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Fuel Gas from Cowdung

by B.R. Saubolle and A. Bachmann

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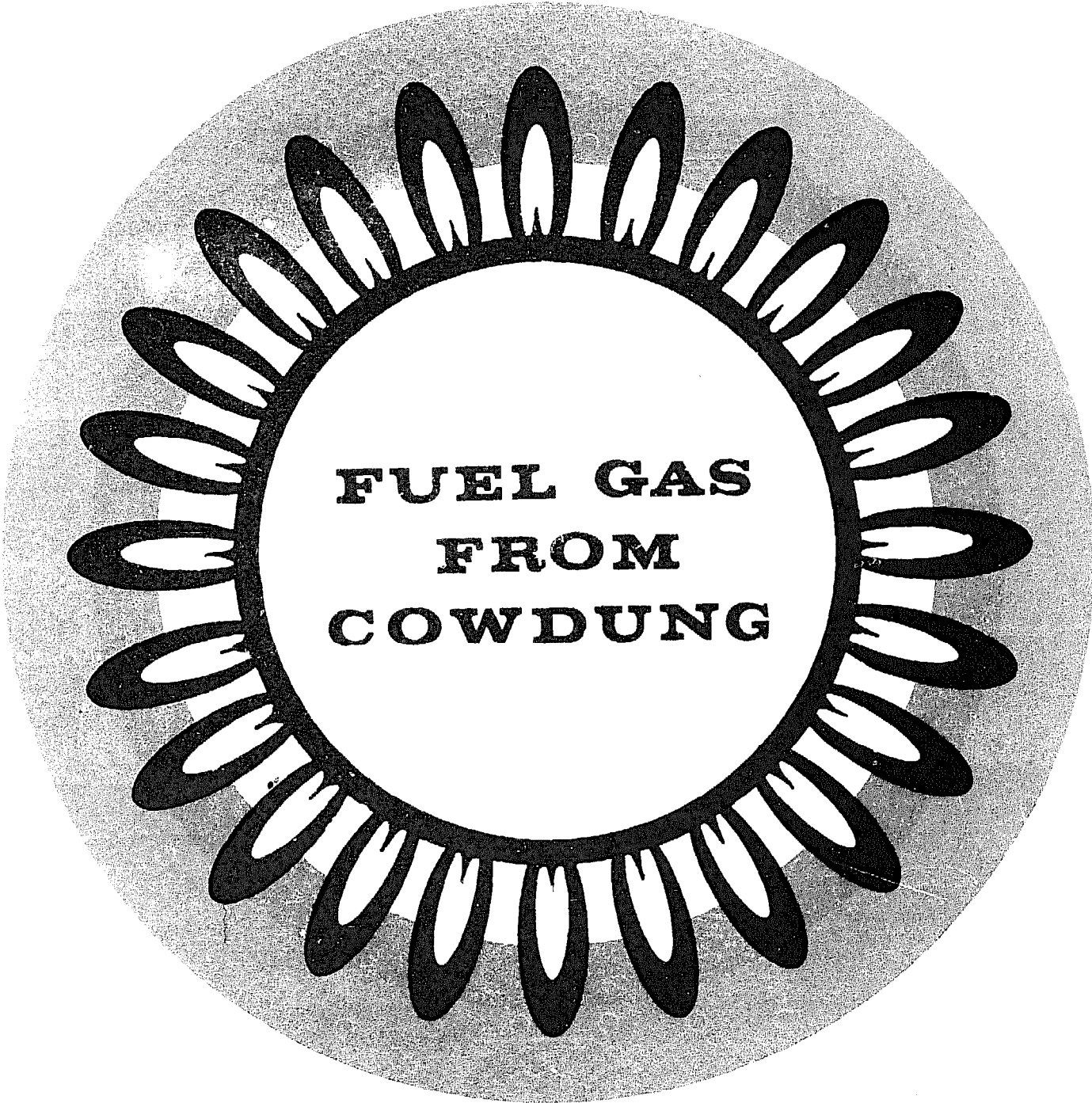
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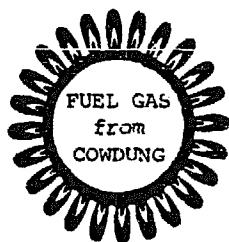
**NEW EDITION**



**FUEL GAS  
FROM  
COWDUNG**

**B.R. SAUBOLLE  
A. BACHMANN**

# FUEL GAS FROM COWDUNG



THIRD EDITION

B. R. SAUBOLLE AND A. BACHMANN

SAHAYOGI PRESS  
KATHMANDU

Published by:  
Sahayogi Press  
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Printed in Nepal  
at Sahayogi Press

THIS BOOKLET IS DEDICATED  
TO THE MILLIONS OF VILLAGERS  
IN THE HIMALAYAN KINGDOM OF NEPAL  
WHOSE NEED FOR FUEL  
HAS BEEN THE AUTHORS' SOLE REASON  
FOR WRITING IT.

I GRANT YOU COWDUNG.  
YOU ARE TO BAKE YOUR BREAD ON THAT.

EZEKIEL 4.15

Rev. Saubolle is the pioneer of biogas in Nepal. His oil drum plant, built in 1960 at St. Xavier's School in Godavari, twenty kilometers south-east of Kathmandu, was used for boiling tea, which "Father" offered to his guests. The biogas plant offered brilliant demonstration of fuel from waste long before it became "fashionable". Many of us here in Nepal were inspired by his pioneering work.



Late Rev. B.R. Saubolle, S.J.  
1904 - 1982

Rev. B. Saubolle came to Nepal in the early fifties, and loved this country. A versatile man and a great thinker of things small and beautiful. His interests ranged from bee-keeping, roses, solar heating, to orchid cultivation. To many villagers of Godavari, "Father" was a man they were proud to call a friend and one of their own kind.

BIOGAS NEWSLETTER

## C O N T E N T S

Preface _____	9
Introduction _____	10
Gas Production _____	11
Slurry _____	11
Pit Volume _____	12
Output and Temperature _____	13
Output and Pressure _____	15
Consumption _____	16
Nature of Gas _____	18
Points to be considered before constructing a Plant _____	19
Data Sheet _____	21
Gas Drums _____	24
 <u>Constructing a Plant</u>	
- The Pit _____	25
- Input _____	25
- Paddle-Wheel Mixer _____	27
- Gas Outlet _____	29
- Moisture Release _____	30
- Gas Drums _____	34
- Flame Trap _____	37
- Gas Pipe Line Dimensions _____	38
 <u>Using the Gas</u>	
- Burners _____	40
- Lamps _____	47
- Running Engines _____	50

Double Chamber Construction _____	54
Gas in Bags _____	62
Stirrer or No Stirrer? _____	64
Gas from Night Soil _____	67
A Biogas Demonstration Plant _____	70
Chinese Biogas Technology _____	73
A Nepali Version of the Chinese Design _____	94
A Comparison: Chinese vs. Indian _____	99
Possible Troubles _____	101
Temperature Table _____	102



## PREFACE

It was slightly more than a quarter century ago that biogas plants first appeared as a practical source of renewable alternative energy. The idea took time to catch on and to be accepted, but these plants are now in world-wide use. In a recent five-year plan India set itself the task of installing 25,000 cowdung gas plants a year. China claims at present the present moment to have some 7,000,000 biogas plants scattered all over the country, ranging from small family plants to huge government installations for running buses, trucks and diesel-electric generators, besides steadily providing a colossal amount of rich fertilizer and humus for field and garden.

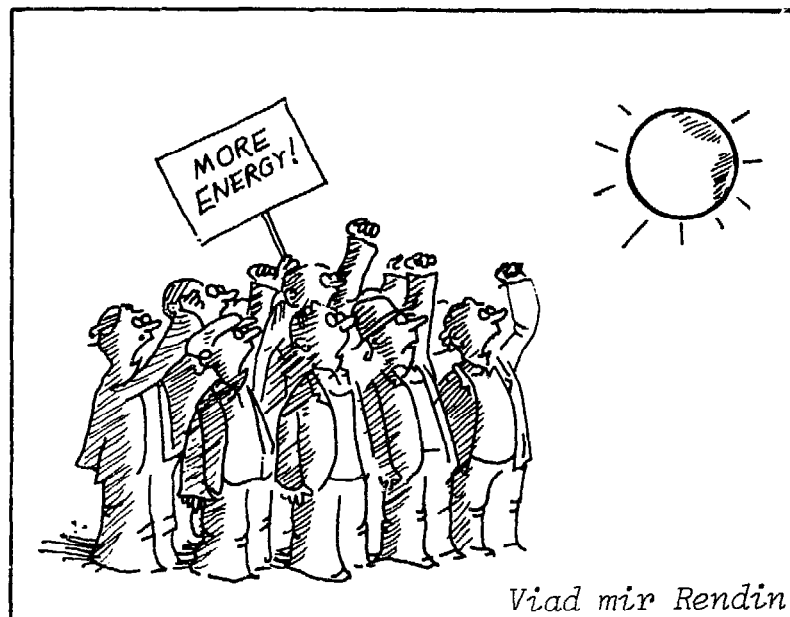
The welcome given to FUEL GAS FROM COWDUNG by readers around the world has been very heartening. Since it first appeared it has several times been reprinted at the special request of UNICEF. We have the pleasure in offering the public the present third edition, which we hope will be still more useful to readers in developing countries.

In preparing this edition we have borrowed rather freely from articles which have appeared in the BIOGAS NEWSLETTER of Nepal. For permission to do so we are grateful to the Editors. We wish also to thank the Development and Consulting Services (D.C.S.) of Butwal, Nepal, for kindly allowing us to include designs of several appliances produced and perfected by them.

B.R. Saubolle, S.J.  
Andreas Bachmann

INTRODUCTION

People living in remote areas of South-East Asia, or other tropical or sub-tropical countries, where electricity is not available and fuel is hard to get, have a very cheap, abundant and efficient fuel in the gas produced from ordinary cowdung. This gas (marsh gas or methane) is generated with the greatest ease simply by letting a slurry of cowdung and water ferment in a well-like pit without exposure to air. The gas rises to the surface and collects in a drum, whence it is piped to the kitchen stove. A farmer with a couple of bulls or buffaloes for ploughing and one or two cows for milk gets enough dung every day to produce sufficient gas for all the cooking needs of a village family of six. The cooking is clean and hygienic, the pots do not get black, there is no smoke or smell, and the gas is non-toxic. And after extracting the gas to cook his food, and to light his house at night, the farmer still has all the dung left, well fermented and rotted, to fertilize his fields.



### GAS PRODUCTION TIME

Fresh cowdung, or other animal dung (from horses, mules, donkeys, buffaloes, yaks, pigs, poultry) diluted with water and fermented by bacterium methanogenes, without exposure to air, delivers 90% of its potential gas within a period of four weeks, more than half of it within the first eight or ten days. Six weeks of fermentation produces about 98%. Hence the fermenting pit, in which daily additions of slurry enter at the bottom and gradually raise to overflow at the top, should be large enough to hold each day's addition for a minimum of four weeks or a maximum of six, i.e. from 30 to 40 days. In other words, the volume of the pit should be at least 30 times, or better 40 times, the volume of slurry added daily.

### SLURRY

The optimum dilution of fresh dung with water for making the slurry is one that contains from 7% to 9% solid matter, the peak being 8%. Hydrometer readings show a specific gravity of approximately 1.030 for 7% and 1.190 for 9%. 8% falls around 1.100. The right percentage is obtained automatically by mixing a given volume of dung with from one to one-and-a-half times the volume of water. The fact that thousands upon thousands of gas plants have been working satisfactorily for decades without the use of an hydrometer proves that this instrument, useful though it may be, is not strictly necessary. A good slurry is one in which the dung is broken up thoroughly and makes a smooth, even mixture having the consistency of thin cream. If the slurry is too thin, the solid matter separates and falls to the bottom instead of remaining in suspension; if it is too thick, the gas cannot rise freely to the surface. In either case the output of gas is less.

It has been found that the optimum pH for digesting slurry is around 8. When starting a plant, the early fermentation is acid and much carbon dioxide is given off; but the acidity gradually diminishes, and once the contents of the pit become alkaline, methane generation predominates. If the pit is overloaded, or the slurry too thick, acidity increases, much carbon dioxide is formed, and the gas won't burn. Many users prefer a proportion of 1:1 1/4 (4 parts dung to 5 parts water) and enjoy trouble-free operation. The acidity of the effluent is measured with pH paper (narrow-range: 6-9). It should read from 8 - 8.5, which is slightly more alkaline than the effluent of a municipal sewage plant.

#### VOLUME OF PIT

As was said above, the fermenting pit should have a volume from 30 to 40 times the slurry added daily. Thus:

PROPORTION	DUNG	WATER	SLURRY (x 30 or 40) =	VOLUME OF PIT
1:1	2.5 cft	2.5 cft	5 cft	150 or 200 cft
1:1 1/4	2.5 cft	3.1 cft	5.6 cft	168 or 224 cft
1:1 1/2	2.5 cft	3.75 cft	6.25 cft	187 or 250 cft

OR

1:1	75 ltr	75 ltr	150 ltr	= 4500 or 6000 ltr
1:1 1/4	75 ltr	94 ltr	170 ltr	= 5100 or 6800 ltr
1:1 1/2	75 ltr	112 ltr	187 ltr	= 5610 or 7480 ltr

It is recommended to use 1:1 or 1: 1 1/4 and make the pit 40 times the daily slurry.

Experience has shown that Indian villagers consume on an average 15 cft (425 ltr) of gas per person per day. So for a family of six about 100 cft (say 3000 litres) of gas would suffice. This output would require a pit of at least double that volume, 200 cft or 6000 litres, say 5 ft (1.5 m) diameter by 11 ft (3.40 m) dep, taking 2 1/2 cft or 75 litres of fresh dung every day. Allow 12 litres fresh dung per person per day.

## BACTERIA

For starting a new plant, the necessary bacteria may be obtained from one of the following sources:

- a) Spent slurry from another gas plant;
- b) Either sludge or overflow water from a septic tank;
- c) Horse dung or pig dung, both rich in bacteria;
- d) Ooze from the bottom of any dirty pool.

Without added bacteria fermentation may take about a month to get started.

## OUTPUT AND TEMPERATURE

At a temperature of 85 °F ( 30 °C), 1 cft of dung delivers 40 cft of gas in four weeks; so that if, for example, 5 cft are added daily, the daily output of gas will be about 200 cft. This is not a mathematical constant: it is an average depending on the health and feed of cows. At higher temperatures the output is greater, being 50 cft or more at 90 degrees F, while at 55° it drops to about 20 cft.

MEAN TEMPERATURE DURING MONTH		OUTPUT OF GAS		REMARKS
		(cft/lb.dung)	(ltr/kg dung)	
85 °F	29 °C or over	1.5	92.7	Excellent
75 °F	24 °C	1.0	61.8	Good working average
65 °F	18 °C	0.8	49.5	Serviceable
55 °F	12 °C	0.5	30.8	Hardly worthwhile

In places where for the greater part of the year the mean temperature is 18 °C (65 °F) or more, a gas plant is really worthwhile. In winter the gas will diminish unless something is done to warm the digesting slurry. Several methods are commonly recommended:

1 - DEPTH - Depth is a help. In the tropics and lower temperature latitudes, even in the Himalayas at 5000 ft.; the temperature at 4 m below ground, hardly drops lower than 15 °C. especially if the slurry is added hot, and some gas can be produced.

2 - INSULATION - Fermenting slurry generates practically no heat (only about 3 °C). Pit temperature is only slightly higher than the outside air. Yet if the little heat generated is prevented from dissipating by conduction, something is gained. The insulating material must be kept quite dry. If damp, it can chill instead of keeping warm. In the tropics it should also be something that white ants will not eat.

3 - HOT SLURRY - This helps a little. The daily input is in the order of only 2.5% of pit volume, so that it cannot make very much difference, but it is certainly more helpful if the slurry is hot (35 °C) rather than chillingly cold.

4 - HEATING COIL - When building a pit, a coiled pipe of 2" diameter can be installed inside. It is recommended to allow 1000 cm<sup>2</sup> of coil area per 3 m<sup>3</sup> of pit volume (1 sq.ft./100 cft.). The coil should be heated with water not more than 60 °C (140 °F) or the slurry will cake on the coil surface. A thermostat set at 35 °C (95 °F) should be installed in the slurry. The gas used in heating the coil is repaid three times over by the increase of output. Heating could also be done by solar collectors.

5 - COMPOST TROUGH - Some users build a trench around the upper half of the pit and make compost in it. The heat generated by the composting organic matter keeps the pit warm.

6 - PLASTIC TENT - If the pit and a couple of metres of ground all around it are enclosed in a glass or clear plastic structure, the hot-house effect keeps the slurry warm. A few years ago it was claimed that this system kept gas plants functioning in Korea in the midst of snow and ice; but our own investigation on the spot has led us to doubt its efficacy. However, we do believe that in milder winters (above freezing), the plastic tent may really be useful. We have not experimented with this ourselves.

7 - SURFACE DIGESTER - A horizontal digester built above ground on an east-west axis and painted black would heat up in the sun, more so if covered with plastic sheeting. If it gets too hot in the summer, remove the plastic and white wash the digester.

Rather than bother with any measures outlined above, it is far simpler to be content with whatever amount of gas forms in the cold months and replace the shortage with some other fuel. One will then have cooked on free cowdung gas for nine months of the year, which is not at all bad.

It is good to remember that cows' urine also ferments and forms gas. If a little of this is used with water for making the slurry, the output of gas is thereby increased. But too much urine is harmful: it would increase the ammonia content more than the bacteria can tolerate. About one-third of the water required can be replaced by urine.

#### OUTPUT AND PRESSURE

The output of gas varies with the pressure to which the fermenting slurry is subjected. Taking atmospheric pressure as normal (the drum being perfectly counterbalanced), it has been found that under a pressure of 4" water head the production drops by 5%, while under a negative pressure of 4", production is about 10% above normal.

In practice, however, a little gas may be sacrificed to convenience, the drum not being counterbalanced at all, but left floating on the slurry. There is thus a slight steady pressure at all times caused by the weight of the drum, and the gas is ready for use at any moment without one's having to go outside and remove balance weights. However, in colder climates where gas formation is less abundant, it may be wiser to counterbalance the drum and thus facilitate the production of gas. But it should be noted that a negative pressure could be dangerous if there is a slight leak in the gas drum on the delivery pipeline. Air is drawn in and the air-gas mixture may attain explosive proportions (5% - 15%).

All it then needs is a careless match or a backfire with no flame arrester in the line. We know of one such drum which shot up in the air like a rocket.

A simple way of measuring gas pressure is to disconnect the gas pipe at a lamp or stove and push into a tumbler of water till the gas ceases to bubble through, then measure the depth of water that just balances the flow of gas.

### CONSUMPTION

A pressure of 10 cm (4") water head has been found sufficient for both lighting and heating. Under this pressure a 2" gas ring consumes 280 litres (10 cft) of gas per hour and boils 4.5 ltr (1 imp. gall.) of water in under 20 minutes. Lamps using 40 candle-power mantles take 2.75 cft (78 ltr) per mantle per hour. Under a high pressure, of course, stoves burn hotter and lamps burn brighter. For working internal combustion engines the gas consumption per h.p. is about 15 cft (425 ltr). \*Some authors give a slightly higher figure.

### A NOTE ON OUTPUT, TEMPERATURE AND CONSUMPTION

In this book the calculations for pit size and output of gas are based on a temperature of 27° - 29 °C (80° - 85 °F). As the temperature rises, production is greatly increased, being double or more when the slurry in the pit is 35 °C. In our tropical summers, in places where for days no end the ambient temperature is over 38 °C (100 °F), a family size pit calculated to serve 6 persons may very easily produce enough gas to cook for 12 or 15.

We say (p. 20) that we need 15 cft gas per person per day. This is an average when meals are cooked for 6 to 8 persons. 15 cft. (425 ltr) will suffice one burner for 1 - 1 1/2 hours depending on its

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\* Sathianathan: Biogas Achievements and Challenges, p.74



size and efficiency. This amount is obviously far too little for the cooking needs of one person alone. On the other hand, the greater the number of people cooked for, the lower is the gas consumption per person. When one is cooking for 20 persons, it takes very little additional gas to cook for 25 or 28 in the same pot.

Both points mentioned above, viz., the output at higher temperatures, and the average consumption of gas per person, are well illustrated by the installation at Holy Family Hospital, Patna, Bihar, India. The digester there has a volume of 80 m<sup>3</sup>. Applying the guidelines for family plants, this pit is ought to produce 40 m<sup>3</sup> of gas per day, which at 425 litres per person would suffice for 94 persons. As a matter of fact, for several years already, in summer, four meals a day have been cooked for 400 persons entirely on cowdung gas. In winter, and sometimes even in summer whenever the number of persons increases, some supplementary heating with bottled gas or with coal is necessary.

From all this two facts stand out clearly:

- 1) the summer temperature (37 °C - 45 °C) greatly increases the output of gas;
- 2) when large numbers are cooked for, the average consumption of gas per person is very much lower.

The hospital has no means of measuring the gas. Some is lost because at night gas bubbles out from under the drum (30 m<sup>3</sup> capacity) and is lost to the air. Another very interesting point is that the pit is not being used to capacity. The daily input of slurry is a trifle over 1 m<sup>3</sup>, whereas the pit ought to receive 2 m<sup>3</sup>. So this particular installation could produce very much more gas than it actually does. The input represents approximately half the daily contribution of the animals and birds on the small hospital farm (cows, buffaloes, pigs, chickens).

## NATURE OF GAS

Cowdung gas burns with a clear, pale electric-blue flame, with or without the admixture of air. The flame is invisible in bright daylight. It is hotter than coal gas or oil gas, having a BTU value of approximately 600 per cft (or 5380 cal per litre), though no two authors seem to agree on the exact figure. Probably the gas varies somewhat from plant to plant. Analyses of cowdung gas show that its composition is, with slight variations, 65% methane, 25% carbon dioxide and 10% other gases, in very small quantities. The gas is non toxic and virtually odourless. Mixtures of methane and air are explosive if the methane content is from 5% to 14%.

## MANURE

Spent slurry dried in the sun constitutes an excellent manure, which appears from tests to be richer in nitrates than ordinary farmyard manure, and slightly superior to it. In liquid form too it is good if diluted; but dried slurry is preferable.

## CONCLUSION

Anyone with a few head of cattle can provide enough gas for his daily cooking needs and still have manure for his garden and fields, better manure than he otherwise would have be merely letting the dung rot aerobically in an open pit. Fermenting and fermented slurry gives off no odour. Insects and small animals falling into it cannot survive. Dried slurry is as clean and fresh as sawdust and be be stowed away in sacks till needed for use or for sale.

POINTS TO BE CONSIDERED BEFORE CONSTRUCTING A PLANT

For what purpose is the plant required?

- a) GAS FOR COOKING ONLY - In this case the height of the gas drum is usually one-third the depth of the pit, since it never has to hold more gas than for a couple of hours' use at a time.
  
- b) GAS FOR LIGHTING ONLY - For this the drum must be large enough to hold all the gas generated in 24 hours to be able to deliver it in four or five hours. A pit, at 30 C, generates half its volume in a day. So the drum must hold half the volume of the pit.
  
- c) GAS TO RUN A GENERATOR EIGHT HOURS A DAY FOR A SMALL INDUSTRY - Here again the drum must have at least half the pit volume.
  
- d) RICH FERTILIZER FOR A GARDEN OR FARM  
Gas not needed. Here the drum can be eliminated, and the gas allowed to escape into the atmosphere through a water seal.
  
- e) BOTTLING OF GAS FOR RUNNING CARS - Find out how many cft of gas, when compressed, can fill the size of bottle you intend to use. The drum should be at least large enough to hold that amount.

How large should the plant be?

The average oriental villager uses 15 cft (425 ltr) of gas per day. This amount is generated from 10.6 ltr fresh dung (at 30 °C). Western cuisine would require more, perhaps 500 ltr gas from 12.5 ltr dung per person.

The volume of fresh dung available every day multiplied by 80 gives the volume of the pit most suitable to handle that amount of dung. The pit volume divided by 2 gives the volume of gas generated daily (at 30 °C); and this divided by 425 (or 500) gives the number of persons served. Whence:

$$D \times 80 = P/2 = G/425 \text{ (or 500)} = \text{Persons}$$

Or beginning with the number of persons, to find the size of pit and the amount of dung needed daily, work the formula backwards, thus:

$$\text{Pers.} \times 425 \text{ (or 500)} = G \times 2 = P/80 = D$$

This formula is correct if the slurry is made in the proportion 1:1. The total daily input of slurry, regardless of its proportions, should be 1/40 of the pit volume.

Having found the approximate volume of pit you require, turn to the Data Sheet and select the size of plant most suitable.

DATA SHEET (British)

Pit Volume cu.ft.	Slurry (P/40) cu.ft.	Dung / Water 1:1		Dung / Water 1:1 1/4		Dung / Water 1:1 1/2	
		cft	cft	cft	cft	cft	cft
125	3	1.5	1.5	1.3	1.7	1.25	1.8
200	5	2.5	2.5	2.2	2.75	2.0	3.0
300	7.5	3.75	3.75	3.3	4.1	3.0	4.5
400	10	5.0	5.0	4.4	5.5	4.0	6.0

Size No.	1		2		3		4	
	Diam. of pit	4 ft		5 ft		6 ft		6 ft
Area, sq.ft.	12.5		19.6		28		28	
Depth	10.0		11.0		11.0		15	
Volume, cft.	125		215		308		420	
Slurry, cft/day	3		5		7.5		10	
Gas, cft/day	(40-day cycle) 60 - 50		100 - 80		150 - 120		200 - 160	
Persons served	4 3		6 5		10 8		13 10	
Slurry, cft/day	4		7		10		14	
Gas, cft/day	(30-day cycle) 80 - 64		140 - 112		200 - 160		280 - 224	
Persons served	5 4		9 7		13 10		18 15	

## DATA SHEET (Metric)

Pit Volume in ltr	Slurry (P/40) ltr	Dung / Water 1:1		Dung / Water 1:1 1/4		Dung / Water 1:1 1/2	
		ltr	ltr	ltr	ltr	ltr	ltr
3730	93	46	46	41	51	37	55
6000	150	75	75	66	84	60	90
9000	225	112	112	100	125	90	135
12000	300	150	150	153	166	120	180

Size No.	1		2		3		4	
	Diam. of pit	120 cm		150 cm		175 cm		200 cm
Area, cm <sup>2</sup>	11304		17662		24040		31400	
Depth, cm	330		340		380		382	
Volume, ltr	3730		6000		9000		12000	
Slurry, ltr/day	93		150		225		300	
Gas, ltr/day	1840-1480		3000-2400		4480-3600		6000-4480	
Persons served	4 3		7 5		10 8		14 11	
Slurry, ltr/day	125		200		300		400	
Gas, ltr/day	2500-2000		4000-3200		6000-4800		8000-6400	
Persons served	5 4		9 7		14 11		18 15	

- In the 40-day cycle the volume of daily slurry is  $1/40$  the pit volume.
- In the 30-day cycle the volume of daily slurry is  $1/30$  the pit volume.
- The double figures for gas show first, the volume obtained from a slurry of 1:1, and second, from a slurry of 1:1  $1/2$ .
- At temperatures of 85 °F (30 °C) and above, the gas produced is 40 times the volume of daily dung. This figure has been used in the calculations.
- In the above calculations, here and there the figure has been slightly rounded off for the sake of convenience.

