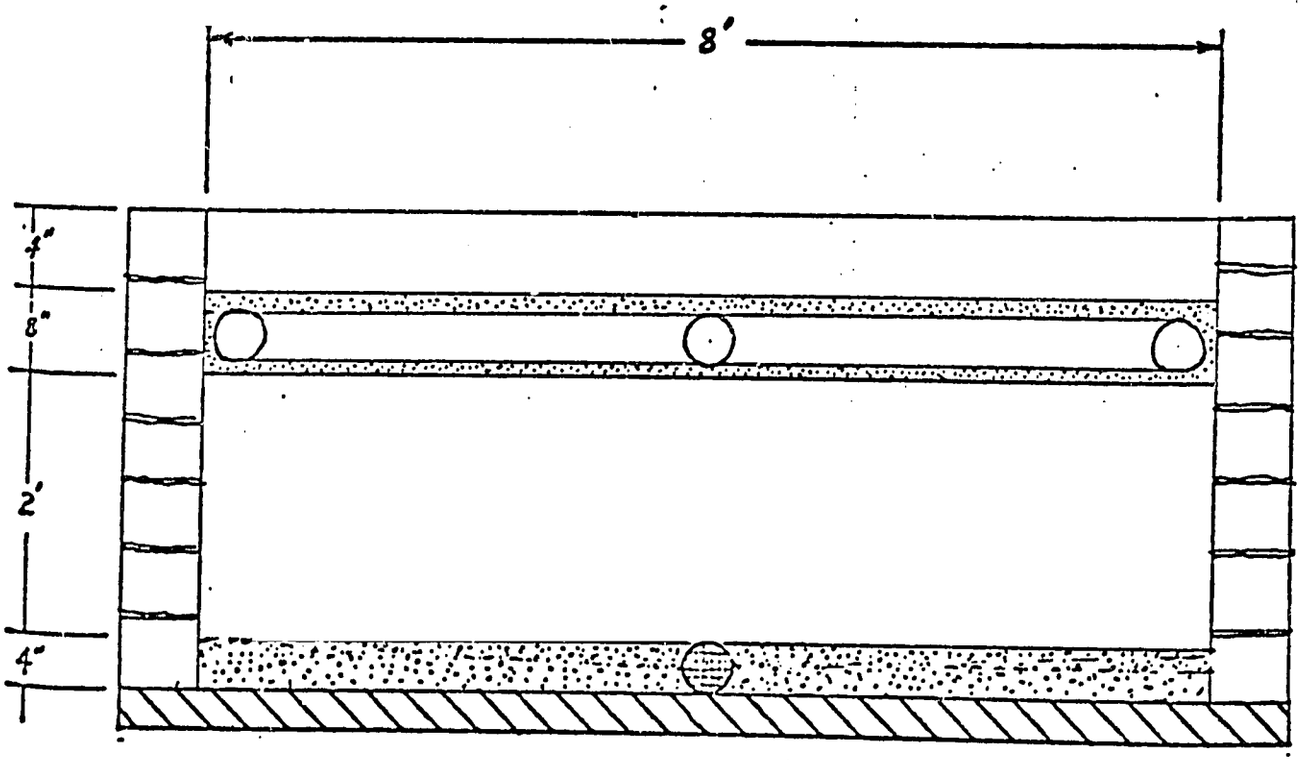
RECIRCULATING SAND FILTER SYSTEM



SAND FILTER



SIDE



END

Portable Toilets

Portable chemical toilets are very useful and provide economic toilet facilities for many occasions such as construction projects, parades, and other public events where large numbers of people congregate for a short period of time. These units are generally equipped with a toilet and urinal and are available for rental or lease from many commercial companies to include installation and routine servicing. Easily transported by truck, any number of these units can be dispersed rapidly to locations to meet the demands for emergency toilet facilities that meet public health standards. A typical unit is shown in figure 19.

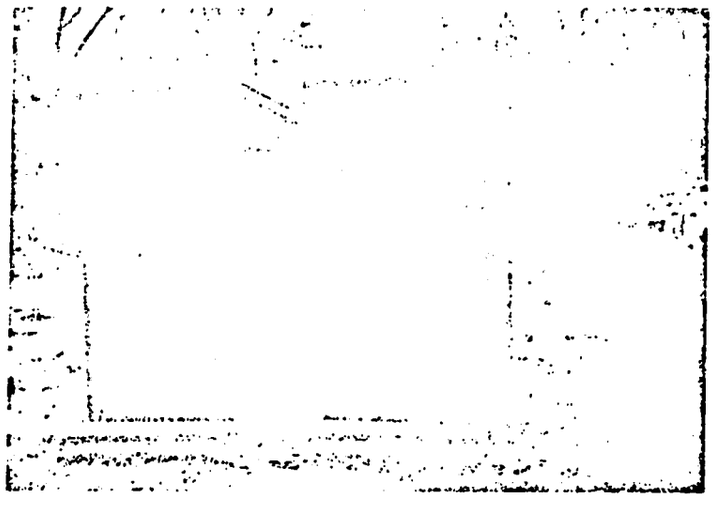


Figure 19.—Portable toilets.

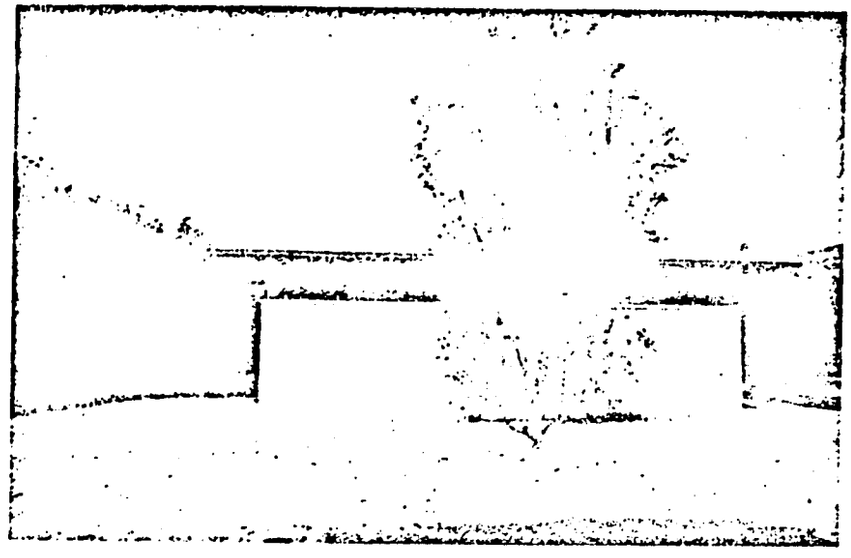


Figure 17.—Comfort station for campground.