It is worth noting from the above mentioned table that the management of a gas plant is somewhat elastic: it leaves the owner a useful latitude. For example, if it is required initially to cook for 10 persons, but it is foreseen that at a future date food will have to be prepared for 18 or 20 a No. 4 plant could be built and run at first on a 40-day cycle with a slurry of 1:1  $1/2$ . It will then serve 10 or 12 persons. When the need for gas increases, the pit can be run on a 30-day cycle with a slurry of 1:1. The output will then suffice for 18-20 persons.

The change over from one cycle to another, or from one density of slurry to another, should be done gradually, increasing or diminishing the volume of slurry, or altering its proportions, little by little, taking a week or ten days for the complete change over. A sudden alteration is likely to affect the pH and produce dioxide instead of methane.

GAS DRUMS

Volumes of different sizes recommended

	SIZE 1	SIZE 2	SIZE 3	SIZE 4
Diameter ( ft - in )	3'- 8"	4'- 8"	5'- 8"	5'- 8"
Area, sq.ft.	10.5	17.0	25.0	25.0
Depth, feet	4	4	4	4
Volume, cu.ft.	42	68	100	100
Burners	1	2	3	3
Hours (10 cft/hr/b)	4	3.5	3	3
Refill, cft/hr. 40-cycle, 1:1	3	4.4	6.5	8.75
Refill, cft/hr. 30-cycle, 1:1	3.3	5.8	8.3	11.6
Diameter, cm	110	140	165	190
Area, sq.cm.	9498.5	15386	21371.6	28338.5
Depth, cm	120	120	120	120
Volume, litres	1140	1846	2564	3400
Burners	1	2	3	3
Hours (280/hr/b)	4	3.3	3	4
Refill, ltr/hr. 40-cycle, 1:1	76.6	125	186.6	250
Refill, ltr/hr. 30-cycle, 1:1	103	166	250	333

The above rates of refill are correct on condition that the temperature in the pit is 85 °F (30 °C).

A size-1 pit will most probably not be used for 4 hrs at a stretch; may be for only 2 hrs. So the drum will hold enough gas for two meals with only one filling, and more gas will fill in between.

The other sizes will surely not use all the burners at a time. Their owner will learn to economize.

People wanting to build pits are advised to choose a size larger than they strictly need (provided they have enough dung). This will make up for slower production of gas in lower temperatures. Any extra gas could be used for lighting.



## SUGGESTIONS FOR CONSTRUCTING A PLANT

Many different shapes and styles of gas plants have been experimented with: horizontal, vertical, cylindrical, cubic. The design that has won overwhelming popularity for its reliable performance in many different countries is the Indian pit design, of which over 70,000 plants are in use in India alone, 25,000 in Korea, and many in Japan, Taiwan, the Philippines, Vietnam, Indonesia, Pakistan, Iran, Africa, Thailand, Papua New Guinea, and who knows where else. This is proof enough of its efficiency and outstanding worth. This is the design, basically, that we recommend here. We describe below the construction of a No. 2-size plant. For other sizes see the Data Sheet.

### 1 - THE PIT

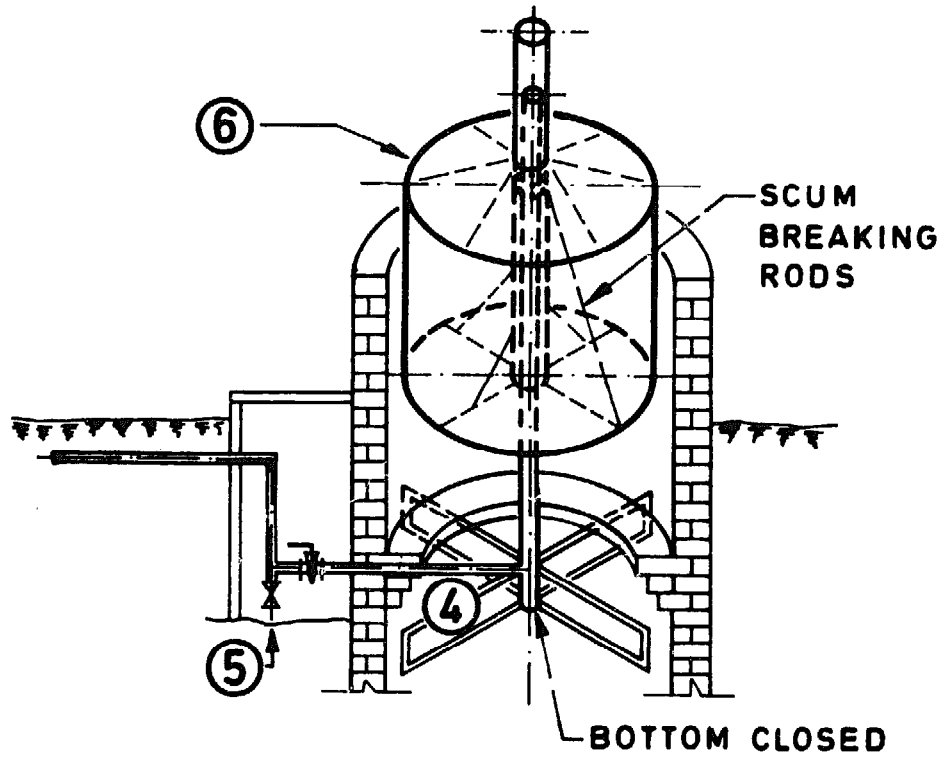
Make the inside diameter of the pit 5 ft and its inside depth 11 ft 4". Of this depth 2 ft are above ground level and 9 ft 4" below. Cement construction is not necessary: baked brick bound with lime mortar or with clay is sufficient. Any porousness in the construction is very soon blocked with the cowdung itself. At two-thirds the height of the pit from the bottom, a ledge or cornice is made some six in wide for the drum to rest on when empty. This also serves to direct into the drum any gas forming near the circumference of the pit, and prevents it from escaping between the drum and the pit wall. The ledge should never be more than 2 ft (60 cm) below ground level. In this case its top should be 7 ft 4" above pit bottom.

Do not construct the pit within 40 ft of a drinking water well or spring. If the water table is reached it is better to cement the inside.

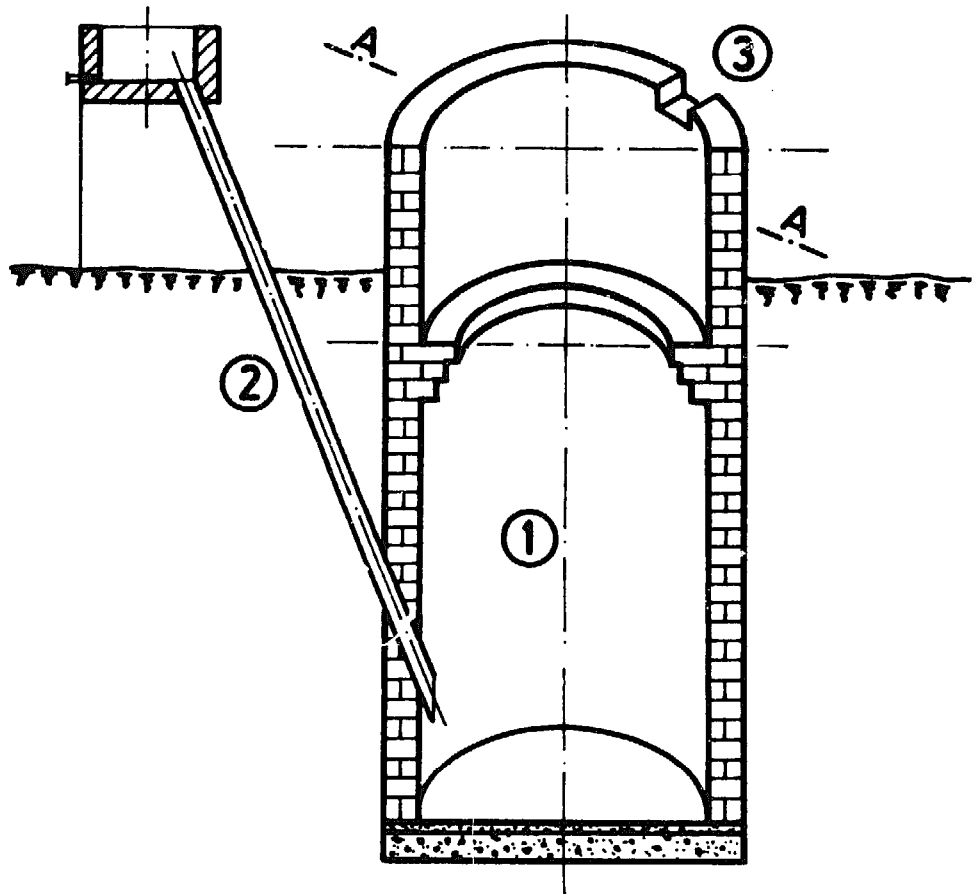
### 2 - INPUT

An ordinary 10 cm (4") rain pipe will do, beginning 90 cm (3') above ground level at the base of a mixing trough and ending in the pit at least 60 cm (2') above the bottom.

PIT (upper part only) cross-section A



PIT cross-section full depth



A SIMPLE SINGLE CHAMBER PIT

THE MIXING TROUGH - Villagers are often careless about the proportions of dung and water in the slurry. They go by guesswork rather than by actual measurements, making the slurry too thick or too thin. This infallibly alters the pH and produces too much carbon dioxide. It helps accuracy to have markers in the trough, one showing the correct level of water, and another nearer the top showing the total level of the slurry after the dung has been added. The markers could be grooves or ridges in the plaster, or a brick sticking out a trifle. To avoid having to build a very large trough, the dimensions could be calculated to hold just half the volume of slurry needed daily. Then the owner knows that he has to put in two trough-fulls every day.

A useful improvement to the mixing trough is to give the bottom a slight slope away from the inlet hole. Any sand or dirt that drops down during the mixing is then not drawn into the pit but remains in the trough to be washed out through a small hole in the wall at the lowest point.

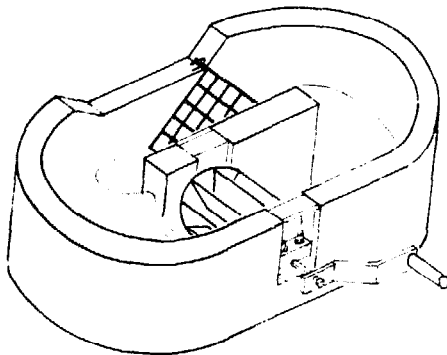
THE PADDLE-WHEEL MIXER - In a biogas digester, as in any compost heap, the bits of raw material are attacked all over their surface by microbes. The greater the surface area exposed, the more thorough the decomposition. Where vegetable matter is used, e.g. straw, grass, leaves, crop stalks, the finer it is chopped up before being put into the pit, the better.

In a cowdung-gas plant the slurry should be thoroughly mixed to make it homogeneous and smooth flowing. The dung should not be used in a lumpy condition. Though such lumps would, of course, ultimately decompose, their breakdown is easier and more rapid, and their gas sooner obtained, if they are first broken up.

It is not too difficult to break them up by hand for small family-size plants, but for larger installations, where the volume of daily slurry may be quite

considerable, hand mixing is far too fatiguing and time consuming. It is much more practical and rapid to use a mechanical mixer. The accompanying diagram shows one such mixer. Dimensions vary with the volume of slurry to be prepared.

While working the paddles, if any splashing takes place (it ought not to), a half-cylinder of tin could be fixed over them to safeguard the operator's clothing.



A paddie-wheel mixer in use. Notice the ugly, old-style outlet through hose pipe.

The dung and water are put into the trough and the handle is cranked. The paddles help to break up the lumps and mix the dung with the water. In the beginning the lumps may be too large to pass through the screen, so the mixer could be used for a while without it. Then as the lumps are reduced in size, the screen can be placed in position. Lumps that get stuck are scraped off and made to pass the paddles again. Soon the slurry flows through easily. The plug is then drawn and the slurry allowed to enter the pit. We think a screen of 1/2" mesh would be suitable, though a finer slurry passing through a 1/4" screen would be still better.

Lumps of dung may sink to the bottom of the pit or rise to float on the surface. With a very fine slurry the dung remains in suspension, and decomposes and produces gas much faster.

### 3 - THE OVERFLOW

Remove a brick or two from the topmost layer of the pit wall. The space left will serve as overflow. The spent slurry is led away in a drain to a long narrow trench 50 cm (20") or more wide with a porous bottom. Here the water seeps out and the fermented dung dries in the sun, to be collected and stored for use as manure. There should be two or three such trenches, one filling while another is drying out. The dried slurry has no smell whatever.

### 4 - GAS OUTLET

The original, primitive method of gas take-off (one still comes across occasionally) is a short length of metal pipe, with the main gas valve attached, welded to the top of the drum. To this is fixed a rubber or plastic hose long enough to allow the drum to rise and fall, whose free end is attached to the moisture release. This method is not recommended nowadays as it has proved unsatisfactory. The floppy hose pipe is ungainly and awkward and sooner or later cracks and leaks and has to be replaced. It has been superseded in Nepal by the centre-guide take-off.(cf. diagram).

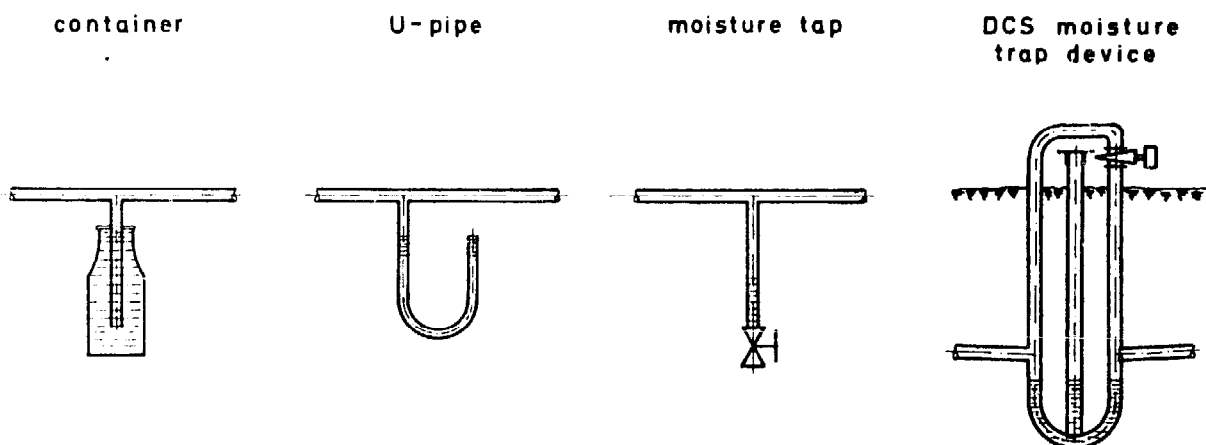
This modern method uses the centre-pipe as the gas-outlet. Gas collecting in the drum passes into the slide pipe through holes near the top of the drum. Since the top of the slide pipe is closed, the gas passes on into the guide pipe and leaves it through a connecting pipe at the bottom which leads it out of the pit. This method is neat, strong and permanent. Furthermore, it has been observed that since air and rain cannot enter the slide pipe and guide pipe, corrosion of these pipes is eliminated, or if any does occur, it is so extremely little as to cause no trouble whatever.

## 5 - MOISTURE RELEASE

The gas in the plant is moist and warm. On its way to the kitchen it passes through piping which in winter may be quite chill and cause moisture to condense inside the pipe. This condensed moisture will accumulate and may eventually block the flow of gas. So a moisture release device should be installed at the lowest point of the delivery line.

Four methods of moisture disposal are illustrated in the accompanying diagram. The first is simply a length of pipe in a bottle of water. The moisture trickles down the pipe into the bottle and overflows onto the ground. It is quite automatic and requires no attention beyond seeing that the bottle is always full. The end of the pipe should be 15-20 cm below the surface of the water.

### MOISTURE TRAP DEVICES



The second is the same in principle, a U-pipe with its shorter arm 15-20 cm long. The pipe must always be full of water.

The third is a length of pipe with a valve at the end, which is occasionally opened to let the water out.

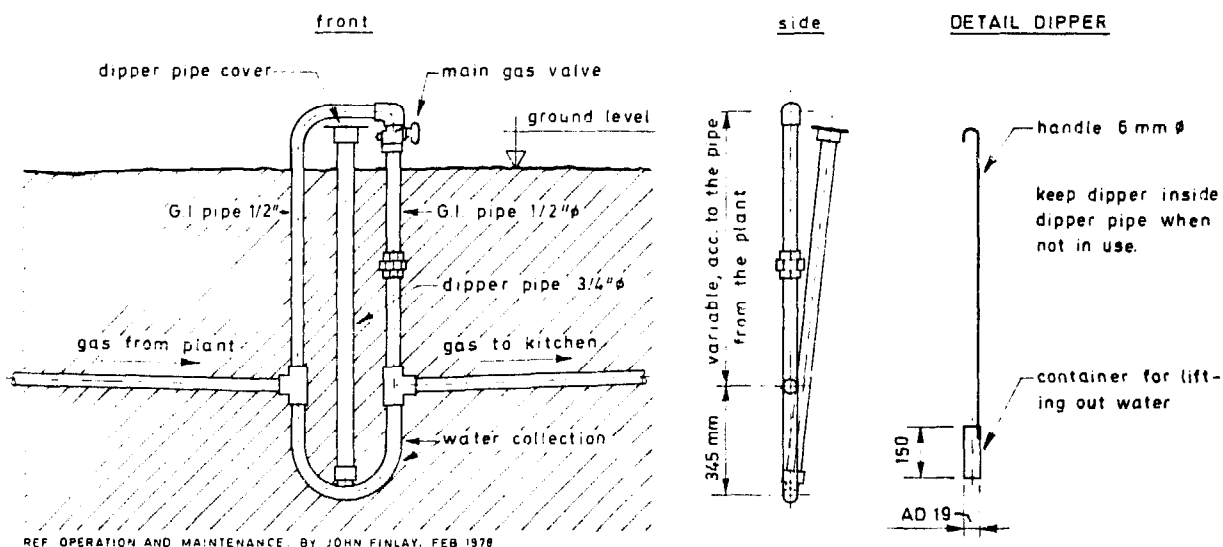
Where there is a high water table, with perhaps danger of occasional mild flooding during monsoon, these three devices have the disadvantage that water may enter the pipeline through them instead of leaving it. Such a contingency is impossible with the DCS Moisture Trap.

In hot climates one may possibly get by with no moisture trap, since moisture condenses only when the pipe is chilled.

### THE DCS MOISTURE TRAP DEVICE

The Development and Consulting Services of Butwal, Nepal, have produced a moisture trap of entirely new design. It is in essence a U-pipe with long arms to which the gas pipe is attached. The moisture collects in the U, to the middle of which another long pipe is fixed called "the dipper pipe". The U must always contain some water in order to form a water seal which forces the gas to rise up the first arm and flow down the second via the main gas valve which is just above ground. The rest of the device can be below ground. The top of the dipper pipe too is above ground. It is kept covered with a screw cap. Inside the pipe is the dipper, a small metal cup attached to a long wire.

### DIAGRAM OF WATER TRAP DEVICE



Excess moisture collecting in the U is taken out with the dipper and thrown away. Extraction of moisture continues till no more enters the dipper, which is then left in the pipe and screwed shut.

In most pit-digester designs, the gas pipe must leave the pit not lower than 60 cm below ground level, otherwise the main valve and the moisture release cannot be conveniently manipulated: they would be beyond reach. With the D.C.S. moisture trap this trouble is avoided. The main gas valve is always conveniently above ground. The gas outlet and even the top of the pit could be much lower if desired. Another advantage of this design is that it is so neat and simple and self-contained. To adapt it to lower or higher gas outlet all that is needed is to shorten or lengthen the dipper pipe and the arm of the U.

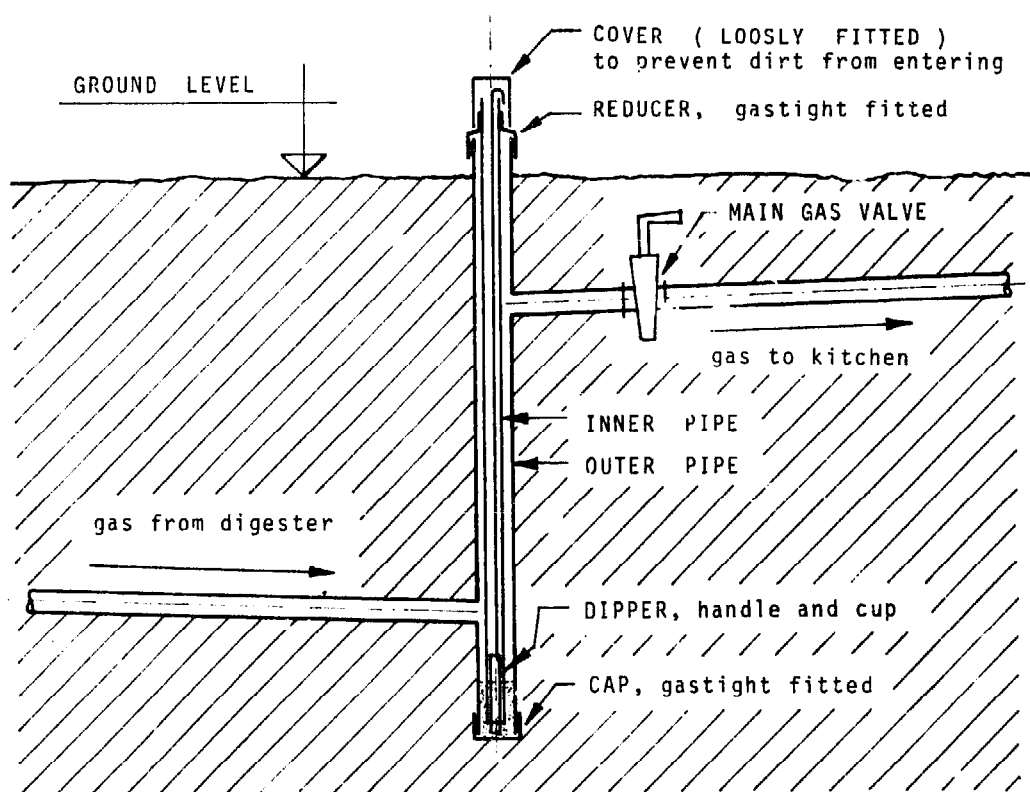
In making this moisture release, make the depth of the dipper cup 5 cm more than the gas pressure. Thus, if the pressure is 10 cm the cup should be 15 cm deep. Join the gas pipe to the U-arms at double the height of the cup, in this case 30-35 cm above the bottom of the U. The water seal will thus never be less than the gas pressure and the gas will have to go round the right way. The water in the U also prevents gas from escaping through the dipper pipe; so there is no need for its closure to be gas-tight. This DCS moisture trap is working satisfactorily in Nepal wherever it has been installed.

#### THE NEPALI SLIMLINE

There is yet one more design of trap worth describing, the Nepali Slimline. While the DCS trap consists of three connected pipes one for gas inlet, one for gas outlet and the third for water collection and extraction, the Slimline has only one pipe: or so it seems. In reality there are two, one inside the other, the outer one for gas and the inner for water. Condensate from the pit and the kitchen pipeline trickles down and gathers in the trap, whence it is extracted with a dipper, as in the DCS trap.



The two pipes can be of any diameter the owner desires. Much depends on the volume of the digester and the diameter of the main gas pipe. The only point to mind is that there be sufficient space between the two pipes to allow the full and free passage of gas. The length of the pipes depends on how deep in the ground the gas comes out of the pit. As for the "sump" for water collection, a 15 cm depth ought to be enough for household plants with a gas pressure of 10 cm water column. This determines the position of the gas inlet pipe. The outlet should be just at ground level or slightly below, so that the main gas valve is conveniently accessible.



In making the Slimline it is necessary to ensure a perfect watertight closure at the bottom, and a perfect gastight fitting of the two pipes at the top.

## 6 - THE GAS DRUM

This is made of mild steel sheeting or galvanized-iron sheeting of any thickness from SWG 16 to SWG 30 (1.63 mm - 0.32 mm). India favours the heavier gauge further strengthened with angle iron or iron rods; Taiwan often uses gauge 30 fixed to a rectangular wooden framework for rigidity (their fermenting tanks too are often rectangular). There is no point in making the drum too heavy and then having to counterbalance it. Except in plants where the whole day's gas has to be stored for use at one time, it is customary to make the drum one-third the depth of the pit, and its diameter 10 cm less than that of the pit. A 2 1/2" pipe\* almost double the height of the drum passes through it and is welded to the top centre; its lower end is held firmly by thin iron tie-rods. The top of this pipe (called the "slide pipe") is closed. A few holes are drilled in the pipe, inside the drum and just below the top. (see diagram).

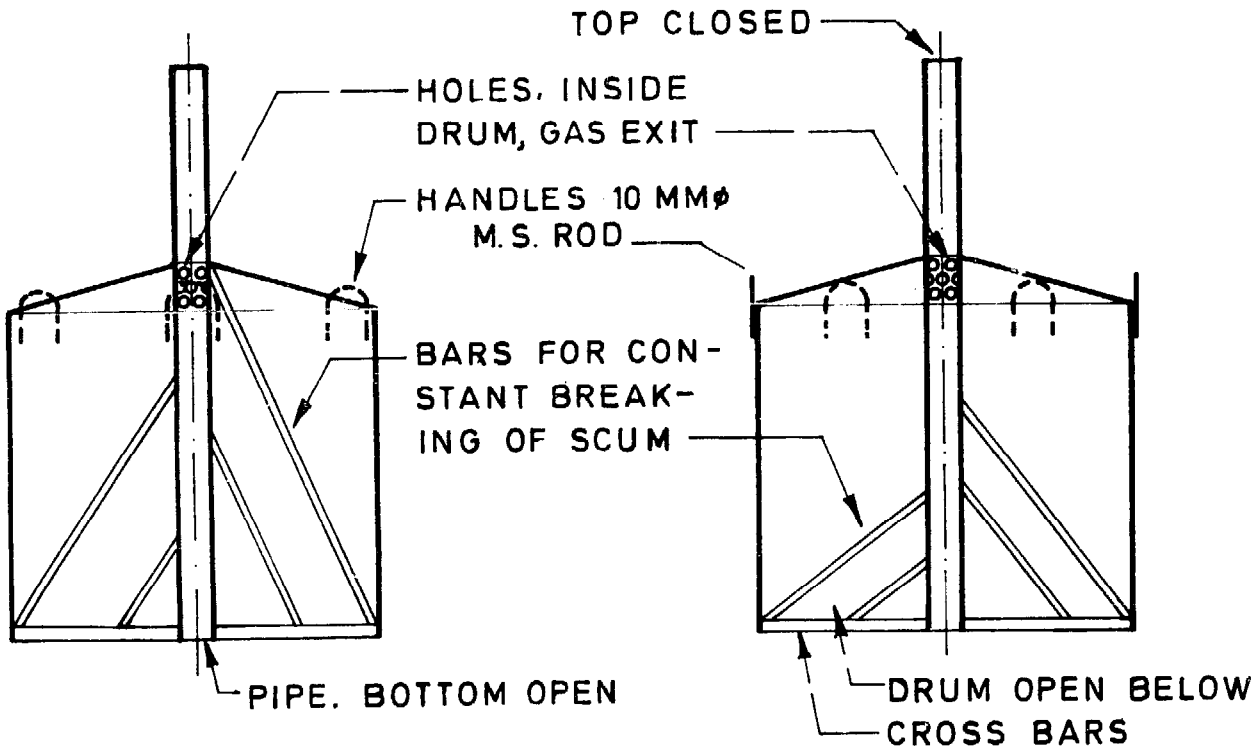
This pipe slips onto a 2" pipe\* held perfectly in the dead centre of the pit by two strong cross-bars, or imbedded in a ferro-concrete beam. As the drum fills and empties it rides up and down on this centre guide pipe, the top of which should stand at least half the height of the drum above overflow level. Make sure that the drum is perfectly airtight. Attach handles to the outside for lifting. Weld four metal rods from the tie-rods to the slide pipe. Stagger them. With a slight rotation of the drum, or with its mere rise and fall, these break up troublesome scum that forms on the slurry and tends to harden and prevent the passage of gas. Protect the outside and inside of the drum with a coat of paint.

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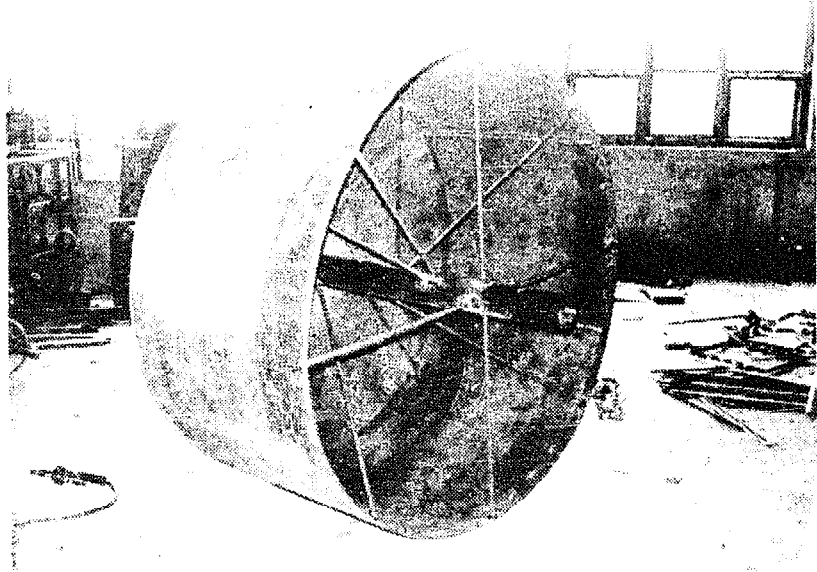
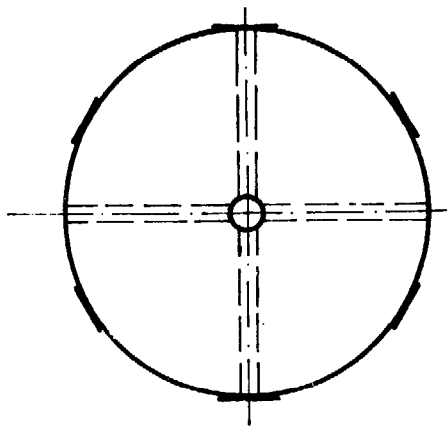
\* This diameter is suitable for small family-size plants. Larger installations of course require sturdier pipes of bigger diameter.

front / cross

side / cross



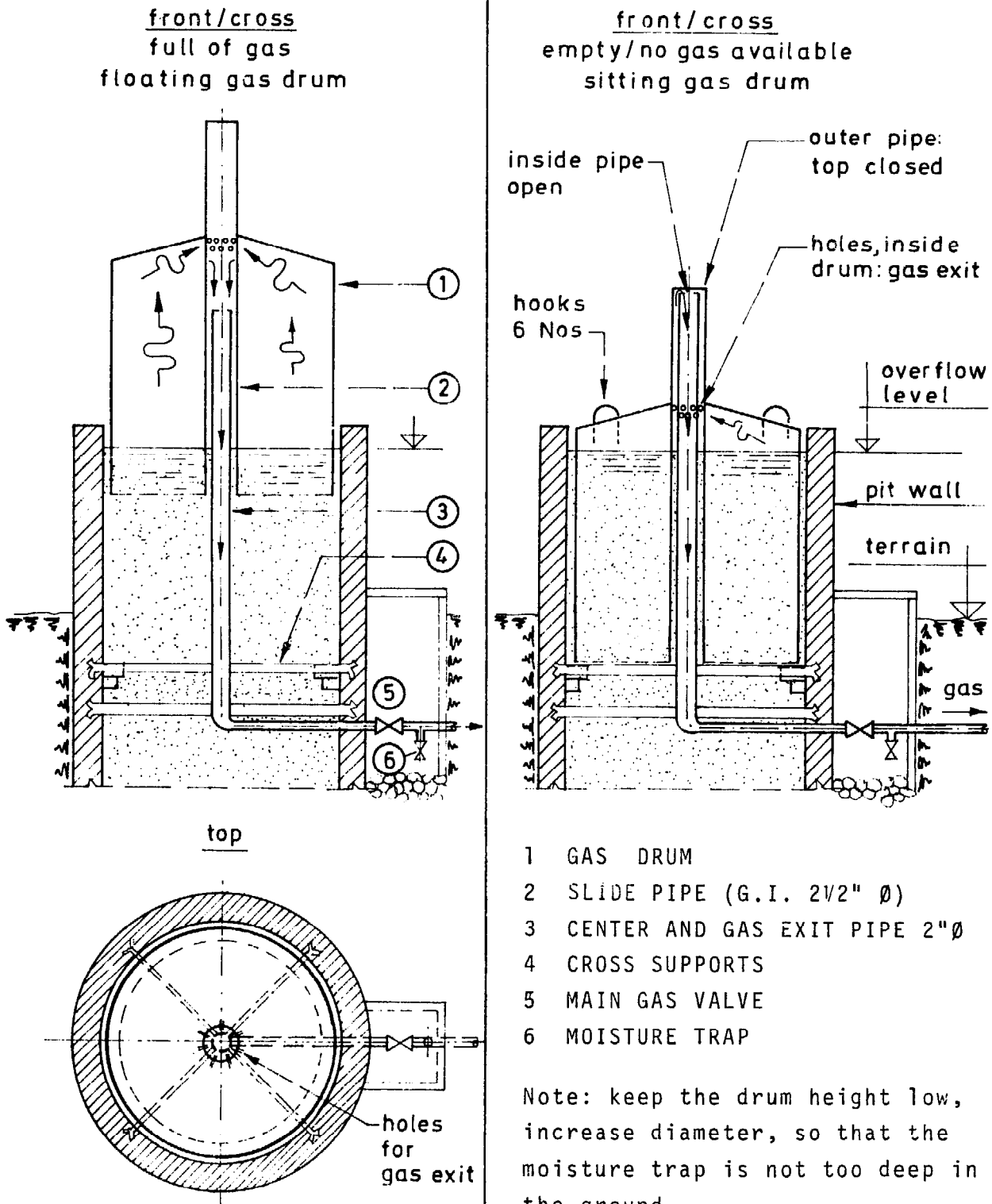
top



Gas drum showing scum-braking rods fixed all helter-skelter, not as recommended in the text.

A NEAT AND MODERN WAY OF GAS TAKE - OFF  
eliminating the ugly, old-style, flexible pipe

SCHEME OF PRINCIPLES



- 1 GAS DRUM
- 2 SLIDE PIPE (G.I. 2 1/2" Ø)
- 3 CENTER AND GAS EXIT PIPE 2" Ø
- 4 CROSS SUPPORTS
- 5 MAIN GAS VALVE
- 6 MOISTURE TRAP

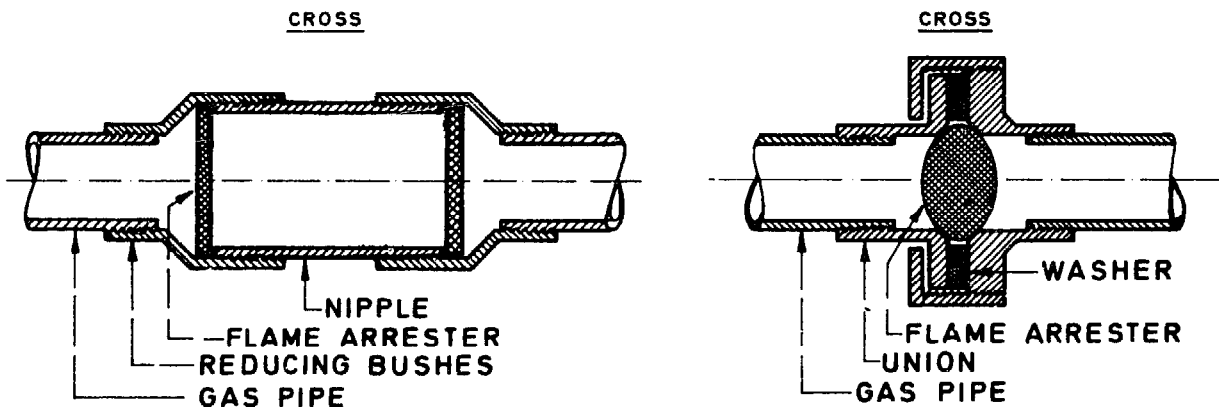
Note: keep the drum height low, increase diameter, so that the moisture trap is not too deep in the ground.

## Note:

- For making drums, cold-rolled steel sheeting is preferable to hot-rolled. It resists corrosion better.
- Plants using only cattle dung suffer less from corrosion than those whose slurry is augmented with human waste.
- Plants where night soil is the only, or the predominant, raw material are most liable to corrosion. This may be due to increased hydrogen sulphide.
- It is wiser to paint all drums, whether of G.I. sheeting or of plain iron, with a coat of red oxide followed by a coat of bituminous paint.
- Corrosion of concrete too, or of brickwork, in a drumless Chinese-model gas plant is prevented by bituminous paint.

## 7 - THE FLAME TRAP (Not shown in plant diagram)

A flame arrester is a safety device that should be incorporated into every gas line. It is commonly placed either just after the main gas valve near the digester, or just before a gas stove or lamp. It is safer to have one in both places. Its purpose is, in case of accidental back-fire, to prevent the flame from running down the gas pipe into the collecting drum and causing an explosion.



The arrester can be a ball or roll of fine mesh copper wire (copper, not galvanized wire which would rust away) inserted into the gas pipe. It is sometimes not realised that this necessarily forms an obstruction to the free and full flow of gas. It is therefore recommended that the flame arrester be placed in a length of pipe of slightly larger diameter than the gas pipe, especially if it is placed near the main valve. For a 1/2" main gas pipe use a 3/4" arrester, for a 1" pipe a 1 1/4" arrester.

An arrester could also be made by brazing a copper wire disc at either end of a short bit of pipe joined into the pipe line.

#### GAS PIPE LINE DIMENSIONS FOR LOW PRESSURE GAS (10 CM)

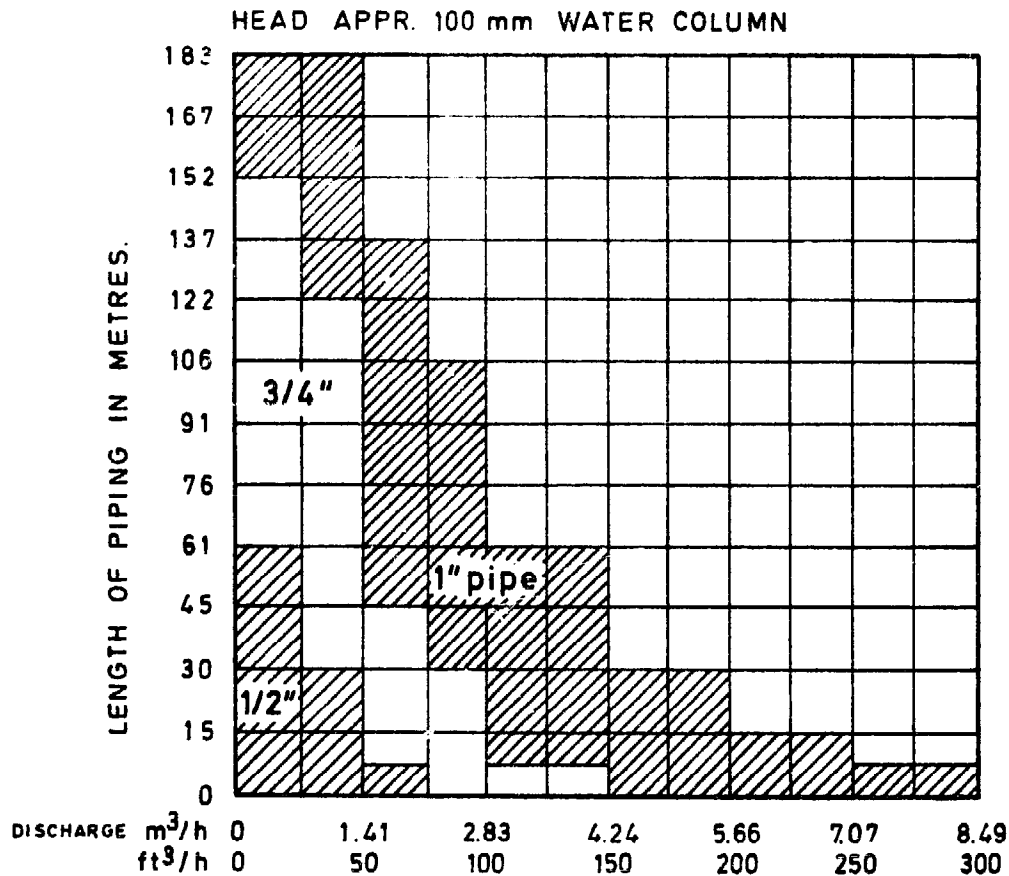
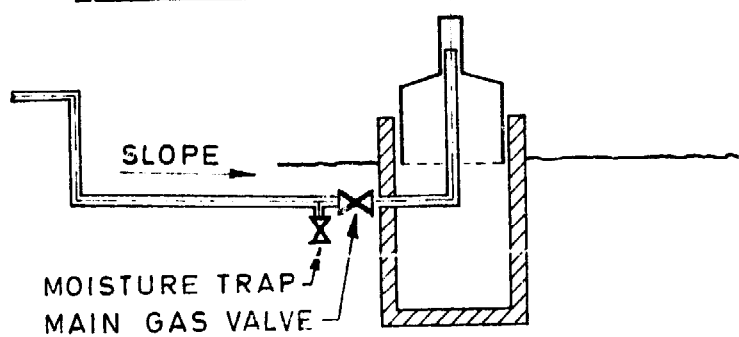


DIAGRAM BASED ON A FALL OF 3/16 WATER GAUGE FOR  
FOR ORDINARY LOW PRESSURE GAS SUPPLY

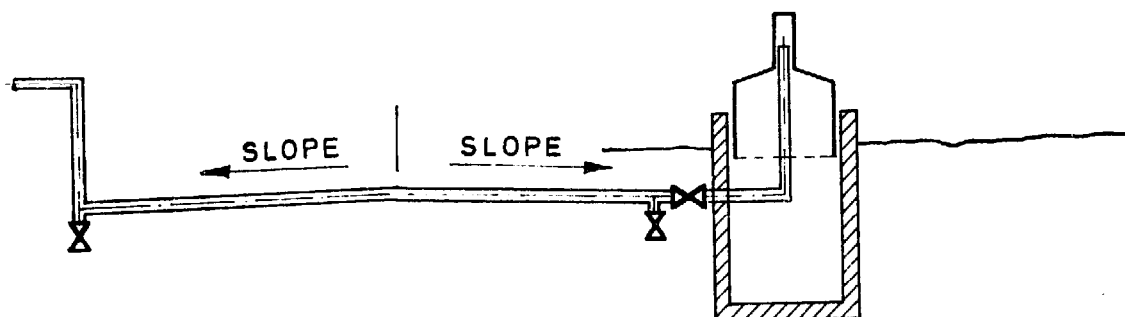
## PIPE INSTALLATIONS

a) short distance

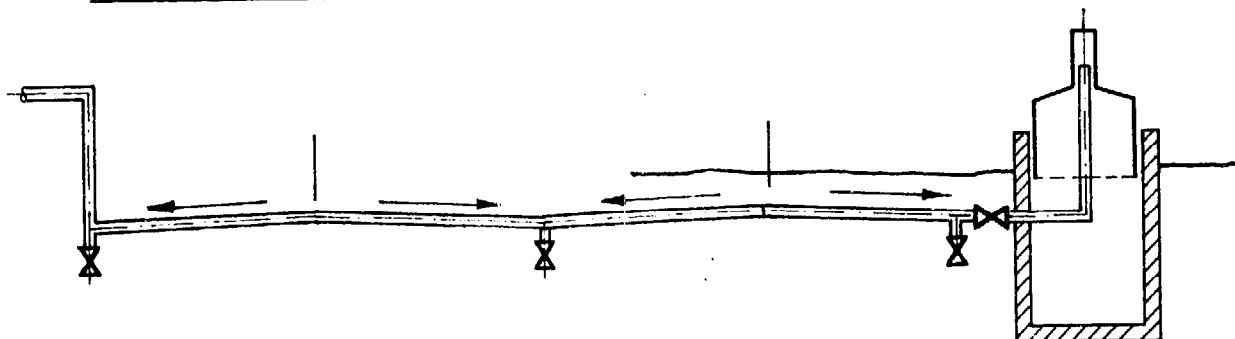
SLOPE = 1cm/mtr



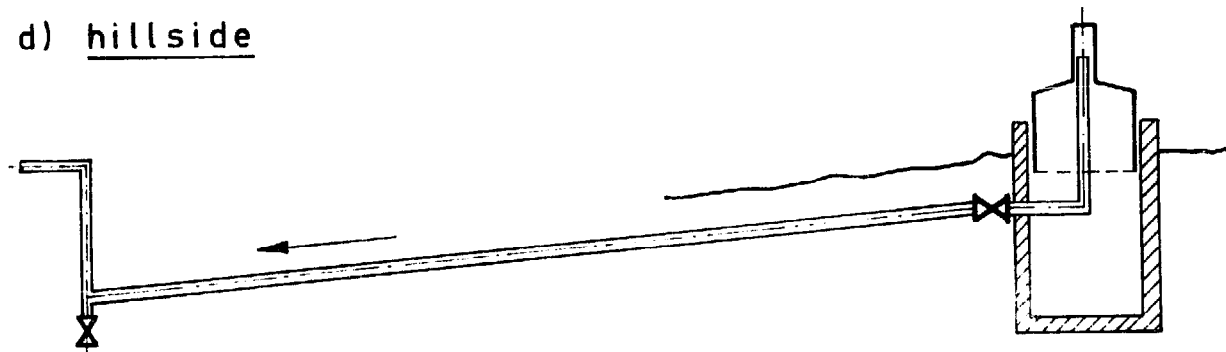
b) medium distance



c) long distance



d) hillside



Ideally, the shorter the pipe line the better, the gas pit being as near the kitchen as possible. But sometimes this is not practicable. The greater the distance, the larger should be the pipe diameter, unless one uses a pump. For a distance of 150 m Khadi and Village Industries Commission (Bombay) recommends a 1 1/2" pipe. At a college in Patna a 2" pipe line, too big in our opinion, was installed for a distance of 160 m. It has worked with entire satisfaction for several years.

Galvanized iron water pipes have proved to be the best. Plastic could be used; however, field tests have shown that due to various factors (poor quality material, ill-fitting adapters, &c. this is not as satisfactory as metal piping). G.I. pipes laid underground should be protected against corrosion with durable paint (bitumen) wrapped around with a bitumen-soaked cotton bandage.

Plastic pipes should not be used indoors because their mechanical resistance is not reliable. Testing for gas-tightness should be done with soap water never with an open flame.

### USING THE GAS

The first drumful of gas will probably contain so much carbon dioxide that it will not burn. It may also, just possibly contain some methane and a lot of air in just the right proportion to explode if ignited. DON'T ATTEMPT TO LIGHT THE FIRST DRUMFUL OF GAS. Void it into the air and let the drum fill again.

### COOKING

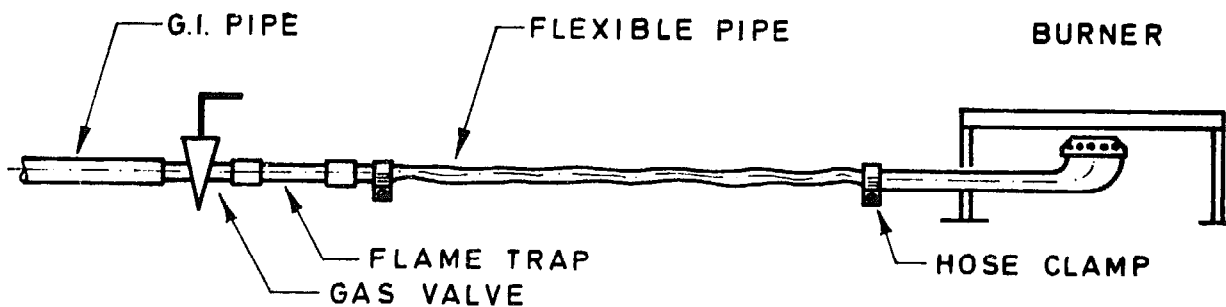
In India special stoves are made for burning cowdung gas. This gas, coming at low pressure of 7-10 cm water head, will not burn in stoves built for high pressure use. However, a "Primus" or other pressure stove burner will work satisfactorily if the centre nipple in the burner is removed, or where there



is no nipple, if the needle-thin jet hole is enlarged to 1.5 mm (1/16"). On the other hand a burner made at home out of half-inch water pipe allows too much gas. The pipe should be choked with a metal disc having the centre hole of diameter 1.5 to 2 mm. An efficient burner is a tin can, filled with stones to balance it, having half a dozen 1.5 mm holes in the top. The gas enters at the bottom through a pipe choked to a 2 mm orifice.



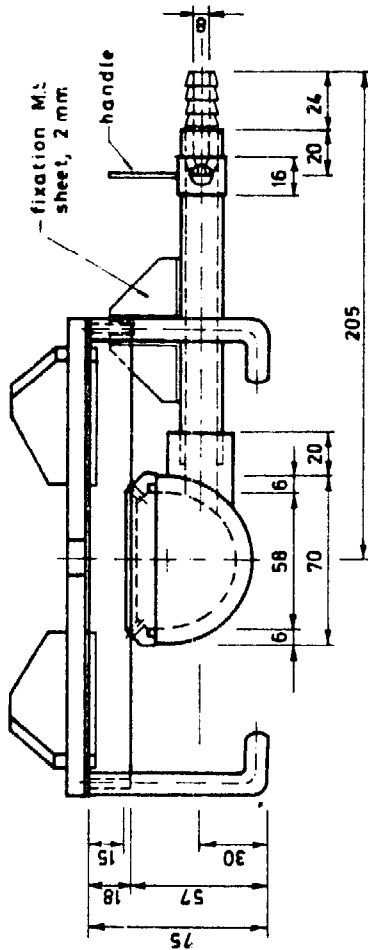
Cooking on gas



Though cowdung gas burns well with or without air it is advantageous to use a burner with an adjustable air inlet, as such stoves burn hotter with less gas.