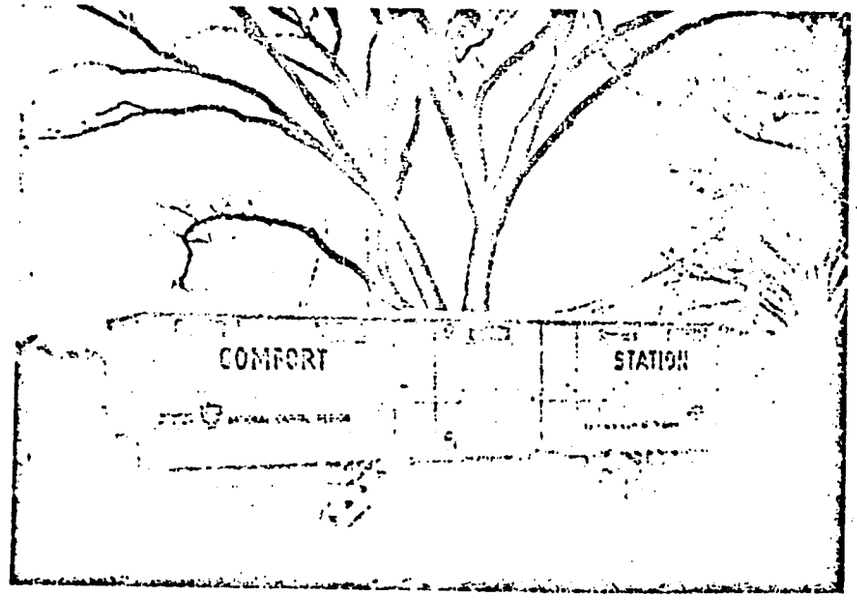
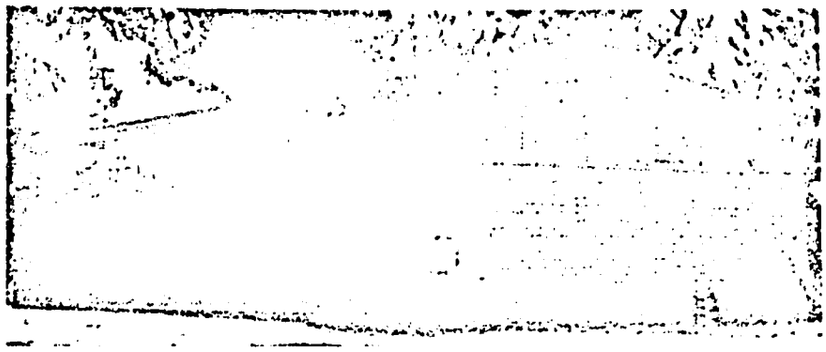
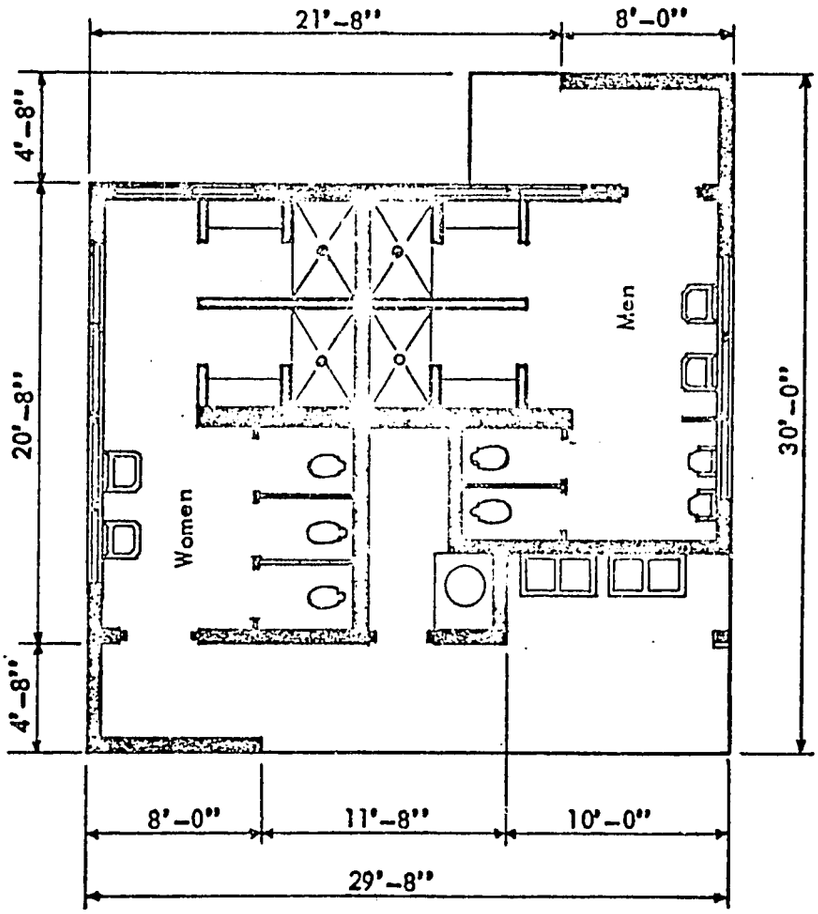


Figure 18. Mobile comfort station.



A comfort station of pleasing design and proportion intended for campgrounds, but one which might profitably be used at the smaller public swimming areas.
A fiberglass roof would make the interior brighter if this building were to be located in shaded areas.



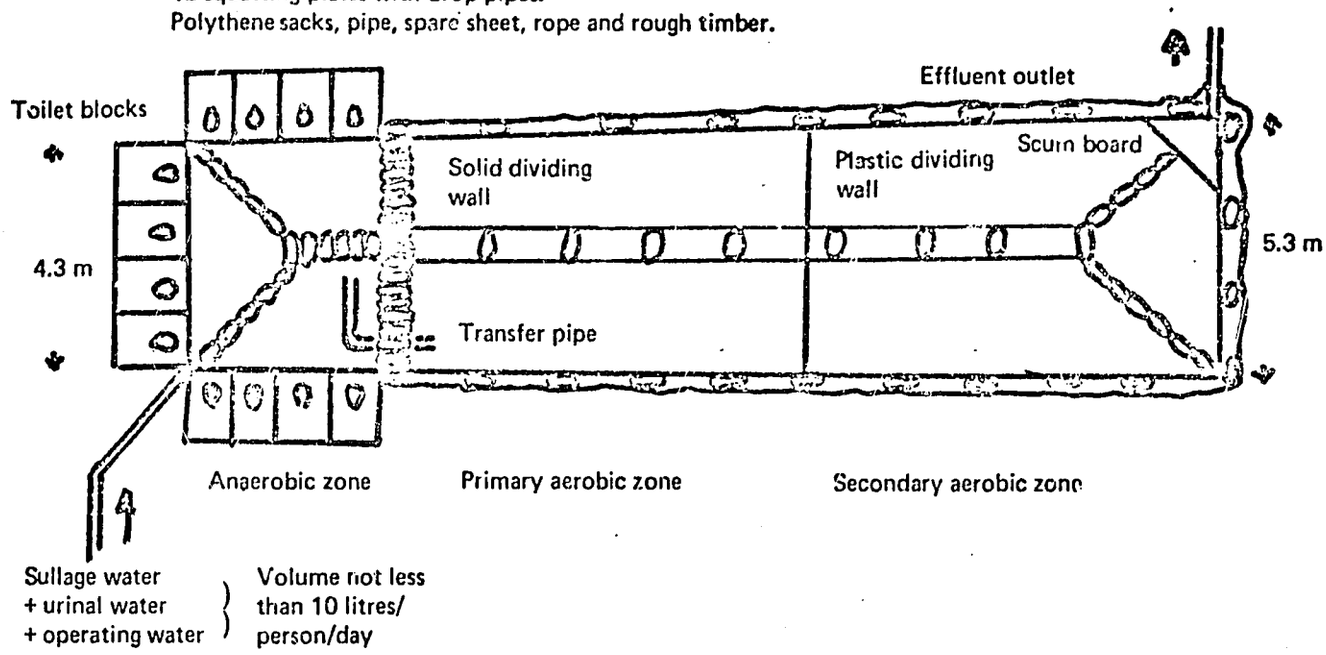
PLAN

Figure 16.—Layout of a permanent type comfort station.

Fig. 39. A UNIT SANITATION SYSTEM FOR EMERGENCIES

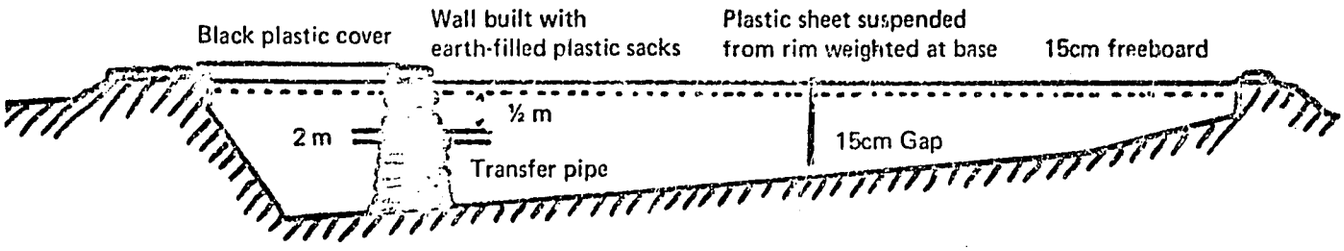
Basic Requirement for 200 People

1 sheet of black plastic film 20ft x 100ft.
12 squatting plates with drop pipes.
Polythene sacks, pipe, spare sheet, rope and rough timber.

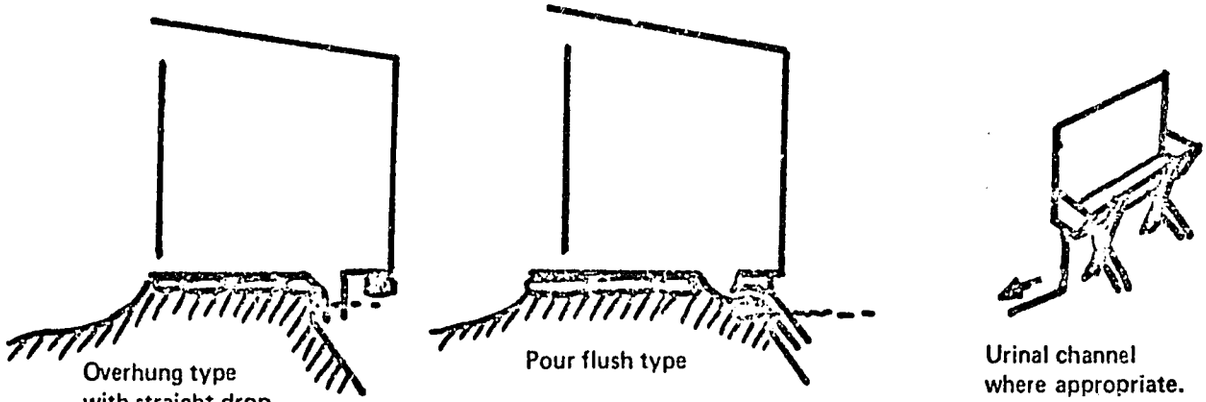


Safety note — perimeter or excavation must be fenced

Plan



Section



Toilet arrangements

Effluent quality depends on pollution load, adequate hydraulic flow and adequate sunshine.

Important Fill with water before use. Desludge anaerobic zone as necessary.