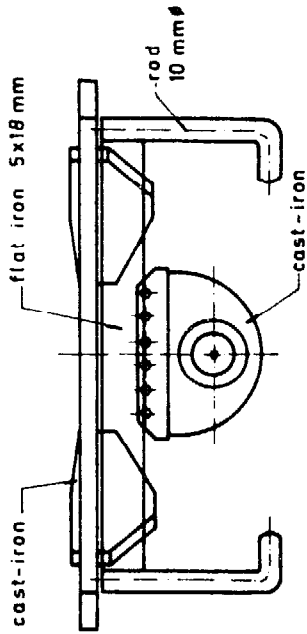
side / cross

shown with grate turned for pots with round bottoms



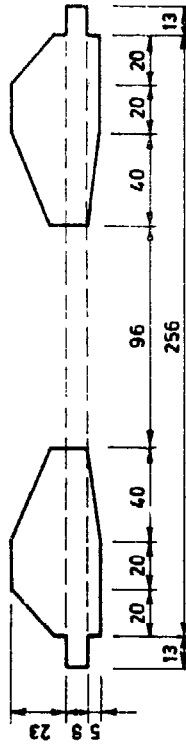
front / cross

shown with grate turned for pots with flat bottoms



A-A section / grate detail

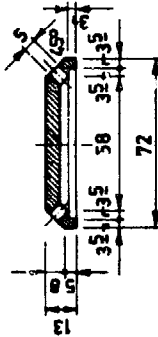
cast iron / 8 mm thick



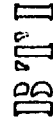
cover - detail

cast - iron

18 Nos holes  $\varnothing$  5 $\phi$



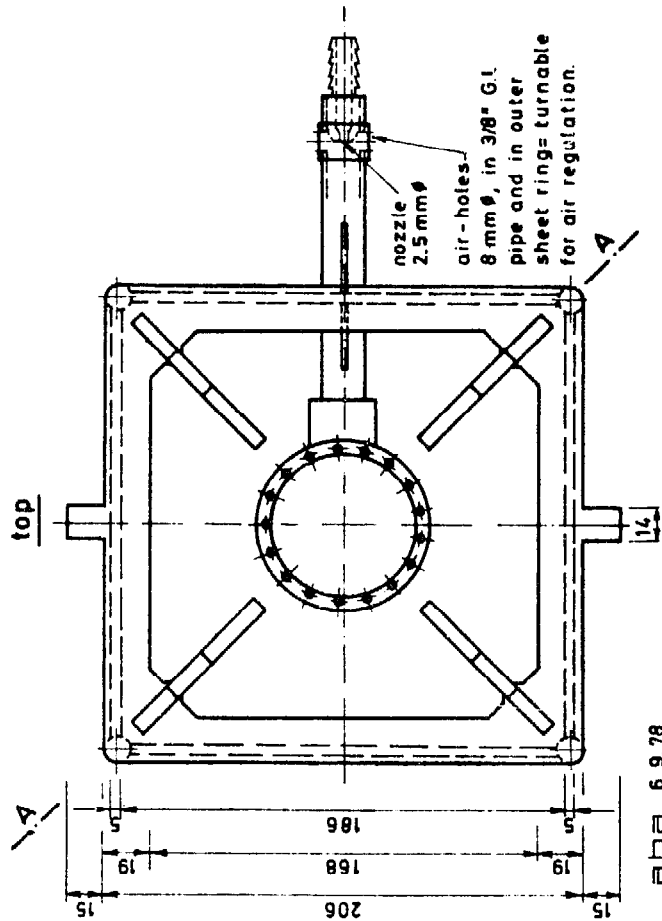
BASICS OF THE (16 cft / h)



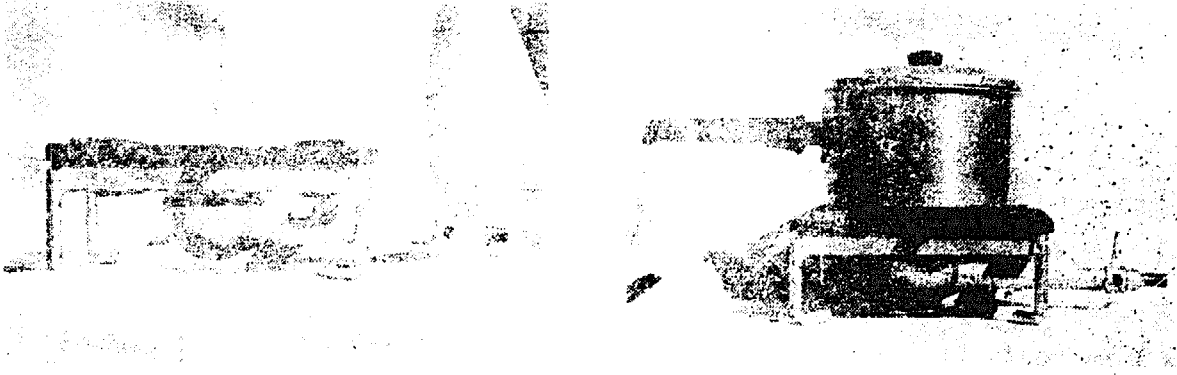
LOW PRESSURE

BIO GAS BURNER

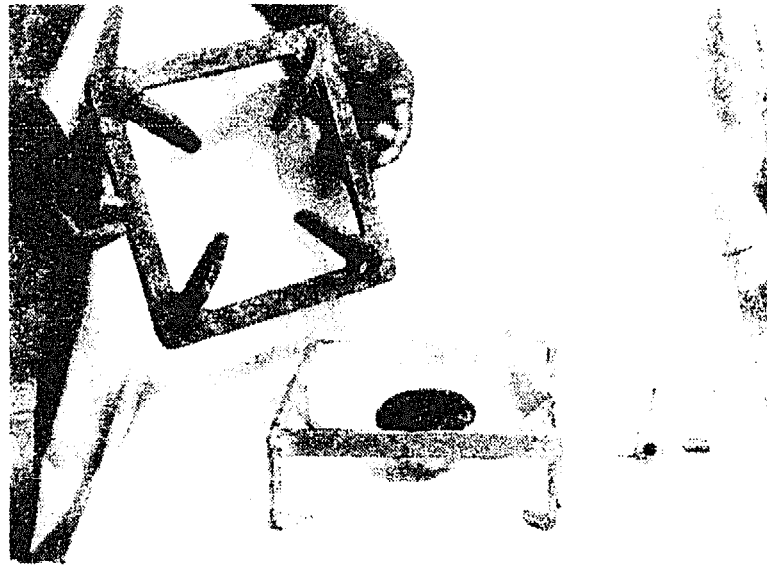
WITH TURNABLE GRATE FOR POTS WITH FLAT OR WITH ROUND BOTTOMS



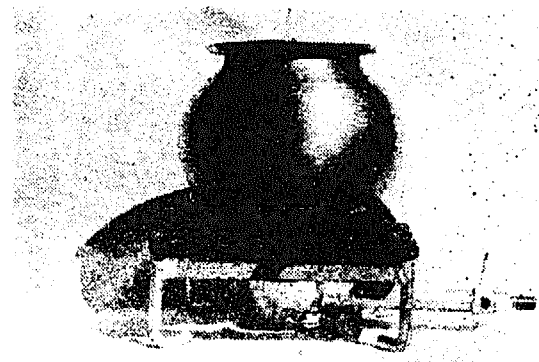
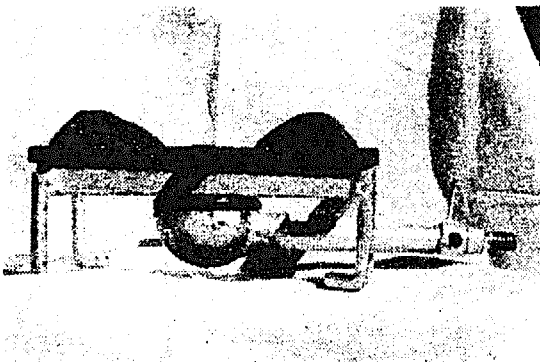
BB 6.9.78  
measurements in mm.



Cooking with flat-bottomed pot

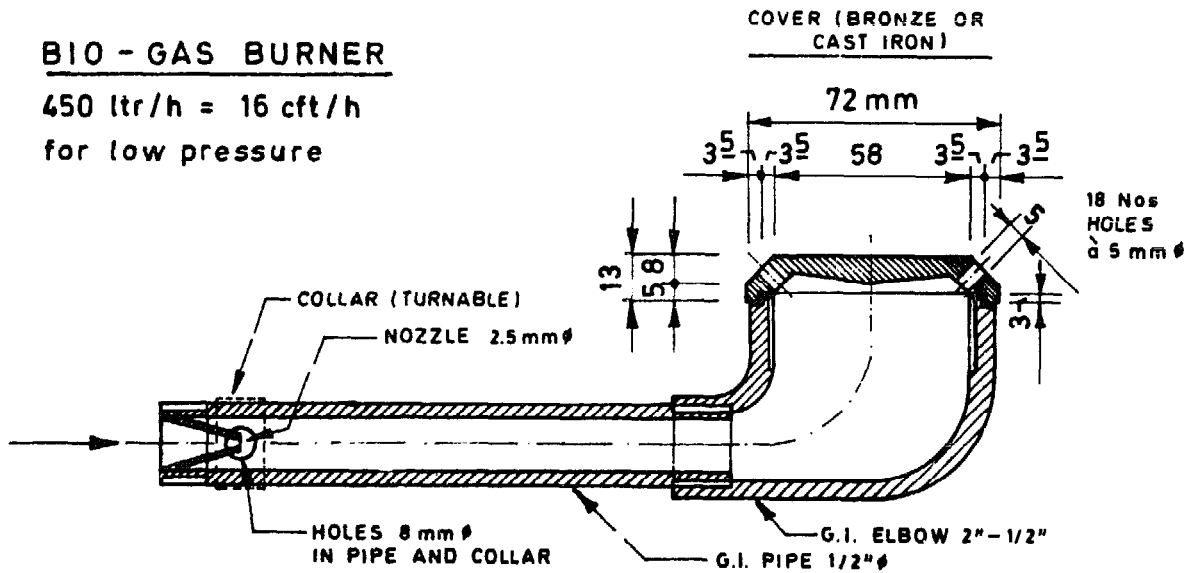


Cooking in a pot with round bottom.

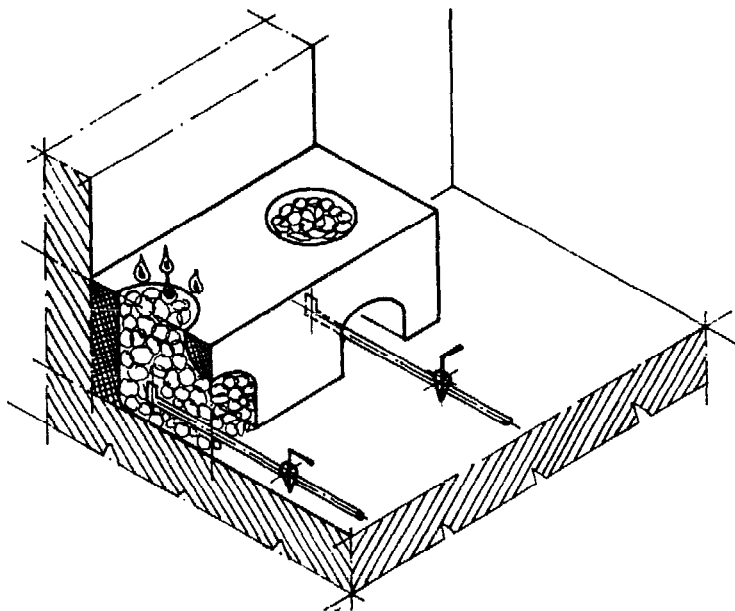


BIO - GAS BURNER

450 ltr/h = 16 cft/h  
for low pressure

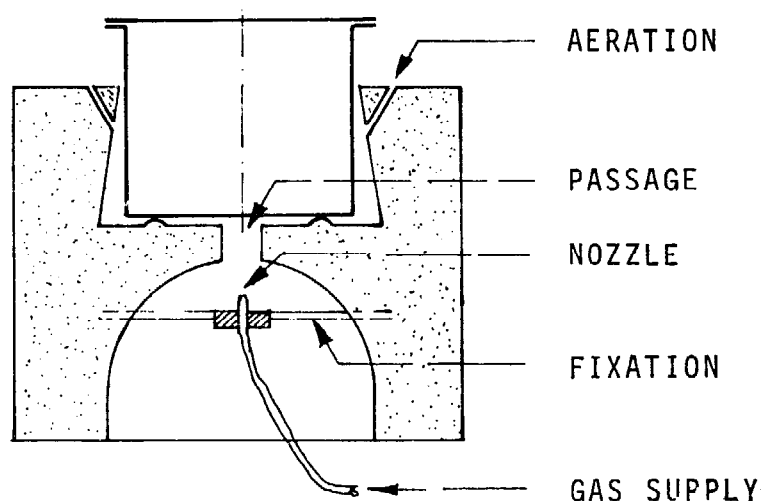
A VILLAGE - MODEL STOVE

A simple solution to the stove problem is to use the existing village "chulo" or stove. Insert a pipe into it and fill the stove with stones. This works quite satisfactorily if fitted with a choked inlet (2 mm) and an air control.



### A CHINESE GAS STOVE

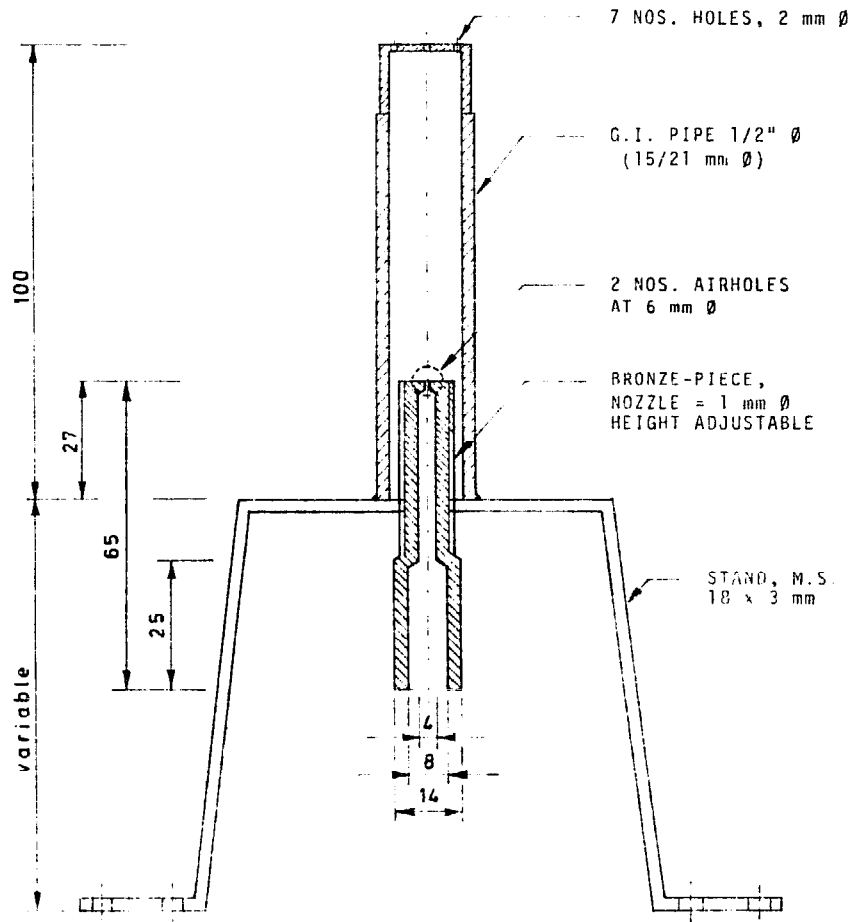
The cooking pot is sunk deep into the stove and rests just off the bottom. Below it, in the centre, is a hole through which is directed a gas jet sufficiently distant from the hole to let air be drawn in together with the gas, thus ensuring a proper gas-air mixture. It makes an audible hiss. The flame licks the bottom of the pot, and the heat that rises up the sides, instead of being blown away and lost (as happens when the pots sits exposed on top of a stove) is totally enclosed and directed against the pot by the tapering configuration of the stove. This novel design is therefore more fuel efficient than a normal open gas ring.



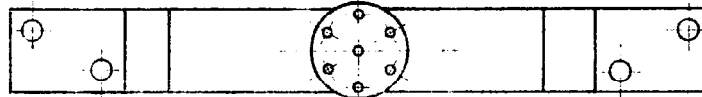
### A REFRIGERATOR BURNER

A fridge that runs on the heat of a kerosene flame can be run on cowdung gas with a suitable burner. The burner whose design is presented here has given very good results in tests conducted in Nepal. With a gas pressure of 8 cm and a consumption of 100 ltr/hr, this burner has successfully worked a fridge of 12 cft capacity over a test period of eight months.

It is simple, elegant and inexpensive. To fit it into the space provided, the stand can be made taller or shorter. The nozzle can be slightly adjusted and fixed a little higher or lower, as may be found necessary.



top

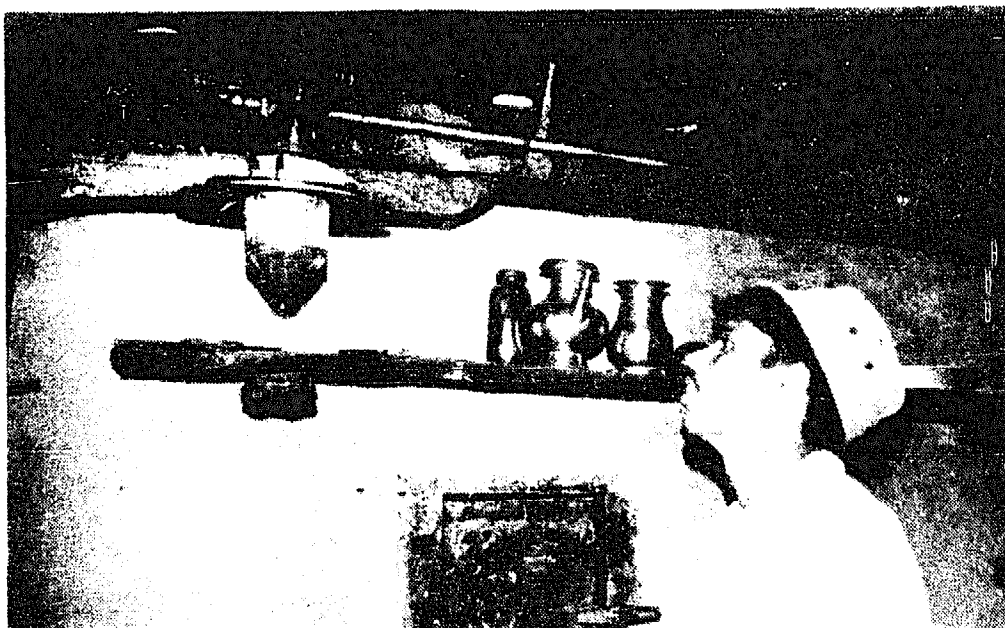


measurements in mm  
a b a 13.12.78

This burner has also run a kerosene incubator (100 egg capacity), and can serve very well as a low temperature bunsen burner, or for any other application requiring a small, continuous, clean, smokeless flame.

## LIGHTING

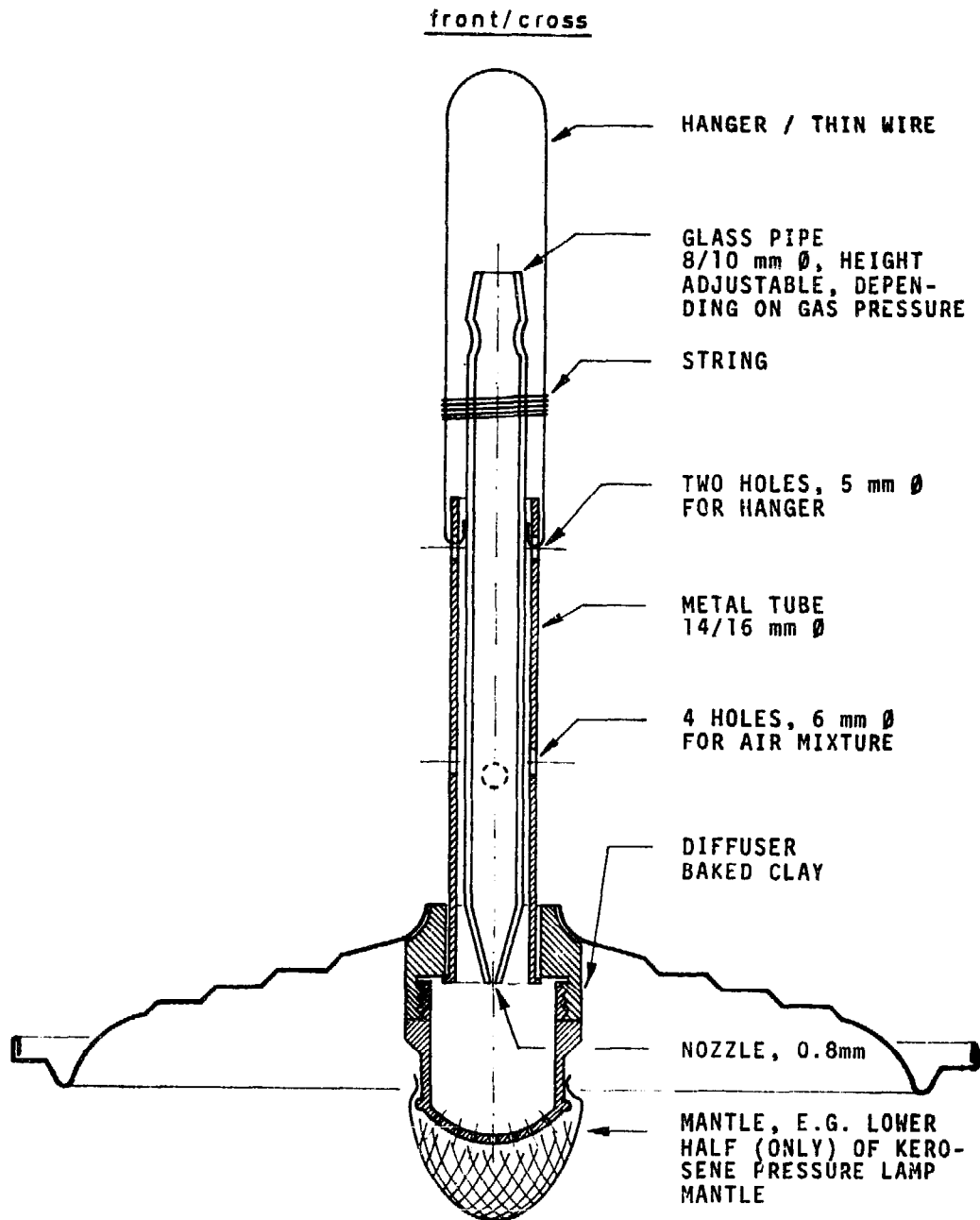
Cowdung gas gives a soft, white light when burnt with an incandescent mantle, very much like the light from an Alladin lamp, and not quite as bright and glaring as a Coleman lantern or a Petromax. Lamps of various styles and sizes are manufactured in India expressly for use with cowdung gas. They may have from one to four or more mantles, each consuming approximately 2.75 cft (80 ltr) gas per hour per mantle. Each mantle, at a pressure of 4" water head burns about as bright as a 40 watt electric bulb. At higher pressure they burn brighter.



For lighting, where many lamps are needed, it is more efficient to run a generator gas and have electric lights than to burn the gas direct in gas lamps. A 40-watt mantle consumes about 80 litres per hour so 25 mantles would require 2000 litres. On an average it takes only 750 litres gas to produce 1 kW/hr of electricity, enough to light 25 Nos. 40-watt bulbs. And wiring a house is easier, cheaper and safer than installing gas pipes with the possibility of cracking and the danger of leakage.

## A SIMPLE CHINESE GAS LAMP

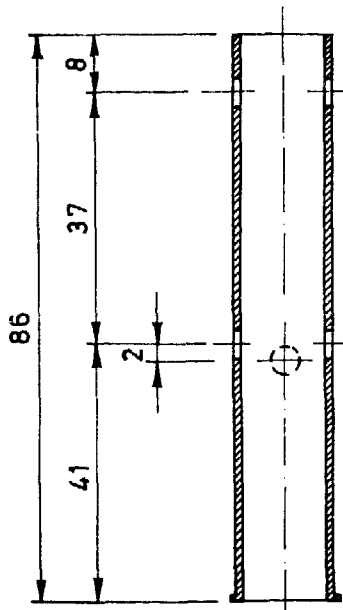
The 0.8 mm nozzle is suitable in China where gas pressure is high (up to 100 cm). For a 10 cm pressure the diameter should be about 2 mm.