EXHIBIT 2 - FARM SEWAGE LAGOON SYSTEM

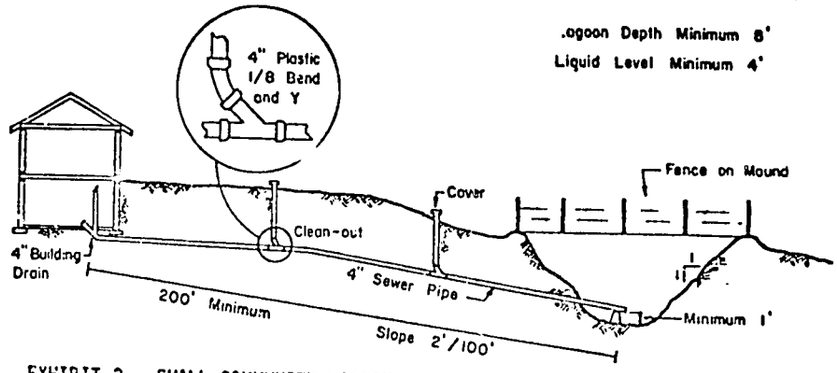
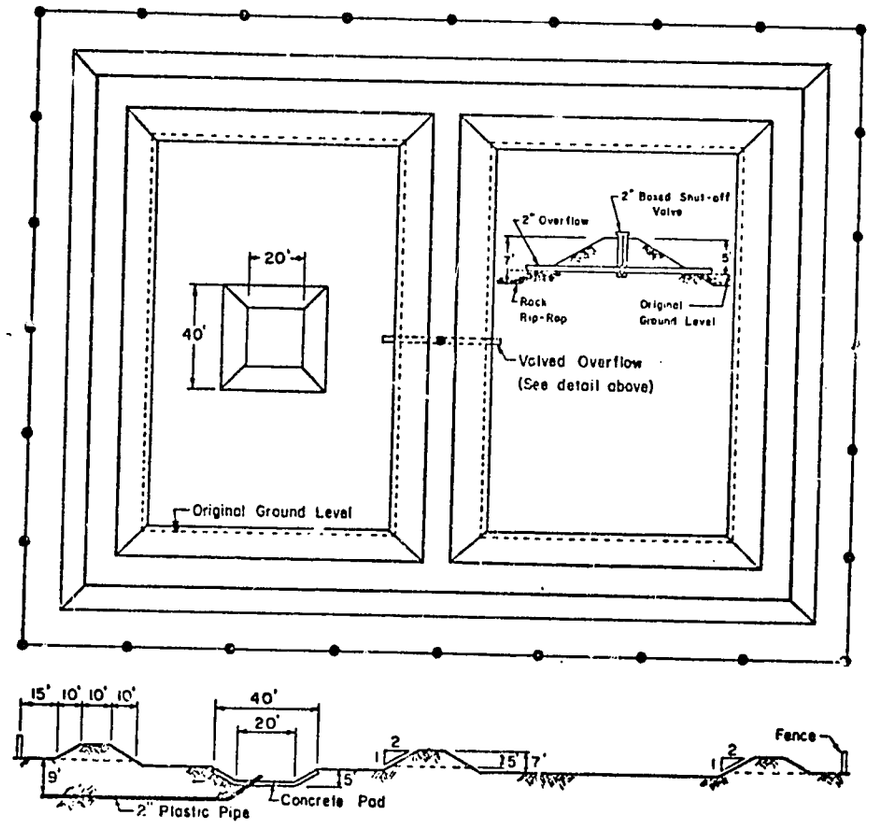
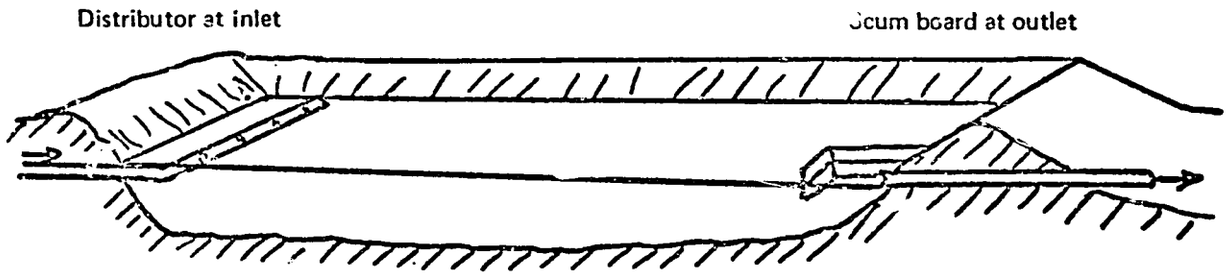


EXHIBIT 3 - SMALL COMMUNITY LAGOON



The author is: William Franko, Supervisor, Technical Services, Family Farm Improvement Branch, Department of Agriculture, Regina, Saskatchewan.

Fig. 30. AEROBIC STABILIZATION PONDS

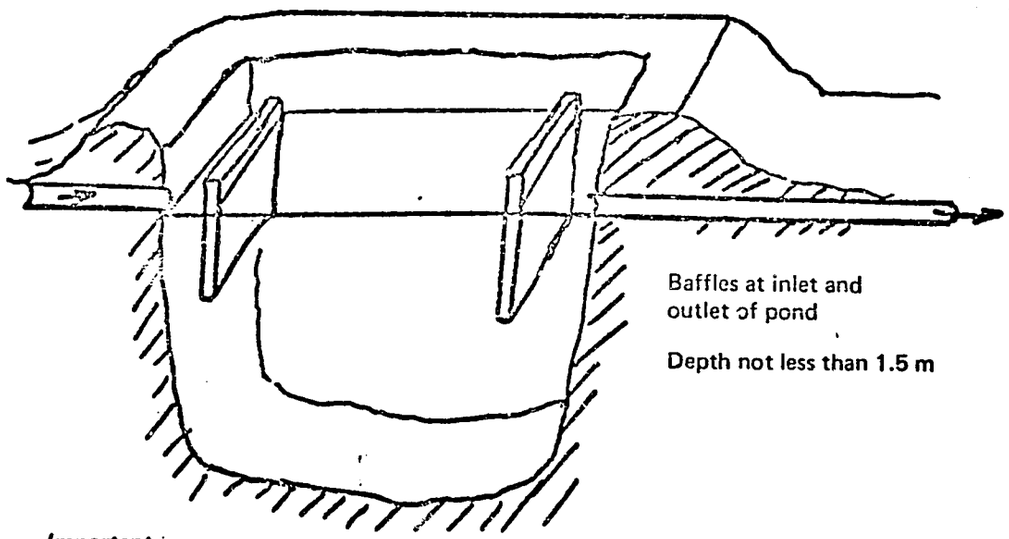


Depth not more than 1 m.

Important

Fill at least half full with water before commissioning. Dense growth of algae forming scum should be removed with a floating scum board.

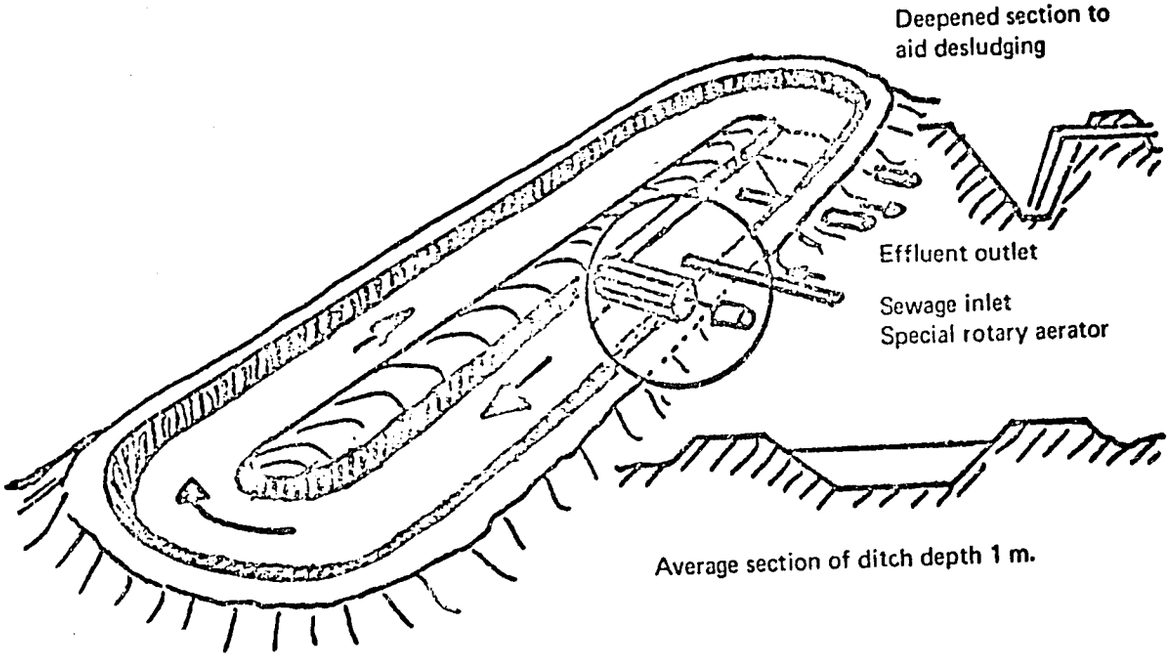
Fig. 29. ANAEROBIC STABILIZATION PONDS



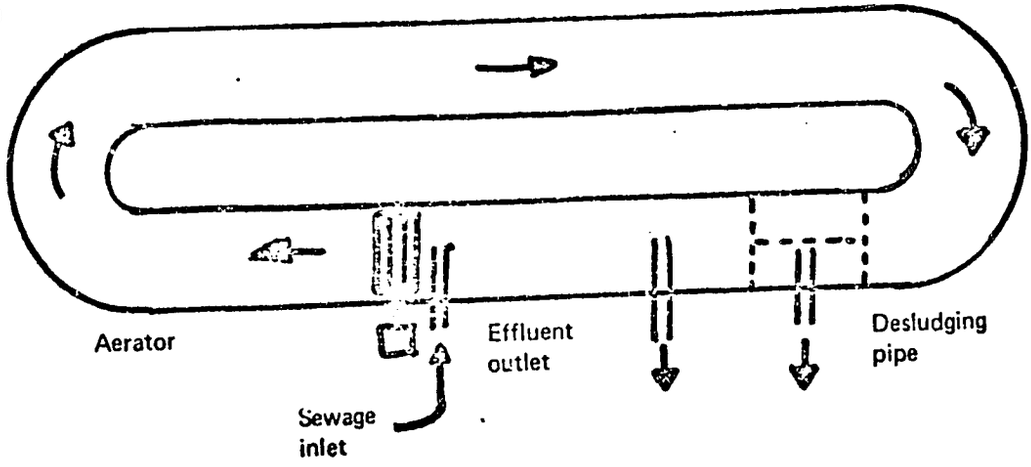
Important
Fill at least half full with water before commissioning

Fig. 32. THE OXIDATION DITCH OR PASVEER DITCH

Intermittent Settling Type



Plan



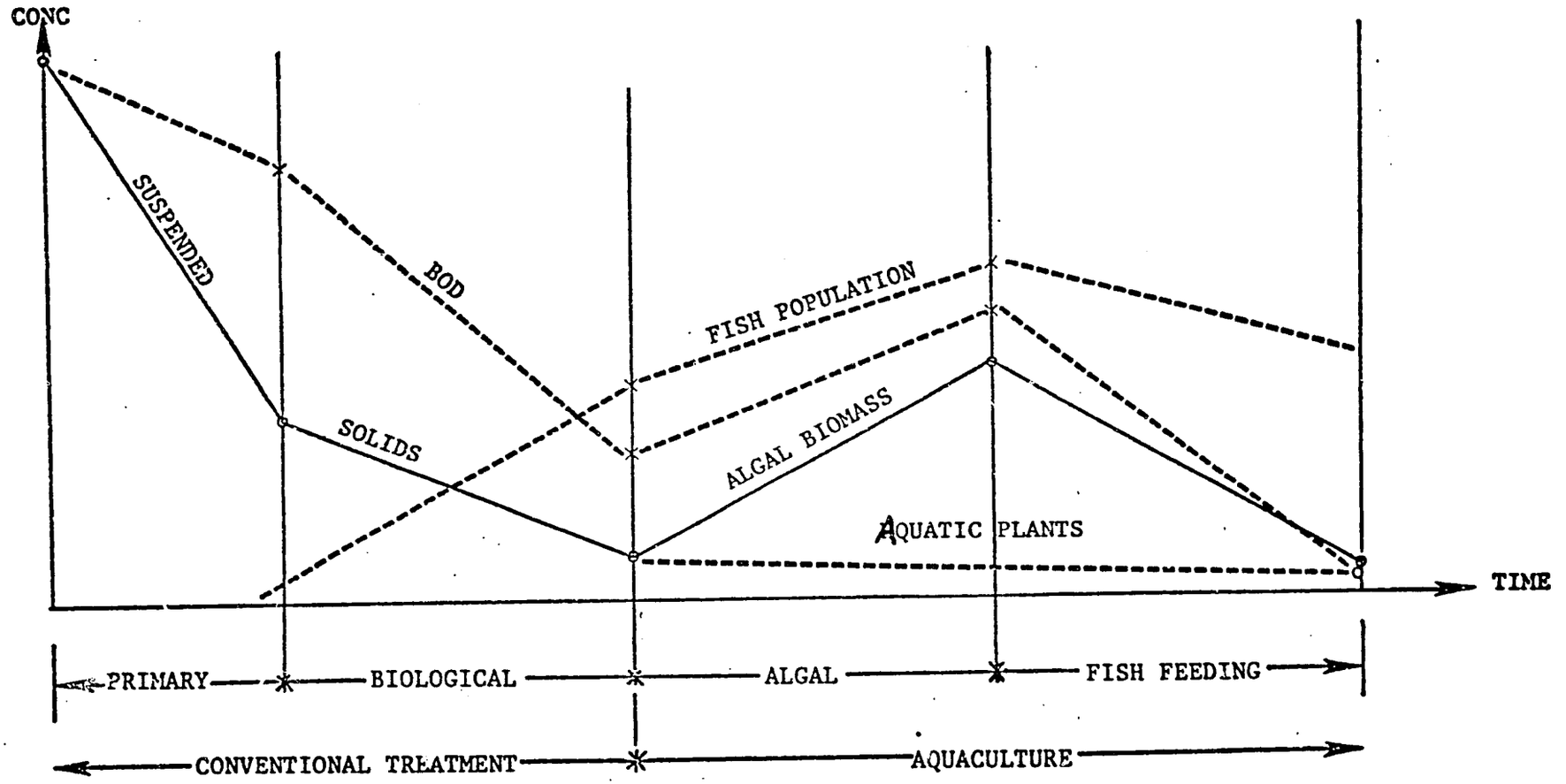


Figure 1. Process/Element Relationships

	Salmon	Tilapia	Bass	Crayfish	Amphipod	Carp	Catfish	Milk Fish	Yellow tails	Fatheads	Shiners	Trout	Biblical fish	Shrimp	Tench	Bluegill	Sunfish	Daphnia
Humbolt State, CA	X				X													
Auburn, AL		X																
Urbana, IL		X	X	X														
Israel						X												
Japan									X									
Indonesia																		
Thailand		X																
Germany						X									X			
Oklahoma		X								X	X	X	X			X	X	
Arkansas							X											
Philippines		X						X										
Ames, IA							X			X								
Ceylon		X						X										
Malaya		X						X										
Borneo		X						X										
Pakistan		X						X										
Trinidad		X						X										
India		X						X										
Puerto Rico		X																
Hawaii		X																
Texas														X				X
Hungry						X												
N. Carolina														X				