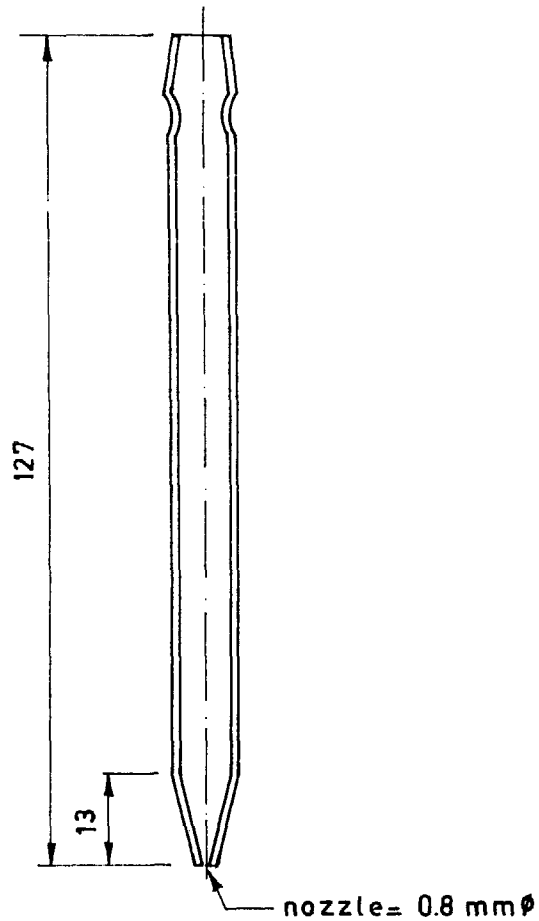
metal tube

14/16 mm  $\phi$

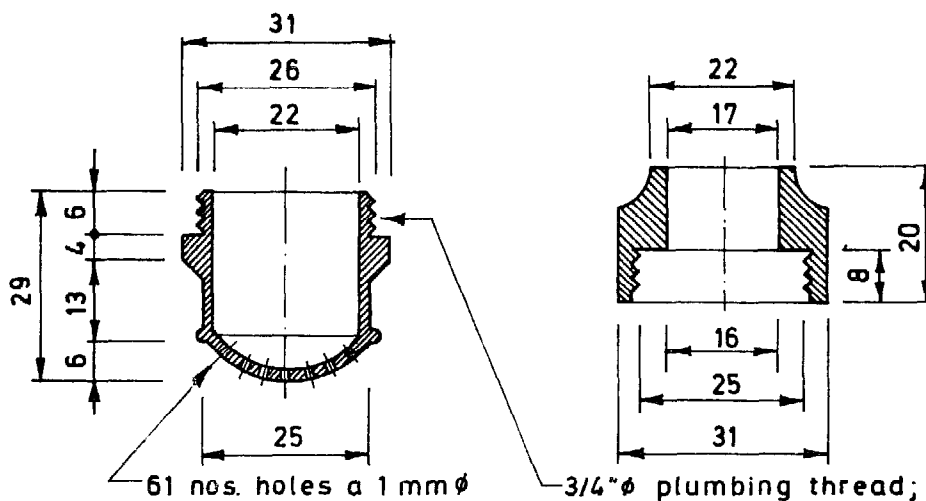


glass tube

8/10 mm  $\phi$



diffuser



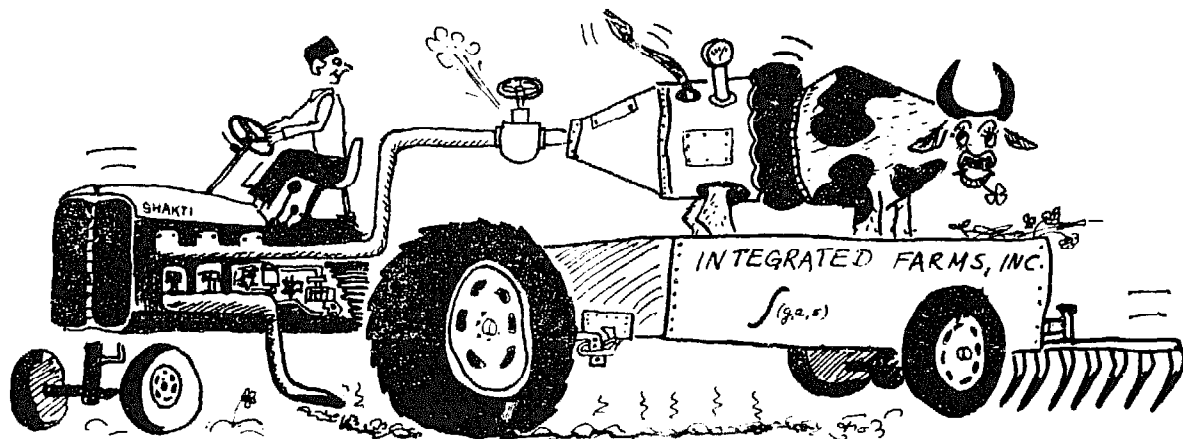
61 nos. holes a 1 mm  $\phi$

3/4"  $\phi$  plumbing thread; the same root-stock head can be used for industrial purposes, when fixed in a row on a pipe with 3/4"  $\phi$  inside threads (branch).

measurements in mm  
Kathmandu, 16.9.78

## RUNNING ENGINES

Any internal combustion engine can be adapted to run on cowdung gas. For petrol engines, drill a hole in the carburetor just near the choke and introduce a 1/4" (7 mm) tube connected to the gas supply through a control valve. The engine may be started on petrol and then switched over to methane while running, or vice versa. For smooth running of the engine the gas should flow at a steady pressure which can be maintained for stationary engines by adjusting weights on the gas drum, or in automobiles through a metering device sold commercially.



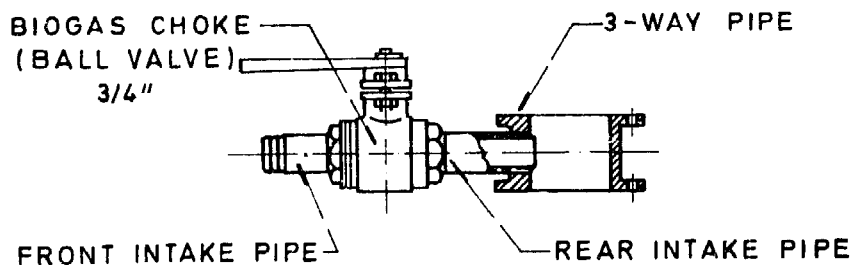
It is commonly recommended that when running internal combustion engines on cowdung gas the gas be first be purified. This is done by ridding it of moisture, of carbon dioxide and of hydrogen sulphide. But at least one experienced authority\* maintains that engines after years of running on un-purified gas have shown no appreciable ill effects attributable to the gas as a such.

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\*L. Fry: Methane Digesters for Fuel Gas and Fertilizer.

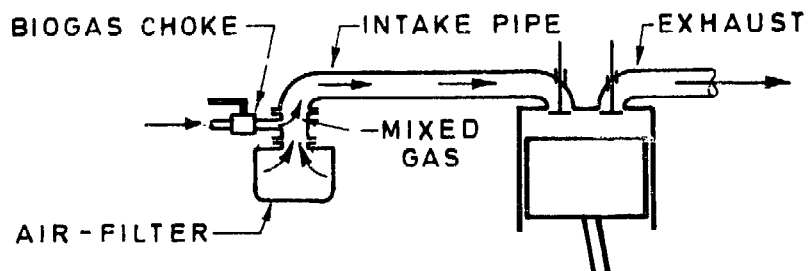
Several manufacturers of diesel engines (Ruston, Crossley, Kirloskar and others) can easily adapt their engines for the use of cowdung gas. It is wiser to have a recognized and experienced agent effect the necessary changes than to attempt the job oneself and risk ruining the engine. This remark applies to petrol engines too.

DIRECT INTAKE MIXER FOR DIESEL ENGINE



Carbon dioxide is removed by bubbling the gas through lime water; hydrogen sulphide by passing it through a tube containing ferric oxide, which is later renovated merely by exposure to air or by gentle heating; and moisture by passing it through a quantity of very dry wood shavings.

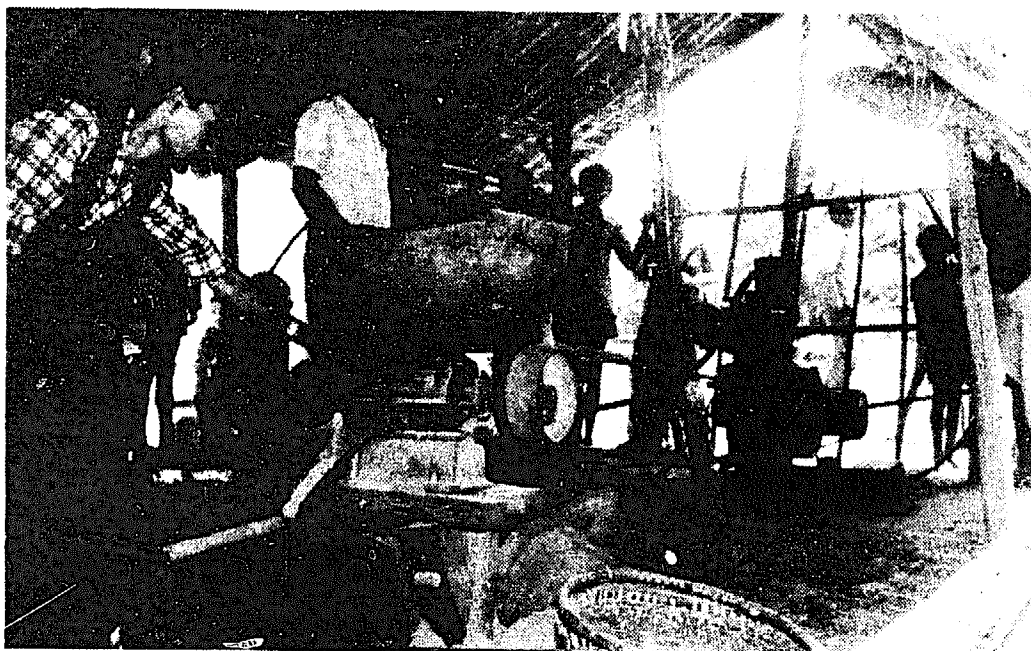
DIESEL ENGINE WORKING WITH BIO-GAS  
SCHEME



Engines usually consume approx. 550 ltr (20 cft) of gas per h.p. per hour.

Rather than alter a diesel engine to run on gas alone, it is far simpler and cheaper and more practical to convert it to a dual-fuel engine. It can then be run either entirely on diesel oil as usual or on 20% oil and 80% gas.

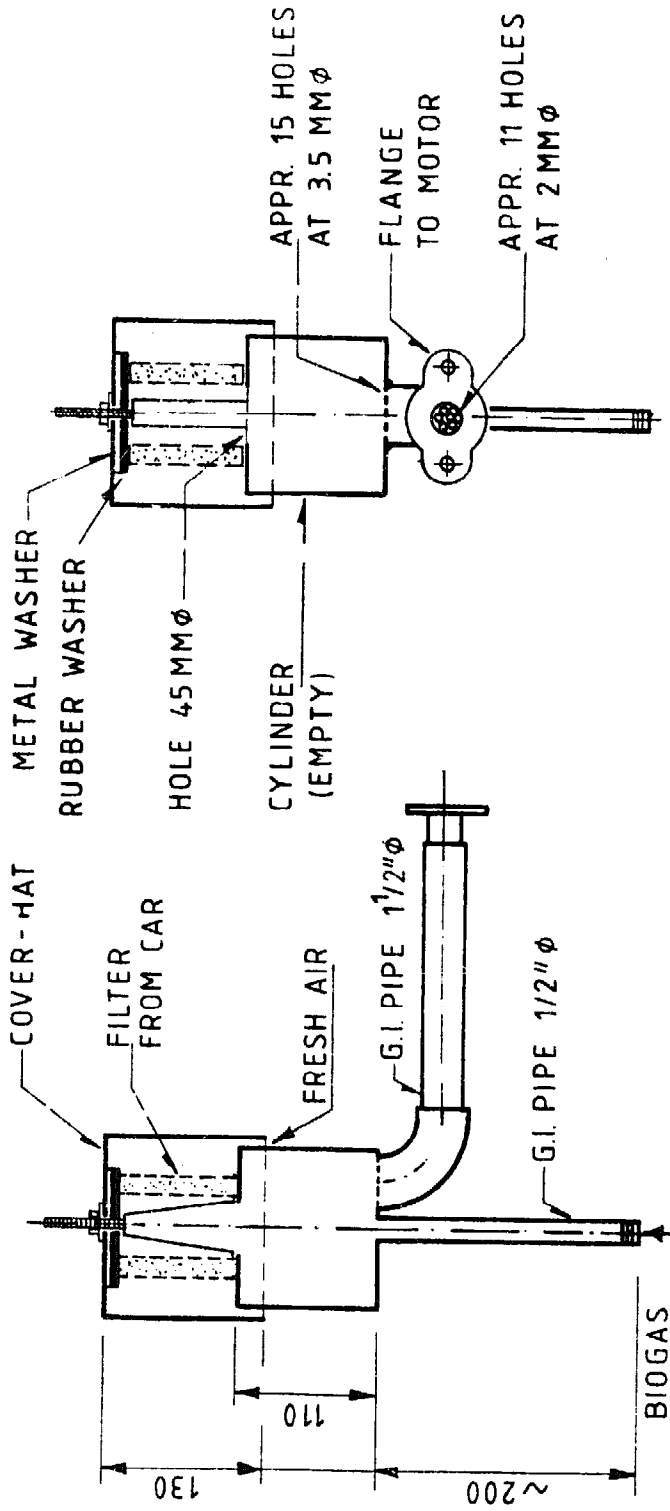
The gas is fed in between the air intake and the engine and the mixture of air and gas is drawn into the cylinder. The engine is started on diesel oil with the gas valve closed, and when running steady under full load, the gas valve is opened very gradually. Because the explosive mixture is now richer than with oil alone the engine tends to run faster, but the governor automatically controls the speed by diminishing the diesel oil supply. If the gas is fed in either too suddenly or too much, the engine may begin to knock and run irregularly. The valve should then be closed, ever so little at a time, till the running becomes quite smooth. The amount of gas an engine will take depends on its make and the efficiency of its governor. The average requirement of oil is between 30% and 20% with a corresponding gas consumption of from 70% - 80%, sometimes slightly more. The saving in oil is considerable.



Agro processing with combustion engine:  
4/5 biogas and 1/5 diesel fuel

A dual-fuel engine works best under a steady load. If the load varies much and frequently, the gas valve requires constant adjustment unless equipped with its own governor. Small infrequent variations are taken care of by the engine governor which allows more or less diesel oil as required.

FRONT



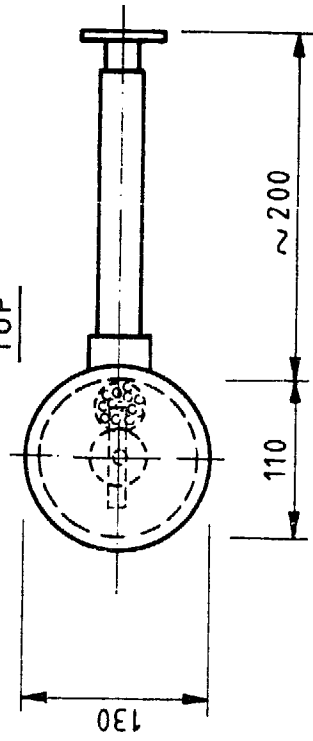
MATERIAL: M.S. SHEET 1.6 MM

BIOGAS ADAPTER  
 TO DIESEL MOTOR

DESIGN: GOBAR GAS COMPANY  
 NEPAL

FUEL CONSUMPTION: 4/5 BIOGAS  
 1/5 DIESEL

TOP



If in the middle of a long steady run the engine suddenly begins to knock, it is a sign that the load has suddenly dropped and the gas input is now too rich. It should be adjusted.

When adapting a diesel engine to run on gas there is no need whatever to lower the compression ratio, nor is it advisable to alter the injection timing. For smooth running it is essential to maintain the gas pressure as steady as possible.

#### DOUBLE CHAMBER CONSTRUCTION

Since light, insoluble or indigestible matter in the slurry tends to rise with the gas bubbles for the first couple of weeks of violent fermentation and thereafter to fall to the bottom and form a troublesome sludge, an improved model of the Indian fermenter is now being used which is divided into two compartments up to the ledge top having a combined volume of 40 times the daily input of slurry. The input pipe ends about 2 ft (60 cm) above the bottom of one compartment. The output is through a pipe beginning about 6" (15 cm) above the floor of the second compartment and ending above ground 4" (10 cm) lower than the drum top when the drum is resting on the ledge.

The advantage of this improved model is that since the daily flow of slurry goes up the first side, when the insoluble matter rises, and down the second where this matter naturally tends to fall, the outgoing slurry daily draws out with any sludge found at the bottom. Thus, having to clean out the pit, if at all required, becomes a comparatively rare necessity.

This two-compartment construction can be used on pits of any size, but is particularly recommended for those of larger volume than 200 cft (6000 ltr).

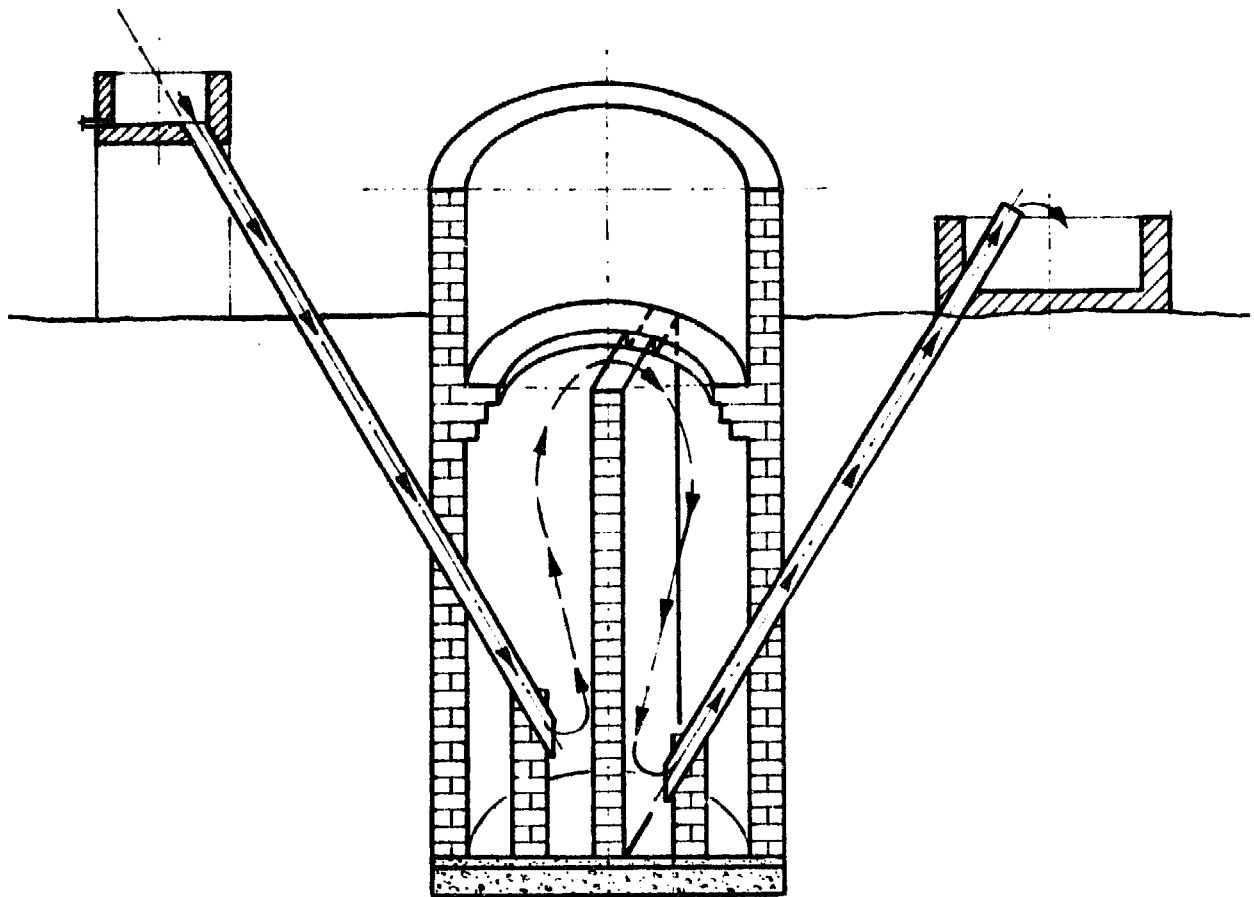
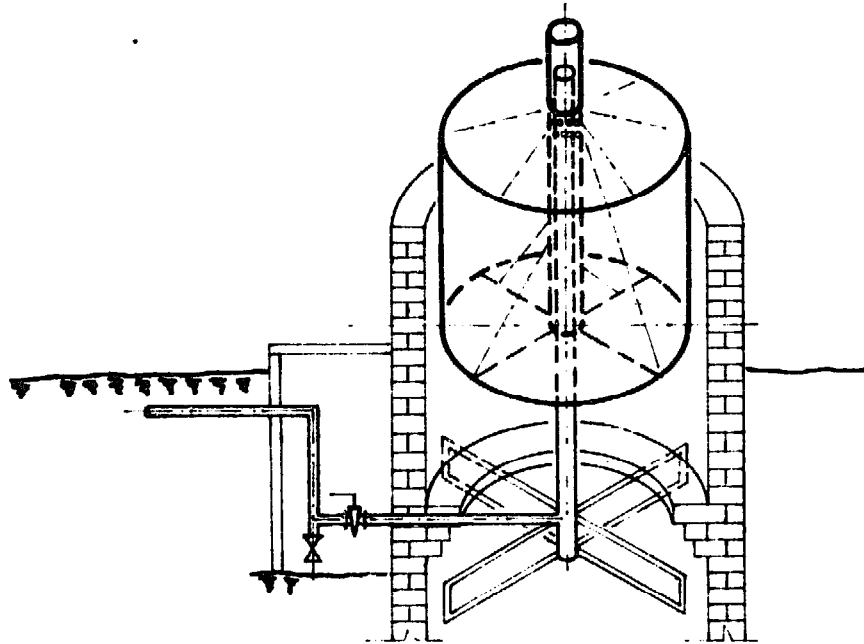
When filling such a pit for the first time, pour slurry into both halves equally to balance the pressure on the thin inner wall, or it may collapse. The dividing wall need not to be thicker than 3" (8 cm), the smallest dimension of a brick.



Indian pit design, two chamber construction

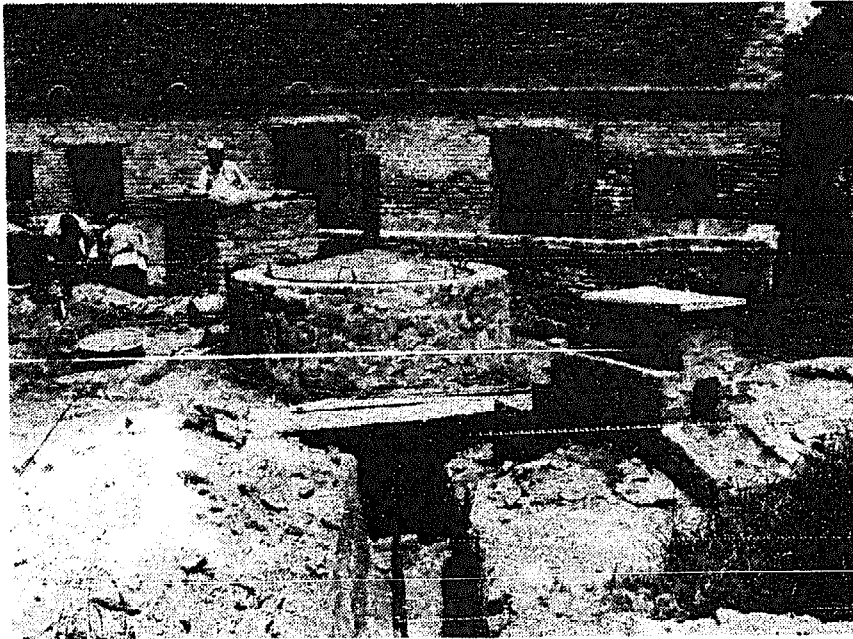
It is better to have a straight input pipe. If the pipe is curved, sticks and stones dropped in by playful boys jam at the bend and cannot be removed without emptying the whole pit. With a straight pipe, such objects can fall right through or be pushed out with a bamboo.

To exclude foreign matter from the pit fix a wire strainer with 1 cm (1/2") holes at the mouth of the input and output pipes.



TWO CHAMBER CONSTRUCTION

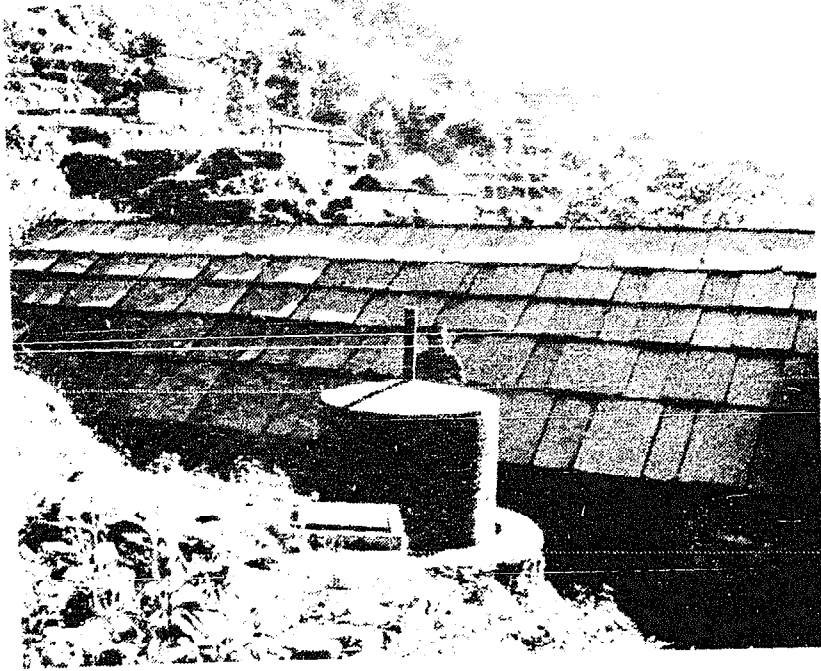




One of the first private gas plants in Kathmandu nearing completion. It is five metres deep and 180 cm in diameter. Notice the mixing trough behind pit, outlet (right foreground) and gas pipe to kitchen.