Table 1. Partial List of Fish & Site Sewage Studies

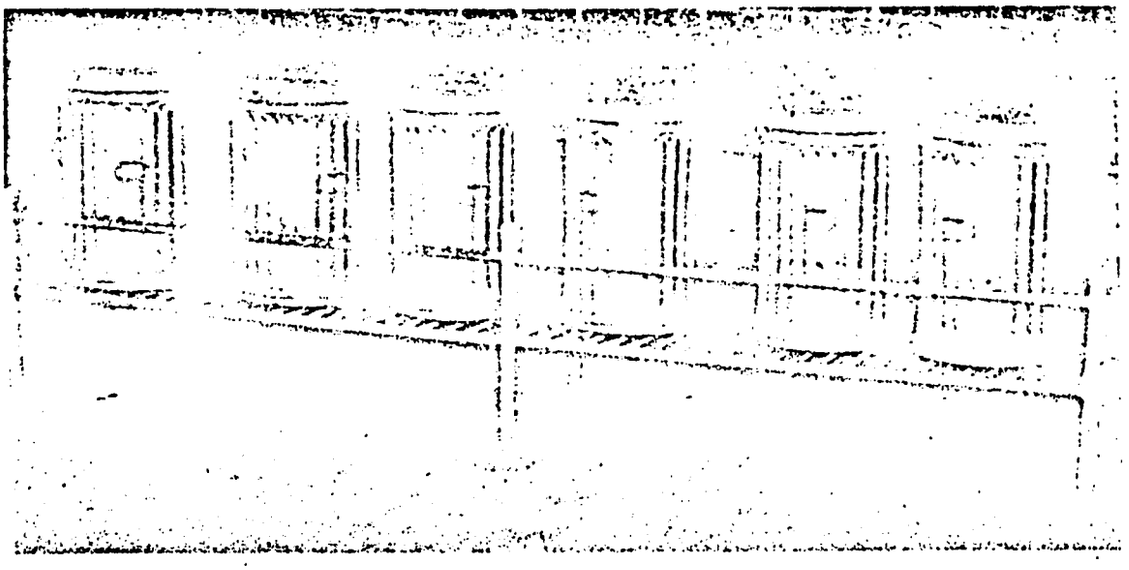


Figure 27.—Refuse container storage rack.

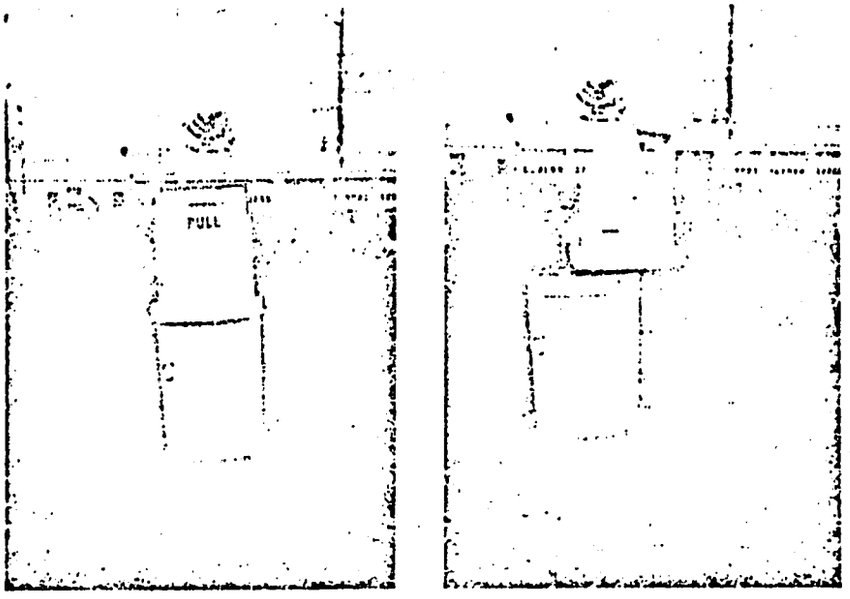
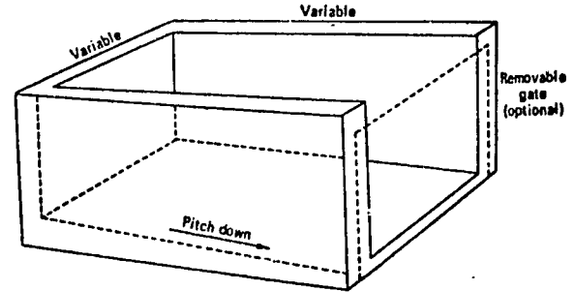
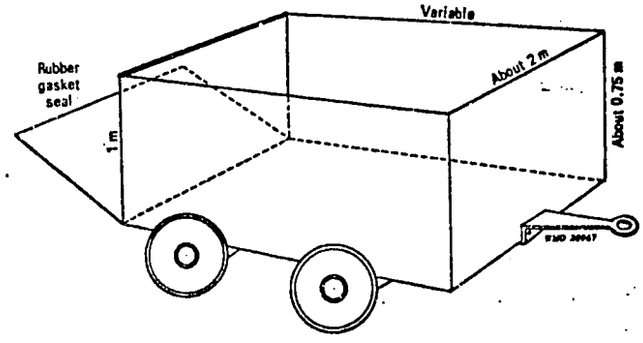


Figure 28.—Bearproof refuse receptacle.

FIG. 33. MARKET PLACE REFUSE CONTAINERS

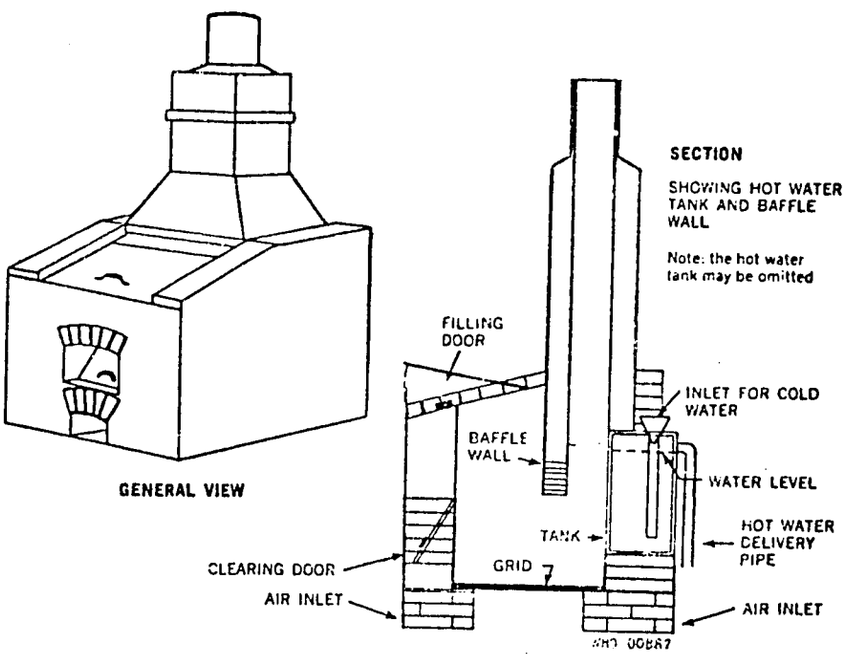


Concreted holding bin (for shovelling accumulated refuse into refuse trucks)



Trailer haul unit (fabricate of steel – reinforce for rigidity)

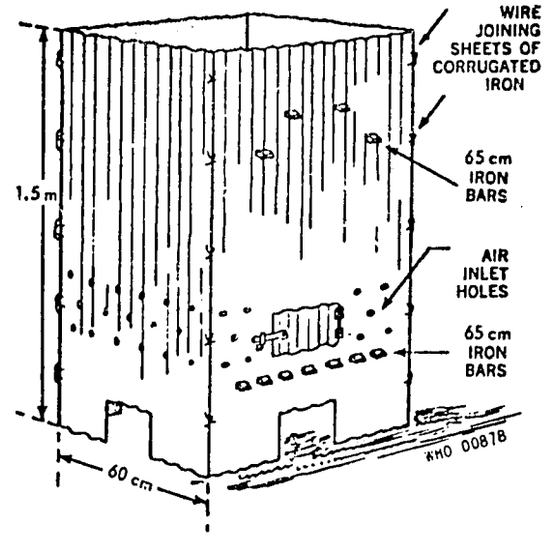
FIG. 29. BAILLEUL INCINERATOR



Adapted from: United Kingdom, Ministry of Defence (1965) *Manual of Army Health*, London, H.M. Stationery Office, p. 235.

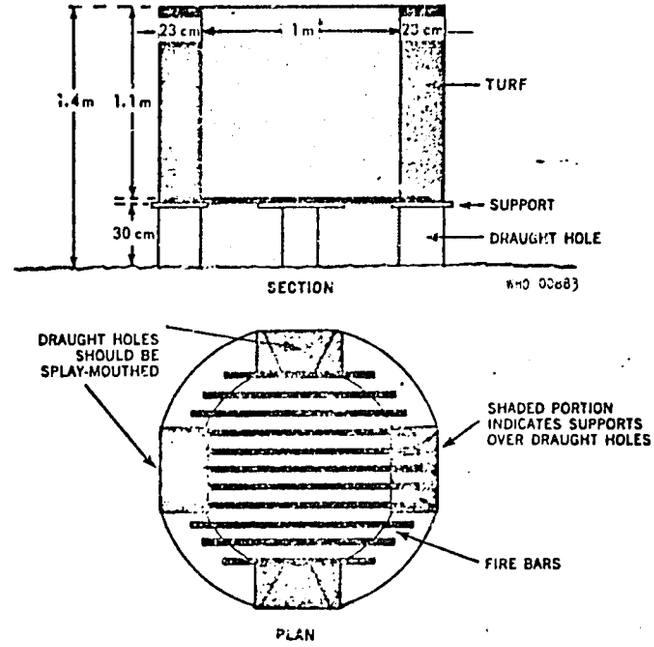
This incinerator may be constructed of brick, stone, sheet metal or tins filled with earth, but the fire chamber should be lined with fire-bricks for prolonged use. Sheet metal is required for the raking and feeding doors. The consumption of fumes and smoke is ensured by an arched baffle wall. A supply of hot water for use at the incinerator site may be obtained by building a water tank into one of the walls.

FIG. 27. OPEN CORRUGATED-IRON INCINERATOR



Adapted from: United Kingdom, Ministry of Defence (1965) *Manual of Army Health*, London, H.M. Stationery Office, p. 240.

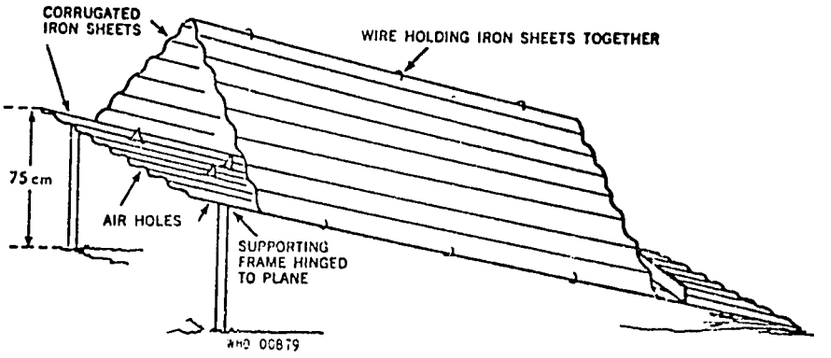
FIG. 28. OPEN CIRCULAR TURF INCINERATOR



Adapted from: Canada, Department of National Health and Welfare (1967) *Environmental health in disaster*, Ottawa, p. 90.

The walls are built of bricks or stones laid loose or cemented together or of turfs measuring 30 × 23 cm. Turfs should be laid grass to grass and earth to earth. Iron fire bars 5 cm apart are built in 30 cm from the ground.