The same plant in operation



A biogas plant in the hills



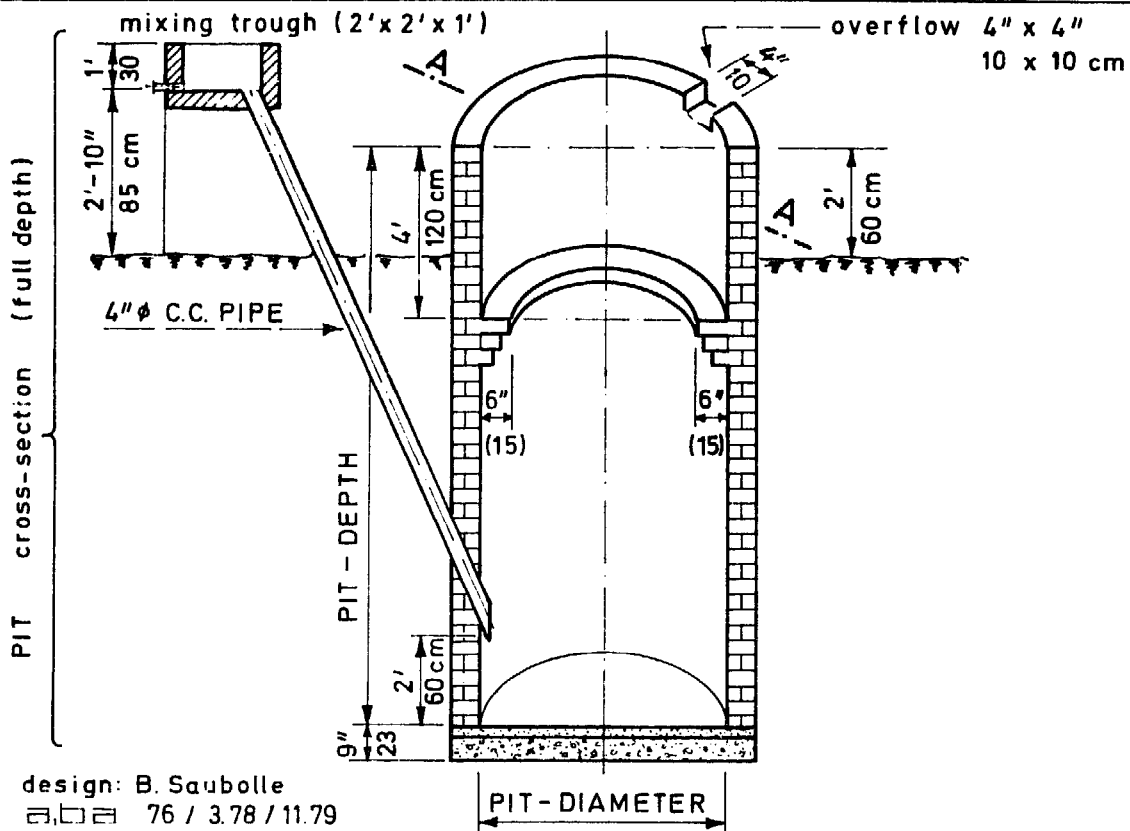
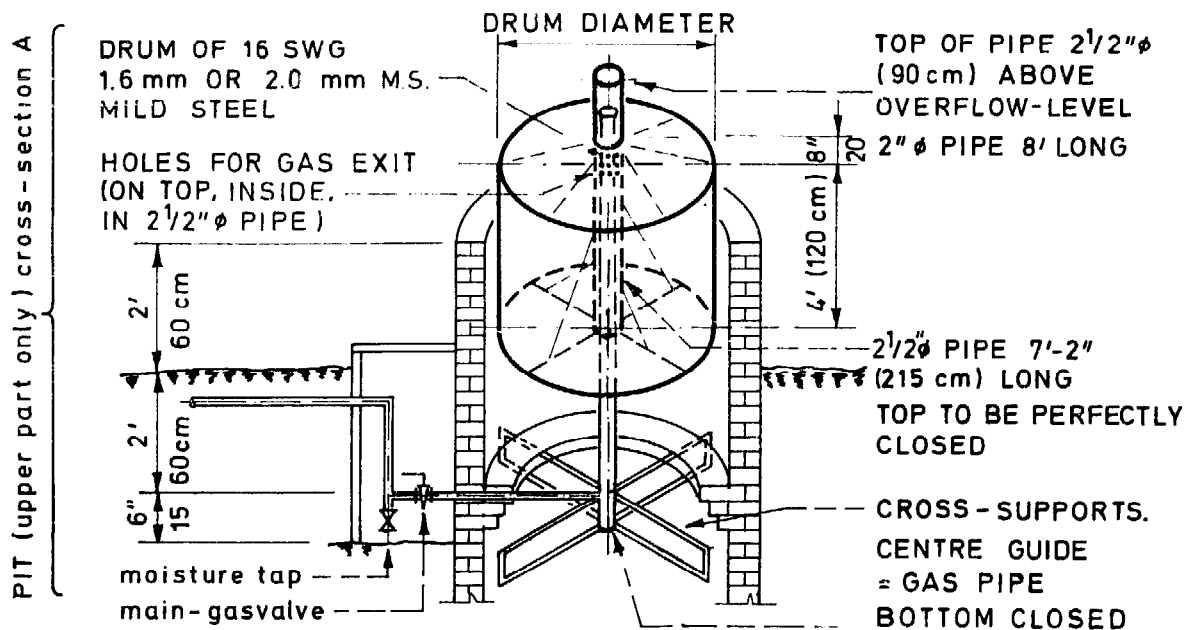
This picture shows the dividing wall in the pit, the fixture of the vertical guide pipe, and the gas outlet.

## FUEL GAS FROM COWDUNG / GOBAR GAS PLANTS

→ FOR SMALLER SIZES THE ONE-COMPARTMENT CONSTRUCTIONS ARE WORKING SATISFACTORILY

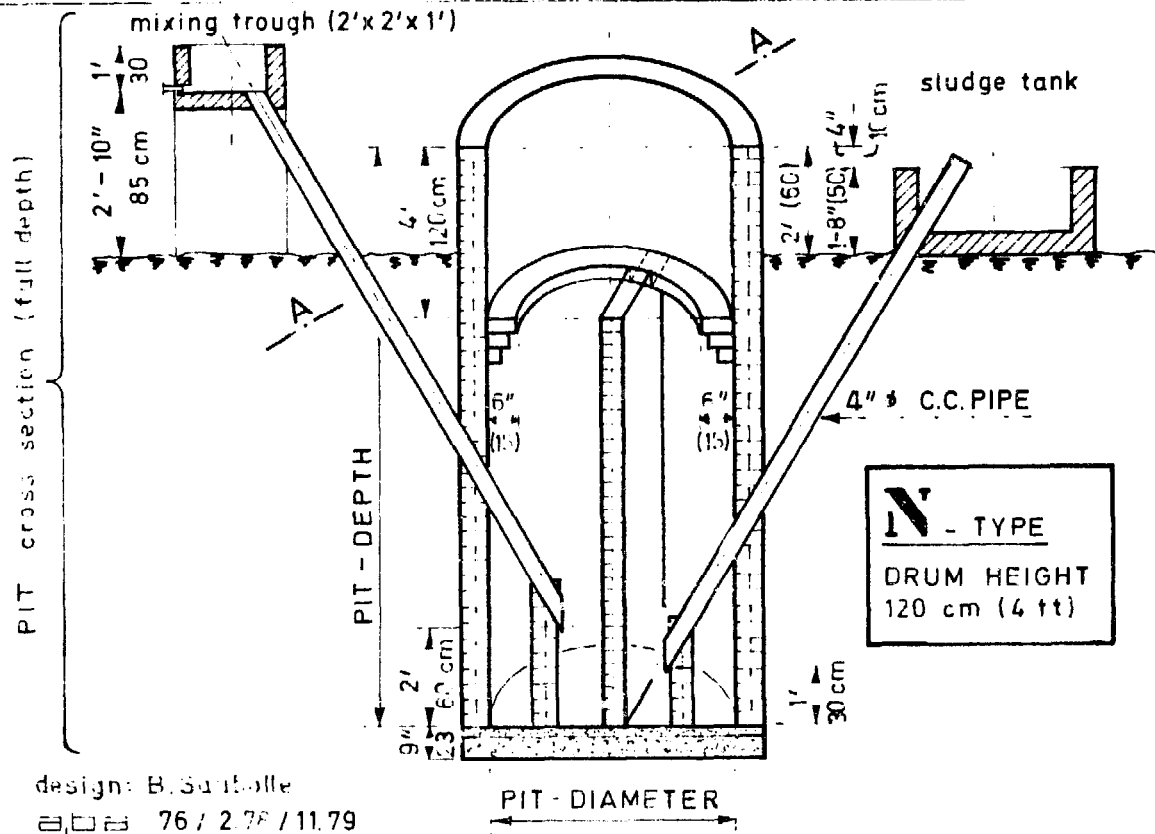
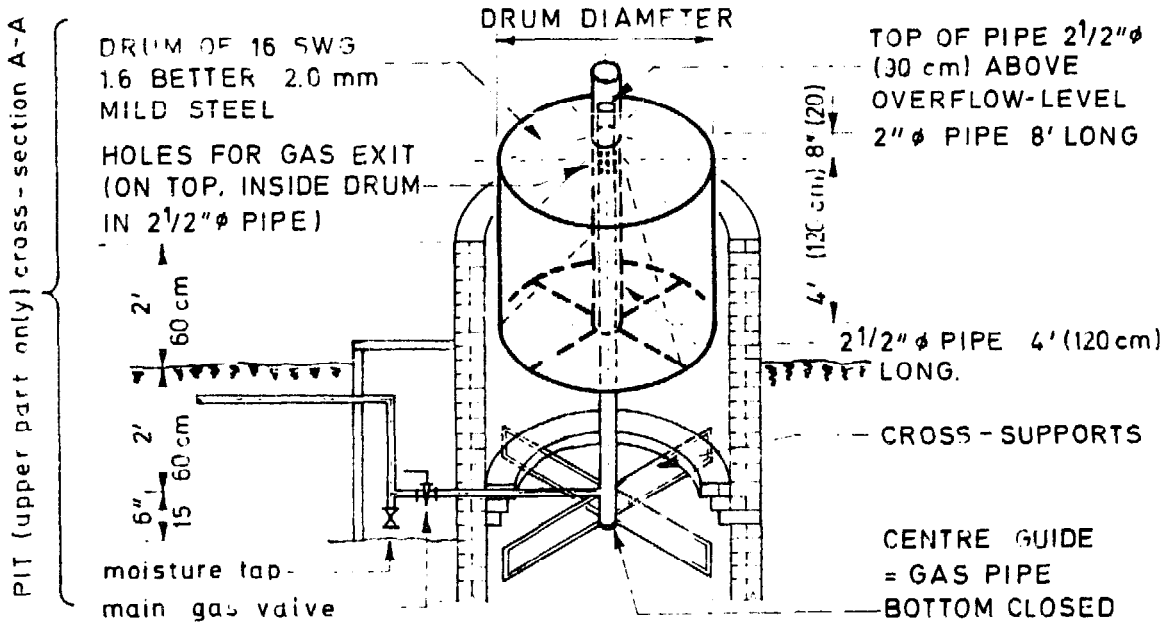
IMPROVEMENT: CENTRE-PLACED GAS-OUTLET PIPE.

SIZE	DAILY GAS-PRODUCTION		PIT DIAMETER		PIT DEPTH		DRUM DIAMETER		SLURRY/DAY 30 DAY CYCLE
			cm	' + "	cm	' + "	cm	' + "	
1	2.25m <sup>3</sup>	80 cft	120	4'	330	10'	110	3' - 8"	125 LITRES
2	4 m <sup>3</sup>	140 cft	150	5'	340	11'	140	4' - 8"	200 LITRES



FUEL GAS FROM COWDUNG / GOBAR GAS PLANTS

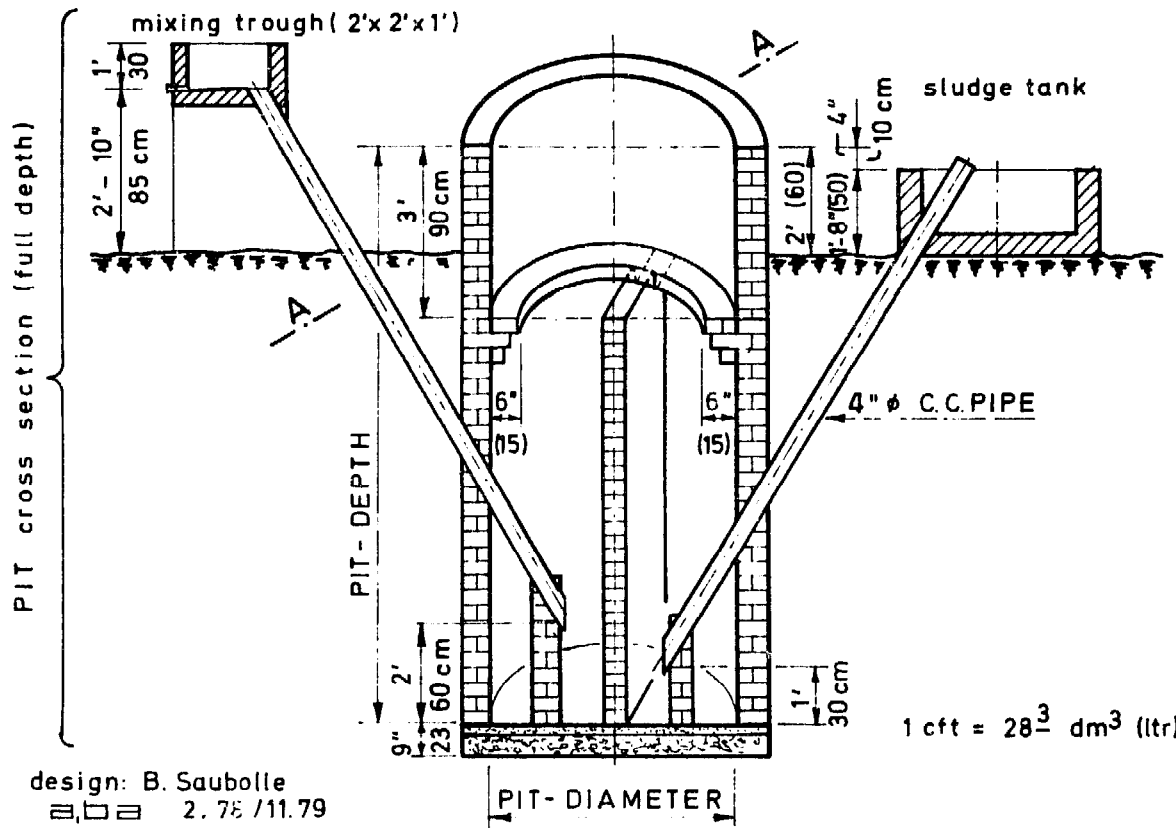
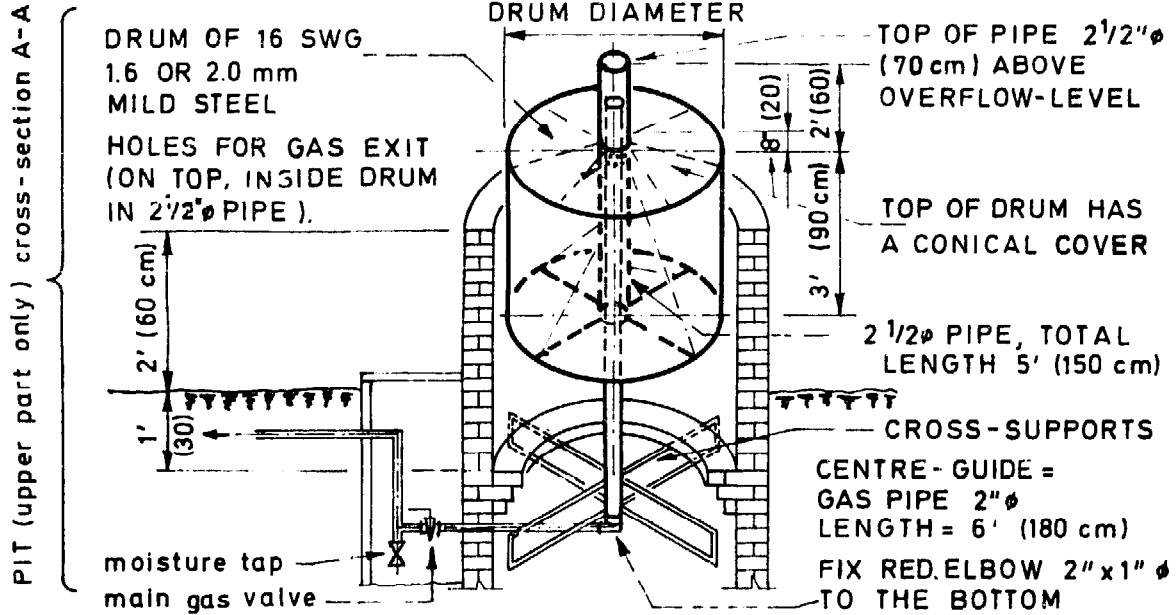
SIZE	DAILY GAS - PRODUCTION	PIT DIAMETER		PIT DEPTH		DRUM DIAMETER		SLURRY/DAY 30 DAY CYCLE
		cm	'	cm	+	cm	+	
1	2.5 m <sup>3</sup> 80cft	120	4'	330	10	110	3' 8"	125 LITERS
2	4 m <sup>3</sup> 140cft	150	5'	340	11	140	4' 8"	200 LITERS
3	6 m <sup>3</sup> 207cft	175	6'	380	11	165	5' 8"	300 LITERS
4	8 m <sup>3</sup> 280cft	200	6'	382	15	190	5' 8"	400 LITRES



FUEL GAS FROM COWDUNG / GOBAR GAS PLANT

TYPE **W'I** FOR PLACES WITH HIGH WATERTABLE = REDUCED PIT DEPTH, BIGGER DIAMETER, RED. DRUM HEIGHT- BIGGER Ø

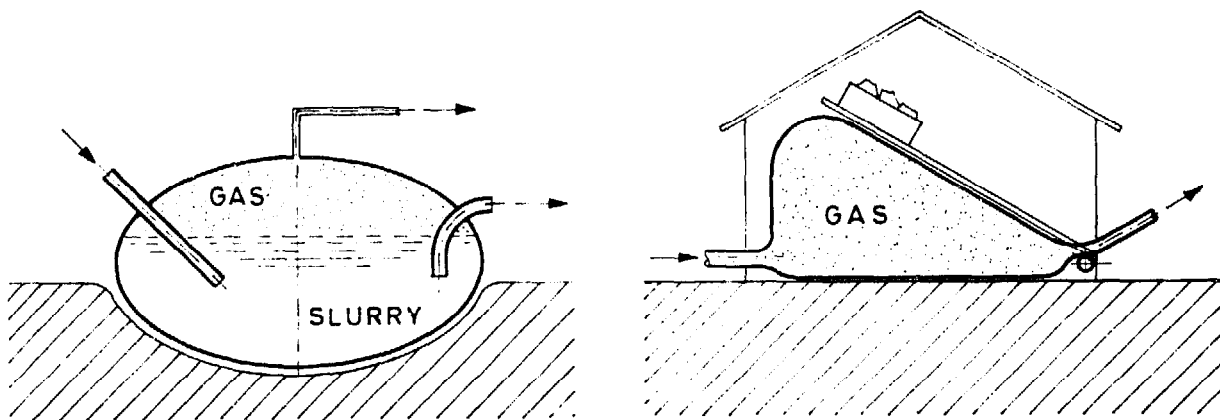
SIZE	DAILY GAS- PRODUCTION		PIT DIAMETER		PIT DEPTH		DRUM DIAMETER		SLURRY/ DAY 30 DAY CYCLE
	m <sup>3</sup>	cft	cm	' + "	cm	' + "	cm	' + "	
1	2.5 m <sup>3</sup>	90 cft	140	4'-8"	245	8'-2"	130	4'-4"	125 LITERS
2	4 m <sup>3</sup>	148 cft	170	5'-8"	265	8'-10"	160	5'-4"	200 LITERS
3	6 m <sup>3</sup>	218 cft	200	6'-8"	287	9'-7"	190	6'-4"	300 LITERS
4	8 m <sup>3</sup>	290 cft	230	7'-8"	290	9'-8"	220	7'-4"	400 LITERS



1 cft = 28<sup>3</sup> dm<sup>3</sup> (ltr)

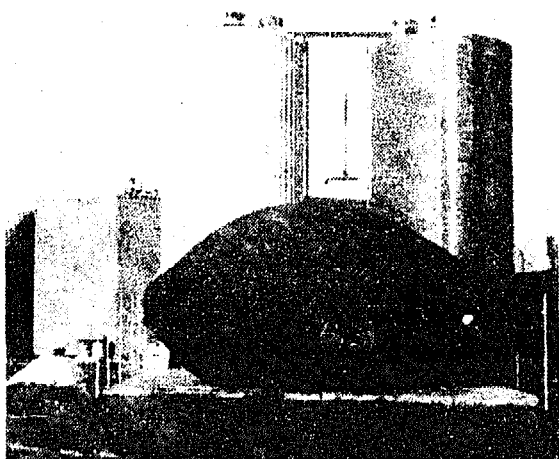
## GAS IN BAGS

In constructing a plant, the most expensive single item is the storage drum. Its cost may amount to half the total expenditure. Villagers balk at it. One alternative is the Chinese drumless plant; another is the bag collector. This may be made of hyphalon, of neoprene or of reinforced synthetic rubber. In Tibet one sees cars and buses with what looks like an elongated baloon on the roof, containing several cubic metres of gas, enough for two to four hours of running, depending on the size of the bag and the horse power of the vehicle. In China gas is taken in bags by trailer or hand cart to the fields where it is needed for working irrigation pumps. In many islands in the Pacific they are simply used for normal gas storage at the plant itself.



To be sure these bags are costly, but not as expensive as metal drums. They have the further advantage that they can be folded, rolled up and transported, which makes them a possible solution for gas plants in far away hilly places. While gas cannot be compressed into them (methane is very difficult to compress into anything, even into strong oxygen cylinders), they can be expected to withstand a pressure of 25 cm water column, which is more than double the working pressure normally needed.

Bag gas holders can serve another very useful purpose when used in conjunction with Chinese digesters. These digesters hold gas under very high pressure, up to 1000 mm, which forces the gas through the concrete cover unless this is rendered very thoroughly leak-proof. Such high pressure is also liable to cause fine cracks in the pit walls or cover. The normal way of dealing with excess pressure in a Chinese plant is to void some of the gas into the air, which of course means a dead loss of so much gas. These three drawbacks are obviated by the use of a bag (or even metal) gas holder. Excess gas need not be wasted; it can be stored. The pressure being lower because of the increased storage space, there is less danger of damage to the pit, or of leakage through the cover.



Capacity 100 m<sup>3</sup> / Walser Biogas Reservoir / Capacity 75 m<sup>3</sup>

As plastic and rubberoid suffer under adverse climatic conditions (fierce tropical sun, heavy monsoon rain) bag digesters and gas holders should be kept under adequate shelter, which will also protect them from damage by playful children.

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Bag holders and digesters may be had from:

- Fa. E. Walser, Kunststoffwerk Istighofen,  
CH- 8575 Buerglen / TG, Switzerland
- Lokestoke Developments, Eastbourne Lane,  
Midhurst, Sussex GU 29 9AB, England

STIRRER OR NO STIRRER ?

Lab tests have shown that cowdung slurry fermented anaerobically delivers 90% of its potential gas in four weeks at a temperature of 27-40 C. To obtain another 8% takes two more weeks. If the temperature is much lower, the whole process will take very much longer; at a higher temperature it is more rapid. The temperature does not produce more gas it merely speeds up the production. A given amount of dung can generate only a certain amount of gas. Whether this takes place in a few days or many, it cannot produce more gas than it can. That is what we mean with potential.

The very, very vast majority of gas plants throughout the world are built to deliver their full potential in 30, 40, 50 or more days. For this the pits are given a volume 30, 40, 50, or more the times the volume of the daily slurry. Pit size is determined also by the time it takes, given the local range of temperature, to exhaust the full potential of the dung. Once it is achieved, nothing we do, whether we compress it, or beat it, or stirr it, or heat it, will make it given any more of what it no longer has.

The gas rises through the slurry into the floating drum. Since tiny particles of solid matter tend to fall to the bottom, the slurry in the pit is necessarily thinner than at the top and denser at the bottom. It is denser here also because the daily input enters at the bottom and fresh slurry is heavier than partially exhausted slurry. For these two reasons we may expect that gas forming at the very bottom has more difficulty in rising up. It is hampered in its movement. We may say it is partially trapped and has to struggle to free itself. But it will and does ultimately escape within the pre-set number of days without our having to do anything to help it. In fact it is naturally helped by the disturbance at the botttom caused by the daily inrush of fresh slurry.



It has been observed in the experiments of many plant owners, especially in the occident, that if the slurry and sludge at the very bottom are stirred up and swirled around, the gas which is "trapped" there is promptly released. This has led some to believe that the use of a stirrer produces more gas, whereas it merely helps to obtain more rapidly the gas that has already been produced. There is undoubtedly truth in the statement that the microbes at the bottom could produce more gas if they could move about more freely and attack more particles of dung. But let us remember that they are daily swamped and surrounded and swirled around by the flood of fresh rich slurry shot at them by the daily input.

If a stirrer is used, it would be reasonable to build a smaller pit, since the full potential of the daily dung would be obtained in a shorter time, and there would be no need to have such a long retention as is required to get the same amount of gas without a stirrer. It's a matter of choice. Occidentals are very conscious of time. They want to do things quickly, and are ready to spend money on a stirrer, and spend energy every day in working it. Orientals are more happy-go-lucky. Why buy a stirrer? Why give oneself the added daily drudge of having to manipulate it, when the same amount of gas will be obtained if one sits down and waits patiently for a few more days? Time is of no consequence, and it costs nothing.

Each day's slurry rises a little higher up the gas pit as it gets lighter by decomposing and giving off more gas and is pushed up by subsequent inputs, till finally, by the time it has exhausted its potential, it reaches the outlet and is thrown out. This is the theory of "passive" operation of a plant, as distinguished from "active" stirring. If a stirrer is used, all the slurry in the pit, fresh as well as exhausted, is mixed up. It is therefore inevitable that daily some fresh slurry is thrown out together with some that is exhausted. This is definitely a loss.

There is another disadvantage to stirring the slurry in Chinese plants. These contain 10% of human waste, and the parasite eggs present in this lie at the bottom. That is why the effluent take-off in approved Chinese plants is half way up the digester where these eggs are virtually non-existent. This is important where the effluent is used in vegetable gardens. The constant rise and fall of slurry due to gas pressure barely affects the bottom.

The loss of gas mentioned above, and the danger from parasites, are present only in single-pit plants. In larger installations where the output flows into a covered sedimentation tank, the unexhausted thrown-off slurry continues to ferment and produce its gas, which is connected by pipe to the main gas outlet. Some installations have even a third tank for storage of effluent. By prolonging the time from first input to final extraction and use of the effluent, these extra tanks serve a further important purpose. It takes ninety days for parasite eggs to be totally destroyed and rendered harmless. If the volumes of the second and third tanks are so calculated as to allow the slurry to take ninety days for processing from start to finish, the health hazard is eliminated. But such installations are very costly and far beyond the means of villagers.

In conclusion we may say that:

- 1 - A stirrer does not produce more gas;
- 2 - It is an added expense and an added complication;
- 3 - It may lessen the cost of a plant by making it smaller, since the gas is obtained more rapidly and the retention time can be shorter ;
- 4 - It causes a loss in gas production by causing unexhausted slurry to be thrown out;

- 5 - It creates a health hazard in any plant where human waste is part of the daily input;
- 6 - It is unnecessary, since the total amount of gas produced, with or without a stirrer can never be more than the potential of the cowdung.

The stirrer we have discussed above must not be confounded with the scum breaker. This latter consists of rods attached to the drum which break up the scum automatically as the drum rises or falls or is slightly rotated. All the cowdung plants with floating drum should incorporate a scum breaker.

#### GAS FROM NIGHT SOIL

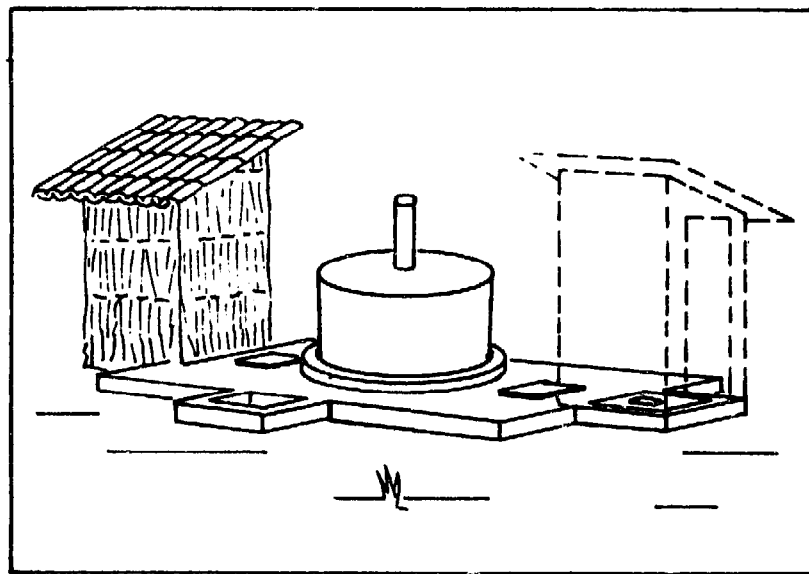
Human waste, though its C/N ratio is not ideal\* does produce an amount of methane that can be useful. In China tons of night soil are gathered in tank trucks every day and fermented in huge installations outside the towns, the chief aim being the production of first grade soil conditioner. The gas produced is abundant because of the proportions of the plants, and is used for running electric generators and pumps, or for cooking and lighting.

Such large plants running exclusively or primarily on night soil have little place in a booklet on cowdung gas. However, it is quite common to add human waste to a cowdung gas plant. The digester is simply used as a septic tank, the toilet wastes being piped directly to the fermenting pit. Where this is done, attention should be paid to one or two important points. The toilet seats should be

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\* Useful information on this topic may be found in the present authors' booklet MINI TECHNOLOGY Volume I, Sahayogi Press, Tripureshwar, Kathmandu.

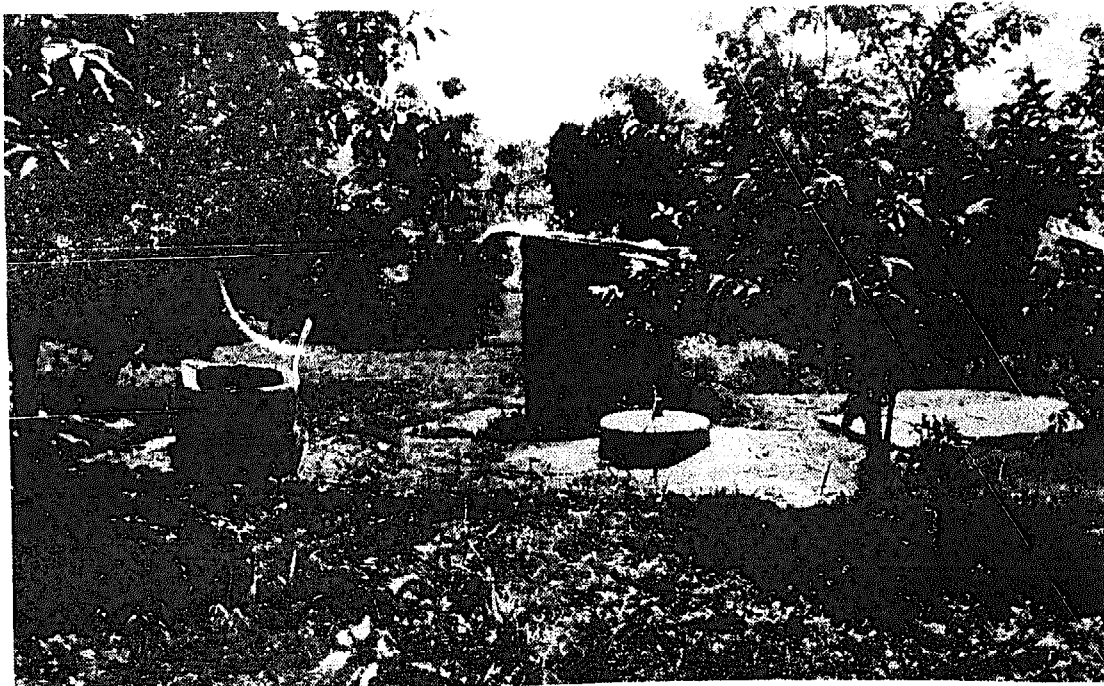
about one metre above the pit overflow level, and the inlet pipe from the toilet should end immediately below the ledge. If it goes deep down, solid matter accumulates inside and is hard to clean out. Then, disinfectants should not be used in the toilet bowls. They would kill the bacteria needed for fermenting the slurry. Too much water should not be flushed into the pit. The amount of water used in flushing could be deducted from the volume needed for making the slurry. The actual slurry would then be thicker, but the total amount of water entering the pit per day would be about right.



Biogas production from septic tank

For night soil gas, what can be done, and has been done with good results, is to use an ordinary two- or three- compartment septic tank. Make it absolutely gastight, except for the gas outlet pipe, and collect the gas in a separate floating drum, from which it can be piped to points of use. In building this septic tank make sure that the outlet pipe begins 15 cm below water level, and that the input pipe from the toilet ends about 5 cm (2") lower than the mouth of the outlet pipe, so that in the event of too high gas pressure in the tank the gas may blow off through the outlet rather than back up into the toilet.

Private family-size septic tanks produce far too little gas to be worthwhile. Only those of big institutions like hospitals, boarding schools, prisons, would have enough daily input to produce a reasonable amount of useable gas. The waste of one adult gives 28-30 litres (1 cft) of gas.



Biogas digester combined with latrine (fixed dome type digester - below ground level) left: mixing trough, middle: latrine, front: turret of biogas digester.

There is enough nitrogen in human waste to produce very much more gas if carbonaceous matter is added. It has been proved that if 500 grams of wheat straw is added per person per day, the output of gas is increased seven fold, coming (at the right temperature) to 200 litres per person. But with such a bulk of dry matter in the input, the plant cannot very well be flow fed. It should be batch loaded.

## A BIOGAS DEMONSTRATION PLANT

For purposes of research and experimentation one would sometimes prefer to work with a small size plant rather than a full size installation of several cubic meter capacity requiring large quantities of slurry every day. Experiments in the effects of temperature variation, different slurry densities, insulation, gas output, etc., can often be more conveniently conducted on a small scale before being tried on a full size plant.

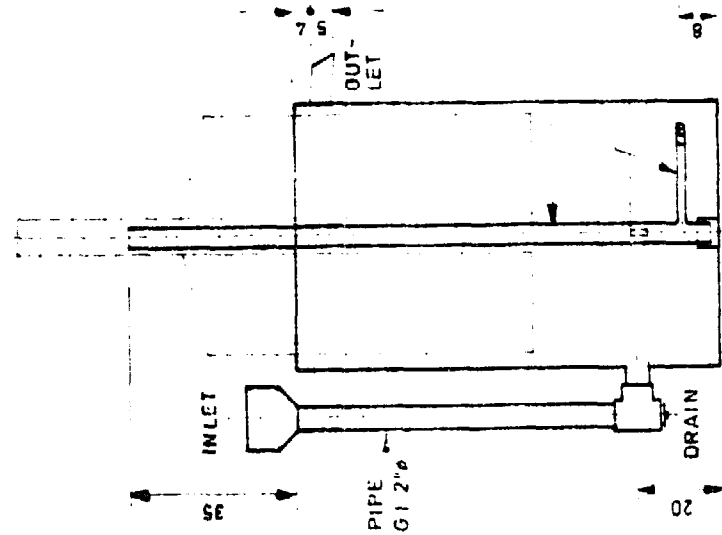
For demonstration purposes too, and for the instruction of learners, a small plant is often preferable. For the Nepali biogas popularization programme in far away villages scattered over the hills of this country, we soon realized that five minutes of demonstration, when villagers could actually see the gas burn, and perhaps even bring a small pan of water to the boil, could be far more impressive and convincing than hours of talking. We had a number of these plants made with handles attached for convenience of carrying from one village to another. They were a success. Though ours were made from sheet metal, a similar plant can very easily be made from a 200-litre oil drum.

A 200-liter digester, of course, will not produce enough gas to do any steady and useful work like cooking a meal. It may light a stove for some 15 minutes once a day, and that is all. But demonstration just to show that the gas does burn does not take more than one minute.

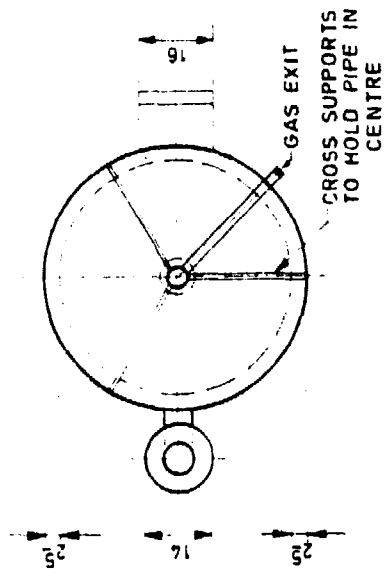
This size of digester would require a daily slurry (1:1) of at least 6 litres. If a little more gas is wanted, the daily input could be increased to 10 litres. But then the full gas potential of the dung will not be obtained. The effluent will continue fermenting slowly after being rejected. But this does not matter, since our purpose is not to get all the gas possible, but to have a sufficient quantity for a proper demonstration.

**BIO-GAS DEMONSTRATION PLANT**

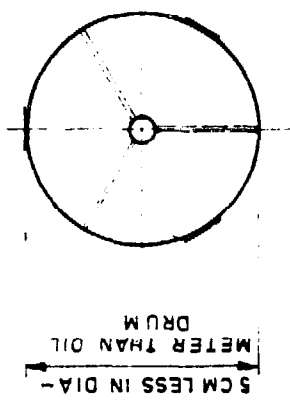
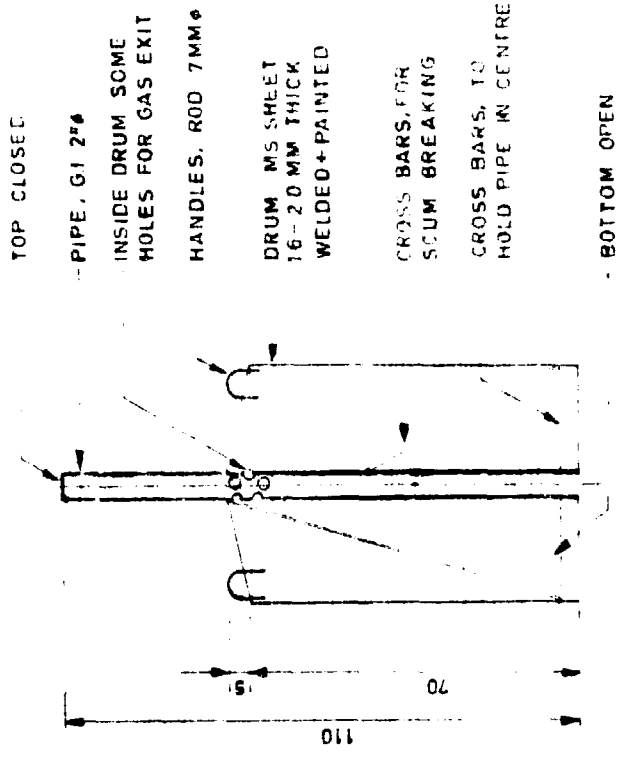
USING AN OLD OIL DRUM



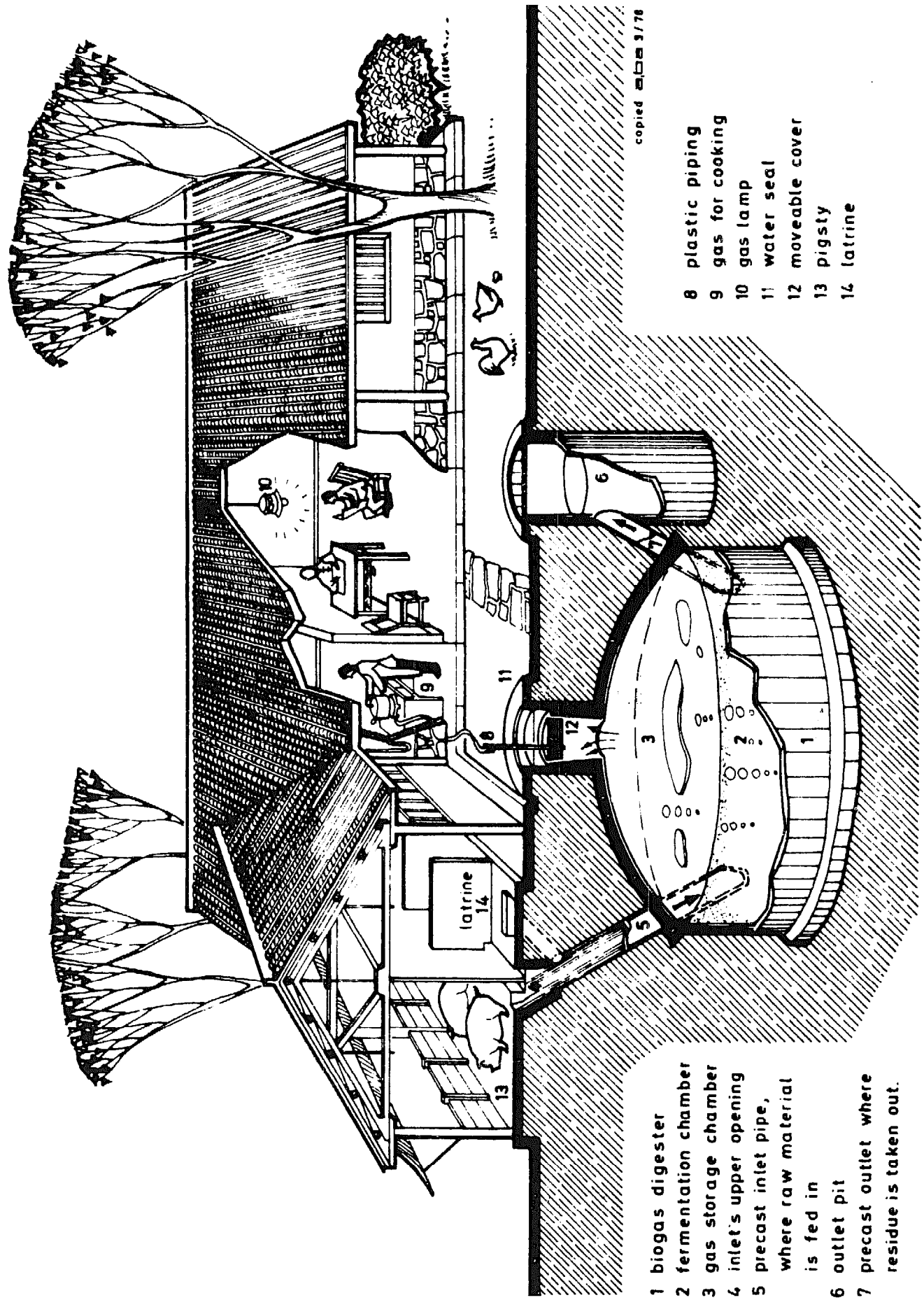
CENTRE PIPE  
G1 5/4"φ  
GAS EXIT G1 1/2"φ



**GAS DRUM**



MEASUREMENTS IN CM / 12.79 IN



copied from 3/76

- 1 biogas digester
- 2 fermentation chamber
- 3 gas storage chamber
- 4 inlet's upper opening
- 5 precast inlet pipe, where raw material is fed in
- 6 outlet pipe
- 7 precast outlet where residue is taken out.

- 8 plastic piping
- 9 gas for cooking
- 10 gas lamp
- 11 water seal
- 12 moveable cover
- 13 pigsty
- 14 latrine



## CHINESE BIOGAS TECHNOLOGY

For building a gas plant, a villager can always manage to dig the pit; he can generally make and bake bricks on his own land; but the expense of buying a huge metal drum he more often than not just cannot afford.

The Chinese have thought up a way of eliminating the drum. They seal the fermenting pit with a dome or a slab of concrete. For the input and outflow of the slurry, in place of a pipe, they have a broad chamber. As the gas forms, instead of pushing a drum up it pushes the slurry down, forcing it into the side chambers. When the gas is drawn and the pressure diminishes, the slurry flows back into the main pit.

The only advantage of this model, apart from its fertilizer value, is that it does away with the expensive drum, thus substantially reducing the cost of the installation. Since the whole plant is below ground level, it is not designed to let the exhausted slurry flow out by itself. It is either pumped out or drawn out with a bucket. This is labour intensive.

There is always slurry in the inlet and outlet chambers and whatever gas is formed in these is lost to the air. But for the Chinese this is no loss. Their main objective in installing a gas plant is top grade fertilizer, the gas being taken merely as a useful by-product. A gas plant for them is first and foremost a private fertilizer factory. However, if the pit is large enough, the gas produced, even if some is lost, is quite sufficient for the family's cooking and lighting needs. There are said to be seven million of these plants all over the country.

Most plants, even of family size, but especially the larger ones, are run on the batch loading system. But pure cowdung plants, loaded with daily input of dung and slurry alone, run just as well. The typical average input of a pit is stated as comprising 10% human waste, 30% animal dung, 10% vegetable matter (chopped crop stalks, dry leaves, grass clip-

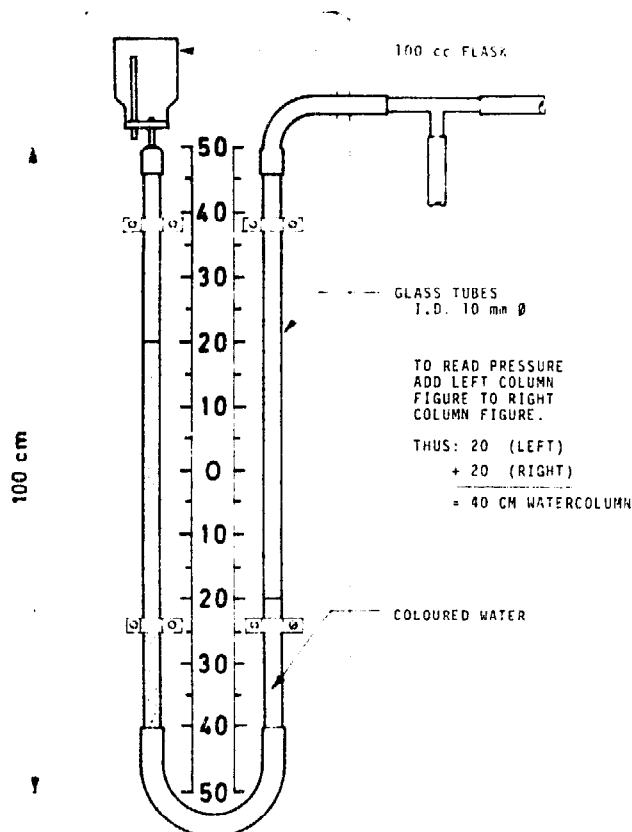
pings, etc.) and 50% water. In family plants the human excreta flow directly into the gas pit, no manipulation being required. The animal dung is put in as a slurry. The vegetable matter is first composted for a fortnight, so that decomposition has already set in and fermentation can begin at once in the pit. The vegetable matter forms much organic acid, which has to be balanced with regular additions of lime or ashes in order to maintain the pH between 7 and 8. So working a Chinese gas plant entails quite a lot of labour and attention, far more, than does the Indian model; but the Chinese manage all right, and their plants give perfect satisfaction.

The plant should be built above the water table to avoid all possibility of seepage, which might dilute the slurry too much. It should preferably be sited in full sun.

The volume of a pit built to supply gas for both cooking and lighting is given as 2 m<sup>3</sup> per person. For a family of six the pit could be 3 m deep x 2 m x 2 m. It should have a strong well-compacted base. The floor and walls are usually of concrete, but baked brick and cement mortar could also be used. While we would use iron rods for re-inforcing, the Chinese use sticks or bamboo strips painted with tar. Special attention is paid to all joints between floor and walls, and between wall cover. All parts interlock very securely, particularly round the cover and the gas outlet.

Unbelievable as it may seem, gas escapes through concrete! It is therefore absolutely necessary to plaster the inside, chiefly the upper portion and the cover. Four plasterings are insisted upon. The first is of concrete with 10% lime. The second is a 3-5 mm layer of sand/lime 3:7. After this the whole interior surface is tapped with a stick to discover hollow spots or air bubbles. If any are found, those parts are dug out and re-plastered solidly. The third plastering is cement/lime/fine sand in the ration 1:2:1. Last of all comes a 2-3 mm coat of lime/sand 1:1. The lime in the above

plasterings is necessary: it makes a denser plaster. Without it tiny air bubbles often form. The whole work has to be painstaking and thorough or the gas will surely escape. A suggested Indian substitute for all this plastering is to cover the whole inside with enamel paint. Nepal is working with acrylic plastic emulsion.



An alternative procedure is recommended by Guangshu Institute of Energy Sources, Chinese Academy of Sciences. The first plastering is of common cement mortar: the second, of cement mortar with 5% by weight of polyvinyl acetate latex; the third, of a cement paste with 10% PAL. Finally a coat of bituminous paint is applied to protect the cement from corrosion. This procedure has been employed for years with the utmost satisfaction. Not a single leak has yet been reported.

Seeing the amount of meticulous care and technical skill required, and the cost of concrete construction, one wonders if it would not be preferable to buy a steel drum and build the far simpler Indian style of gas pit. However, in mountainous country where huge, heavy, unweildy, metal drums cannot be carried up and down steep pathways and across raging torrents on tree-trunk bridges, the Chinese model becomes a very practical solution.

There is no single "Chinese model" gas plant. The basic idea is a digester closed on the top and having a broad outlet chamber instead of merely an outlet pipe. The input may be through a pipe or a chamber. The basic idea is modified ad lib, each Province adopting the design of its choice, which is often dictated by the nature of the soil, the height of the water table, or the availability of construction materials.

In some places the plants are rectangular in design, though in other parts of the country this shape could be considered outmoded and cylindrical tanks are preferred. Sechuan Province favours a shallow digester of large diameter completely below ground level. It is essentially a straight shallow cylinder about 1 m deep with a dome about 50 cm high and a concave bottom about 35 cm deep, though a flat bottom is also allowed. The lower end of the input is about half way up the cylinder. The output begins at about the same level, so as to draw slurry from the middle rather than from the bottom. There are virtually none in the middle. This is important when the effluent is used in vegetable gardens.

The gas pressure in a Chinese plant is always high, but it should never be allowed to exceed 100 cm water column, or the construction may crack. In China each plant has a homemade manometer which doubles as a safety valve. It is made of two glass tubes 100 cm long and 1 cm in diameter connected by a rubber tube at the bottom. One end is connected to the gas mains through a tee. The difference in level between the two columns of coloured water shows the gas pressure. Pressure over 100 cm pushes

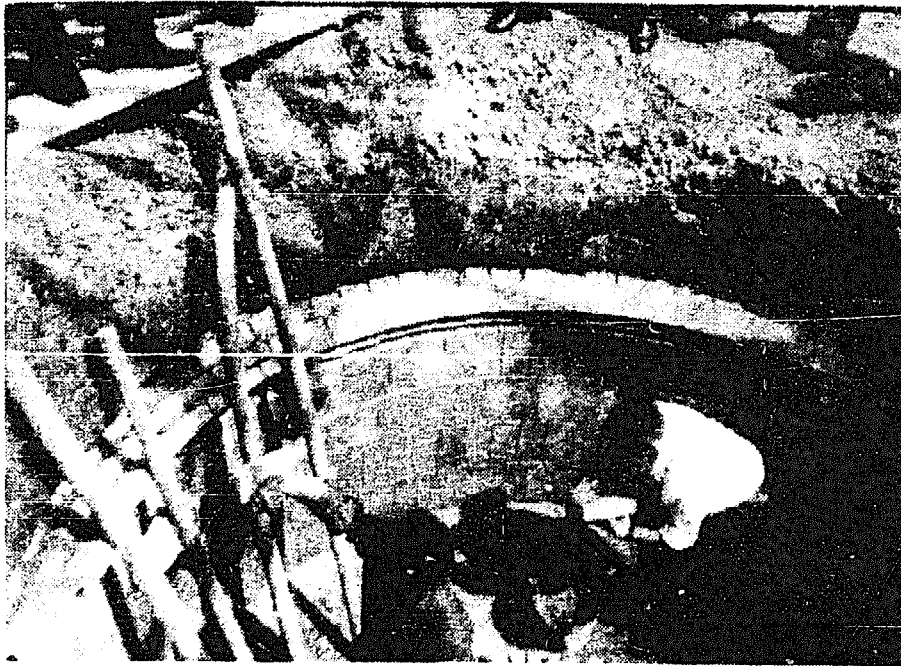
water out of the tubes into a receptacle above and allows gas to escape, thus safeguarding the plant. When the pressure drops, the water flows back into the tubes.