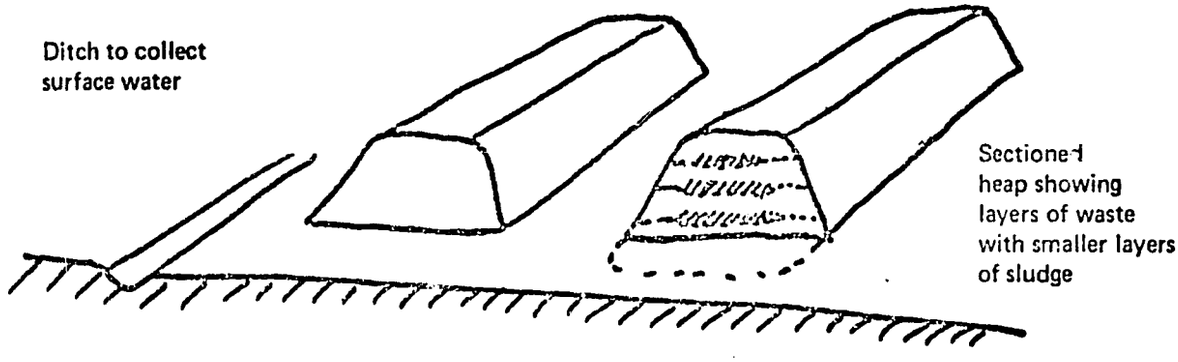
FIG. 26. INCLINED-PLANE INCINERATOR

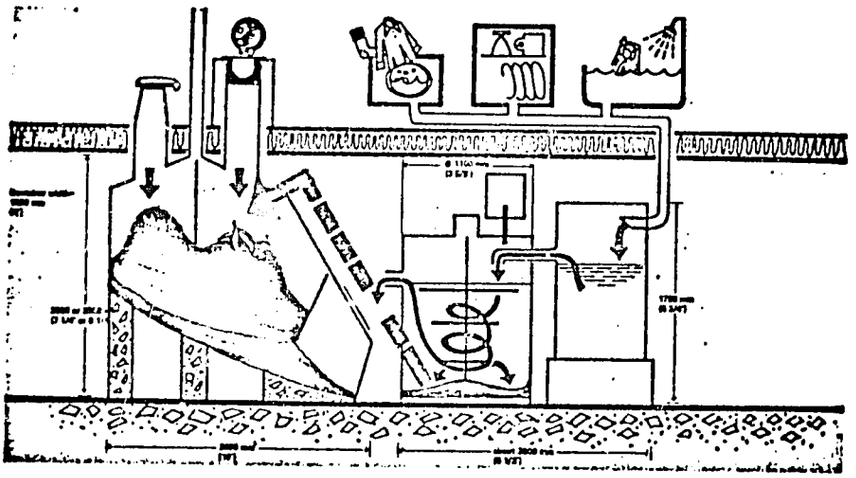


Adapted from: United Kingdom, Ministry of Defence (1965) *Manual of Army Health*, London, H.M. Stationery Office, p. 242.

A readily portable type of incinerator which folds flat when not in use. The V-shaped tongues cut in the base plate serve the dual purpose of supporting the refuse and providing draught apertures. For carrying purposes the wire along one of the edges is removed.

Fig. 36. COMPOSTING





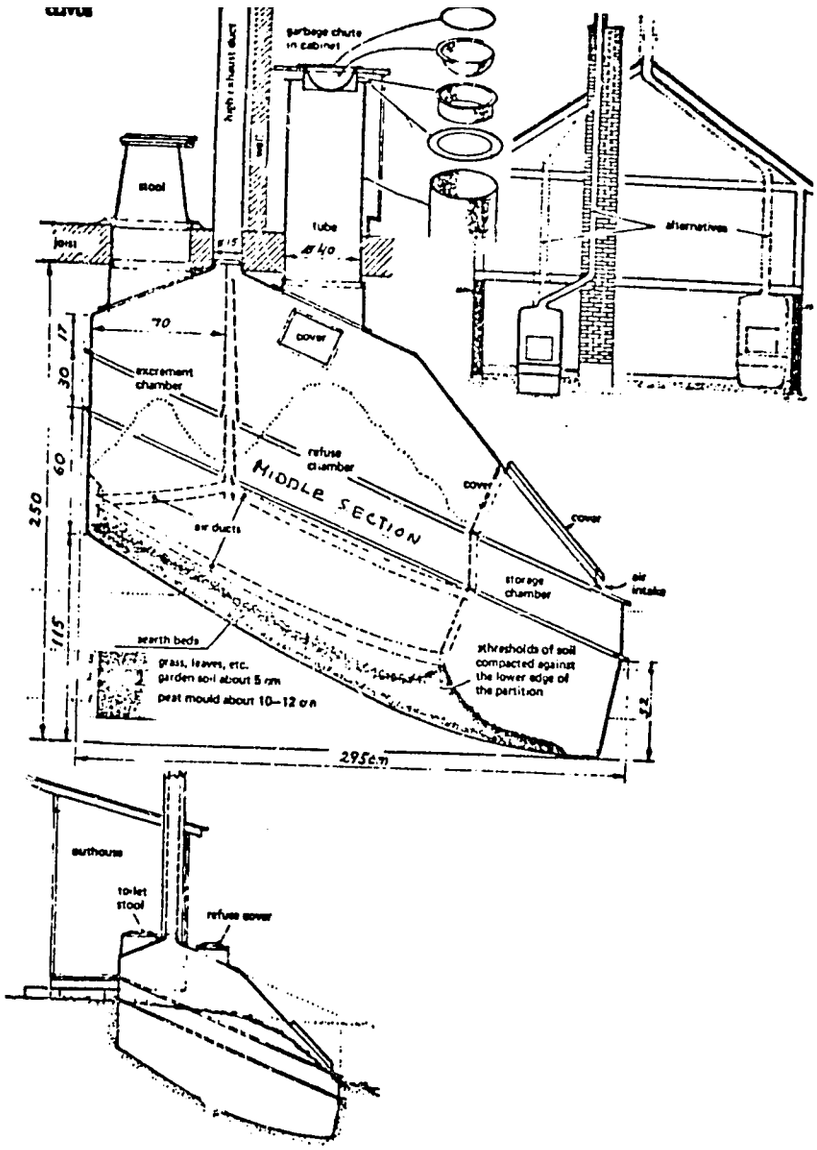
5. The Multrum system.

Compost Equipment

The compost equipment is the main new piece in the system. The Clivus compost reactor works on the principles of gravity, capillary action, and a special ventilation system. The composting material is enclosed in an impervious container (Figure 6). This container is connected to the toilet and kitchen refuse openings by means of two chutes. A vent allows the gases produced in the process to escape. A layer of topsoil placed on the sloping bottom contains the bacteria

Table 5

	Toilet Waste	*Grey water Sludge*	*Organic Kitchen Waste*	*Total*
Average Energy content	1070	850	3450	5370
KWs/person/day				
Energy demand to evaporate water-content	3000	5000 (2-3% dry substance)	100	8100
KWs/person/day		1250 (15% dry substance)		4350



6. The impervious Clivus container. Courtesy of AB CLIVUS, Tonstigen 6, S-135 00 Tyresö, Sweden.

Container consists of a top and bottom section and, where a greater capacity is required, also a middle section.

Container in functioning position: height = 220 cm or 250 cm or 280 cm, length = 295 cm max, width = 120 cm.

For adequate draft, exhaust outlet high and insulated against cold. Sideward exhaust duct (tube with smooth inner surface) gives maximum rising and no sharp bends.

Decomposition generates a certain amount of heat. The container and the parts of the exhaust ducts which are exposed to cold air should be insulated so that a temperature favourable to ventilation and to the process can be maintained.