Batch loaded plants are generally emptied and re-loaded every three or four months. 20-25% of the old slurry is left to inoculate the new material. If the pit is ever entirely emptied for thorough cleaning or repair, precautions must be taken against the fumes inside. A 30% concentration of methane in air can anaesthetize a person, while 70% can asphyxiate. A 5-15% mixture is explosive.

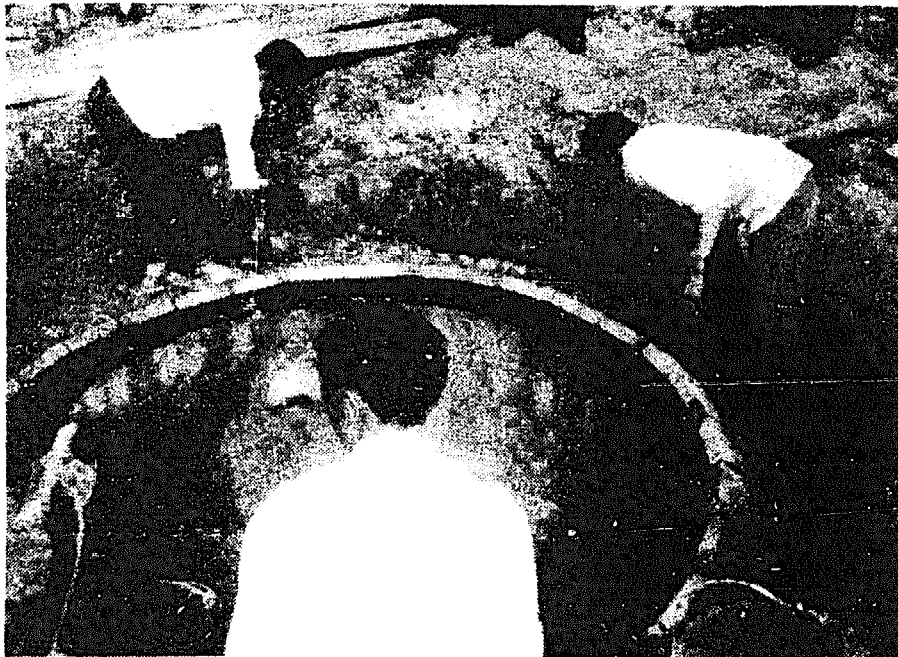
Construction materials commonly employed in China are:

- LIME - CLAY (1 lime, 9-19 clay, moisture about 22%) hardens slowly, requires firm compacting and long curing.
- LIME - CONCRETE (1 lime, 3 sand, 6 crushed stones or bricks) tamped layer by layer.
- CONCRETE usually of compressive strength 400 kg/cm<sup>2</sup> (called No. 400) No. 150, (150 kg/cm<sup>2</sup>) for covers and connections, in special cases No. 100, and for most parts No. 30.
- MASONRY (of brick, stone, cobbles, slate) with a mortar of cement-lime-sand of strength 10 - 50 kg/cm<sup>2</sup>.

We give below three construction plans recommended by the Sechuan Provincial Institute of Industrial Design, one for lime-clay construction, one for lime-concrete, and one for ordinary cement concrete. In addition we give the intriguing Chinese ball digester, and a slightly modified design successfully tried out in Nepal.



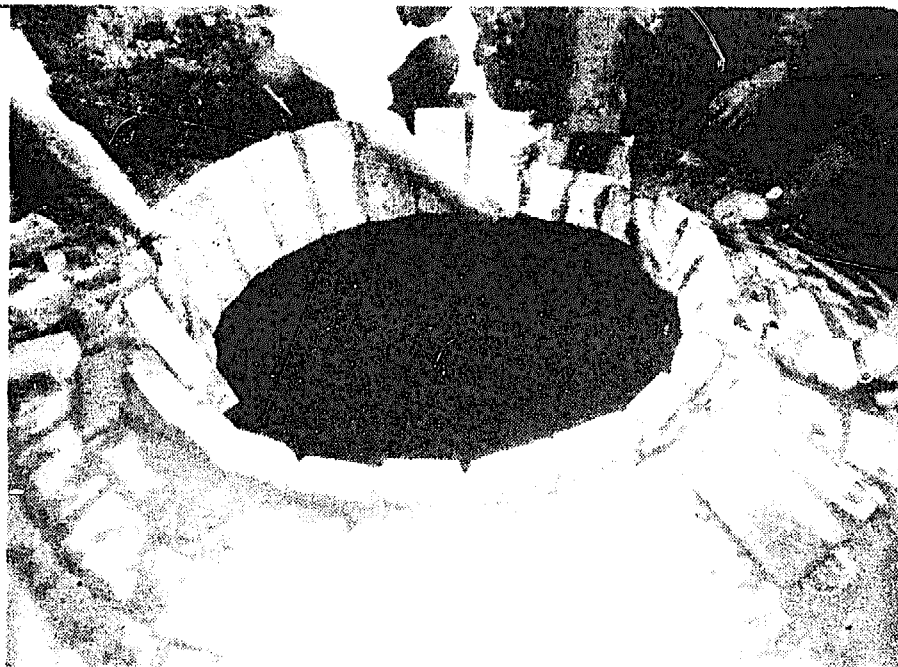
The digester wall is only 6-7 cm thick, the smallest dimension of a brick. The bricks are laid vertically. Notice the shoulder from which the dome rises to strengthen its base.



Beginning the dome. Bricks laid horizontally.  
(Photos: Mrs. S.L. Maskey)



Approaching the manhole. Bricks again vertical, first row half-bricks.



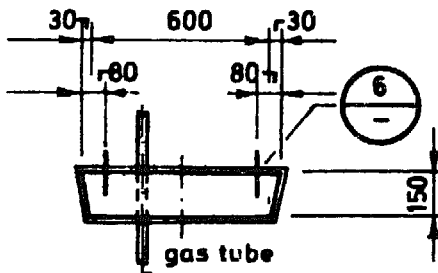
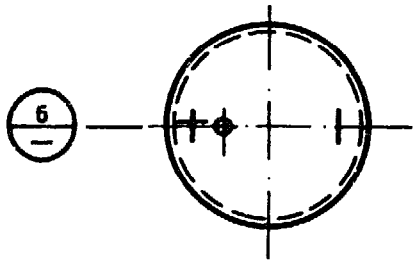
Second row of bricks for manhole are full size. Notice how dome, only just laid, is strong enough to be trod upon.

*(Photos: Mrs. S.L. Maskey)*

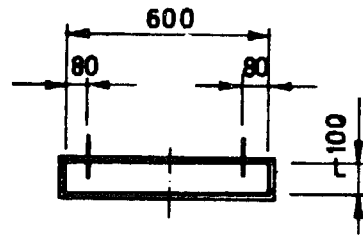
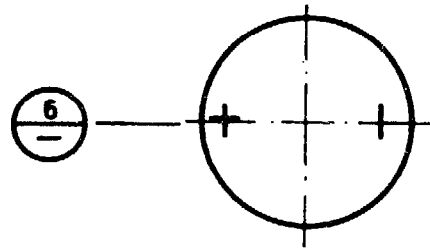
SYMBOLS		SYMBOLS	
	NATURAL SOIL	$R_1$ $R_2$ $R_3$	RADIUS
	TAMPED SOIL	$D$ $D_1$	DIAMETER
	SAND, LIME CLAY, PLASTERING	$L$ $L_1$	LENGTH
	LIME CONCRETE	$H$ $H_1$ $h_1$ $h_2$	HEIGHT
	SLATES (ROCK)	$d$	THICKNESS
	GROUTED COBBLES	$f_1$ $f_2$	
	BRICKS	$m^2$ $m^3$ $(M^2)$ $(M^3)$	SQUARE METER CUBIC METER
	CONCRETE	$1 : 2 : 3$	RATIO $1 : 2 : 3$
	THE LOWER SYM- BOL OF SMALL SCALE		DETAIL (DRAWING) FIGURE FOR DETAIL N <sup>o</sup>
	DETAIL N <sup>o</sup> 5 MEANS IN THIS PAGE		LOCATION OF SECTION BOLD LINE FOR LOCATION
	DETAIL N <sup>o</sup> 5 FOR A SEE PAGE WITH DETAILS A		FIGURE FOR SECTION

SYMBOLS / CONVENTIONS

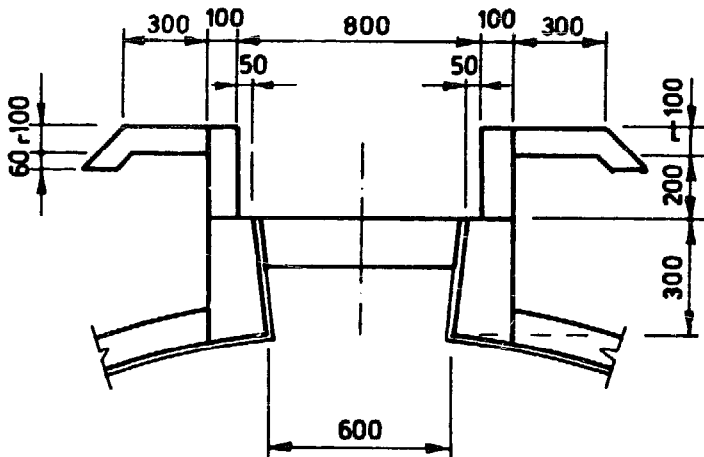




**2** moveable cover



**5** outlet cover

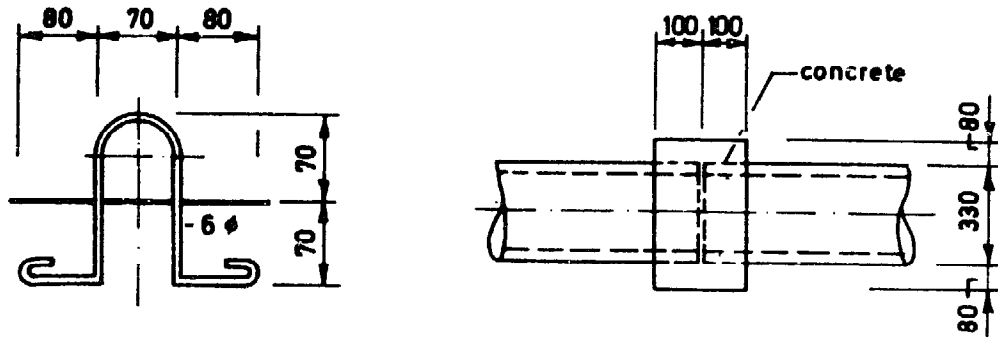


**4** outlet opening

**1** opening for moveable cover

1. covers are made of #150 concrete or slates.
2. gas tubes are of steel, plastic or bamboo, about 25 mm inside diameter, 500 mm long
3. inlet pipes and their connections are made of concrete.

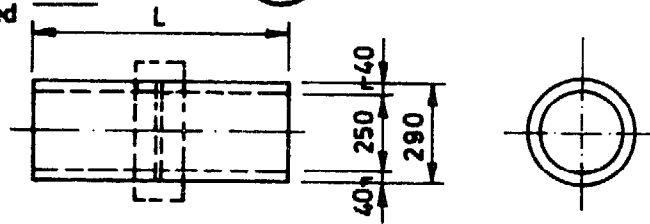
measurements in mm  
copied: a, b, c 9.78



6

7

two pipes connected



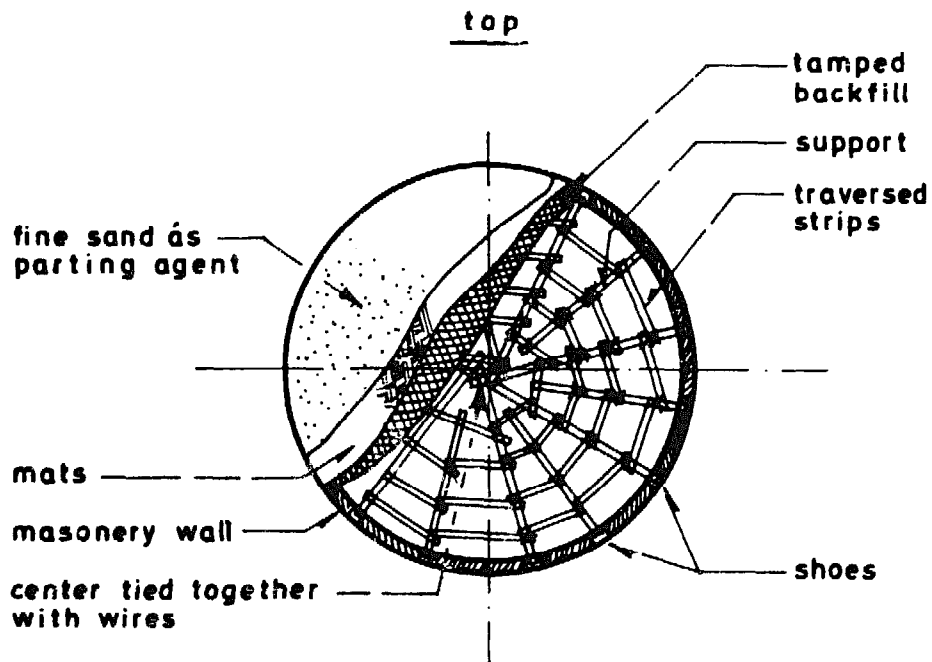
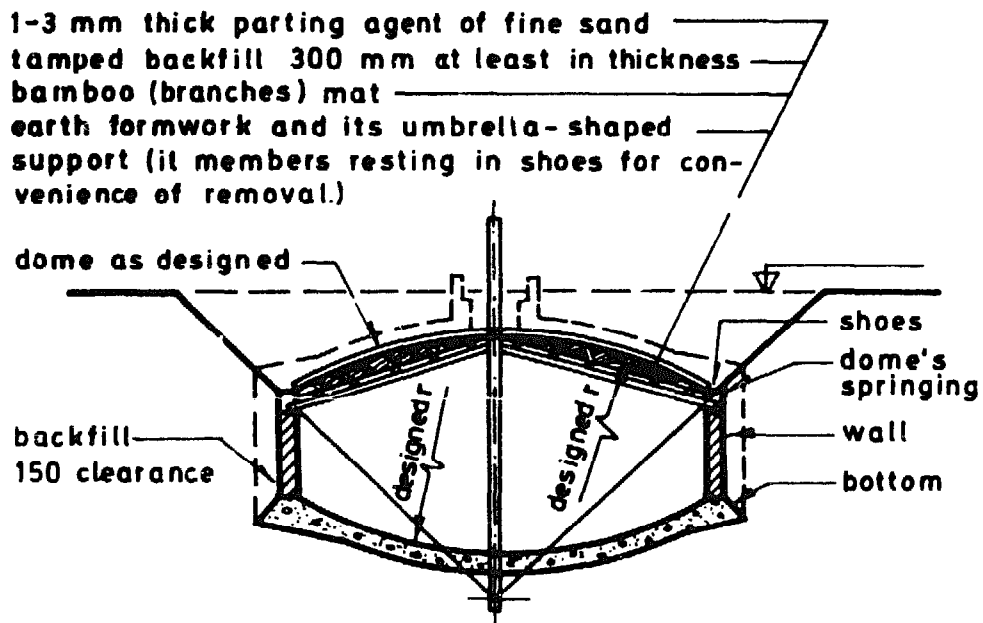
inlet pipe

3

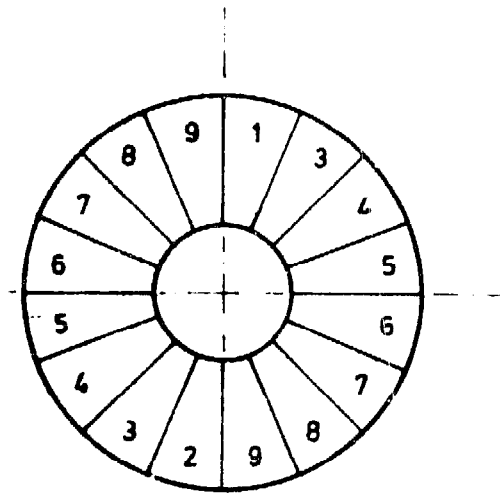
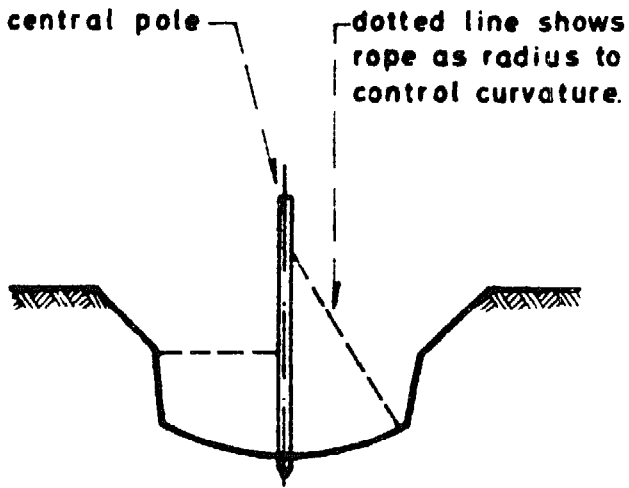
type	B <sub>1</sub>	B <sub>2</sub>	B <sub>3</sub>	
pipe length	2000	1500	1000	

rise 1/5 D				rise 1/2, 1/3 D			
volume	6 12	50	100	volume	6 12	50	100
pipe length	1500	2500	3500	pipe length	2000	3000	4000
type	B <sub>2</sub>	B <sub>2</sub> B <sub>3</sub>	B <sub>1</sub> B <sub>2</sub>	type	B <sub>1</sub>	B <sub>1</sub> B <sub>3</sub>	B <sub>1</sub> B <sub>1</sub>

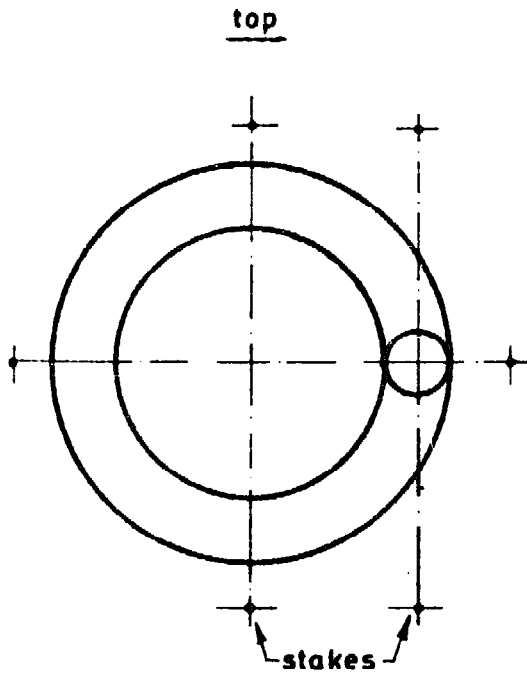
DETAILS (A)



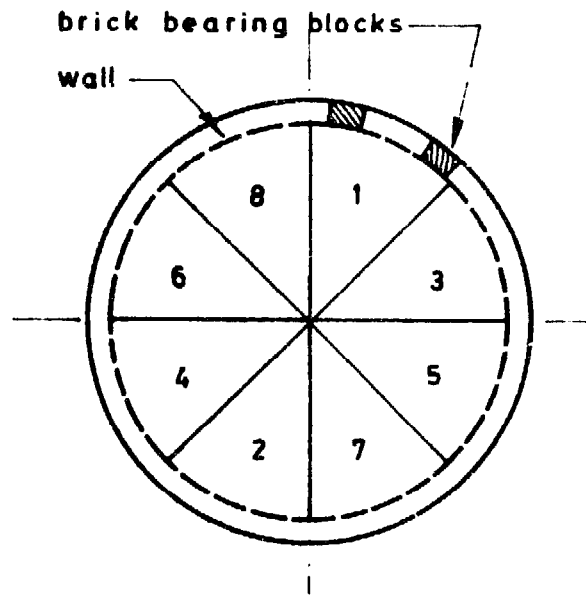
### OVERALL EXCAVATION WITH CAST-DOME ON TIMBER (BAMBOO) SUPPORT



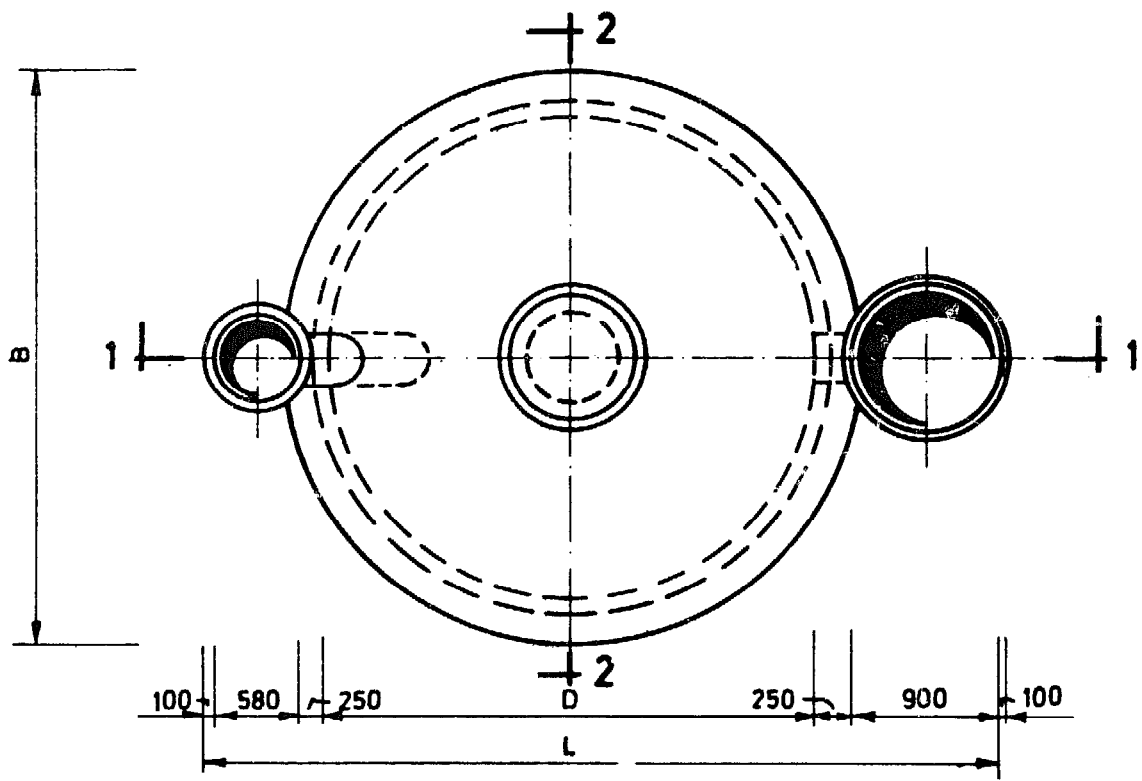
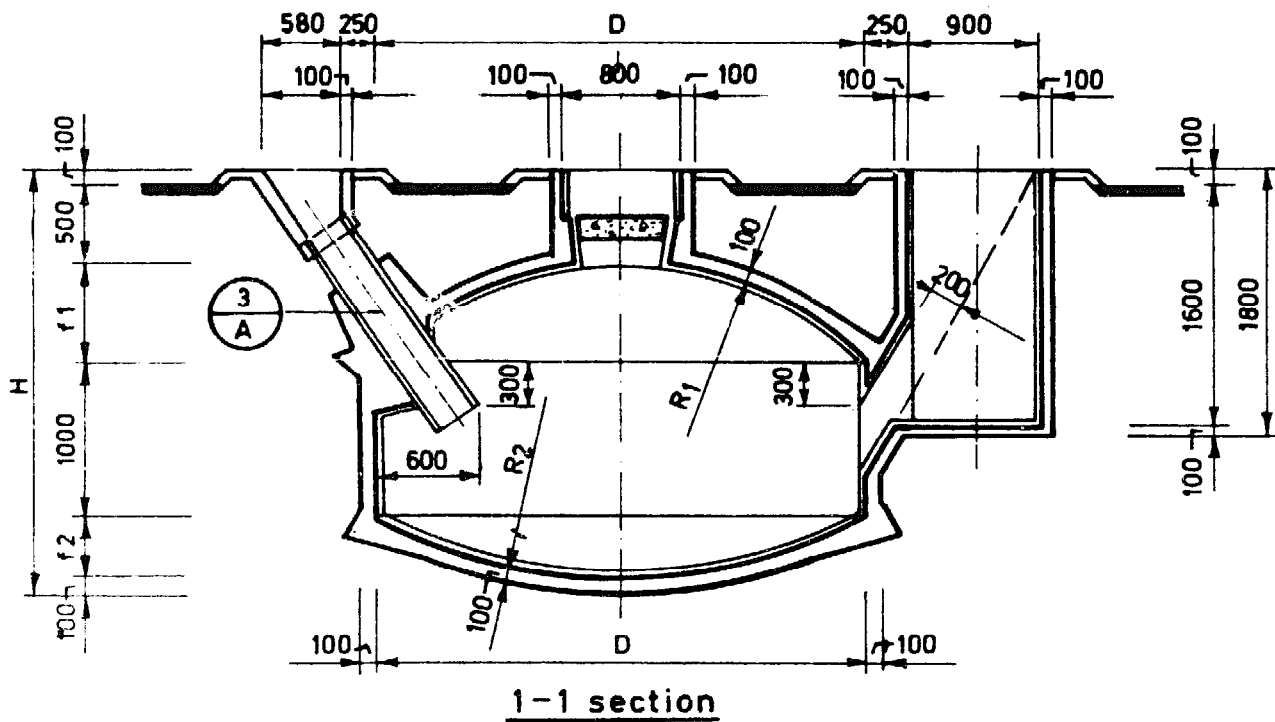
**CASTING OF DOME  
ACC. TO NUMBERS**



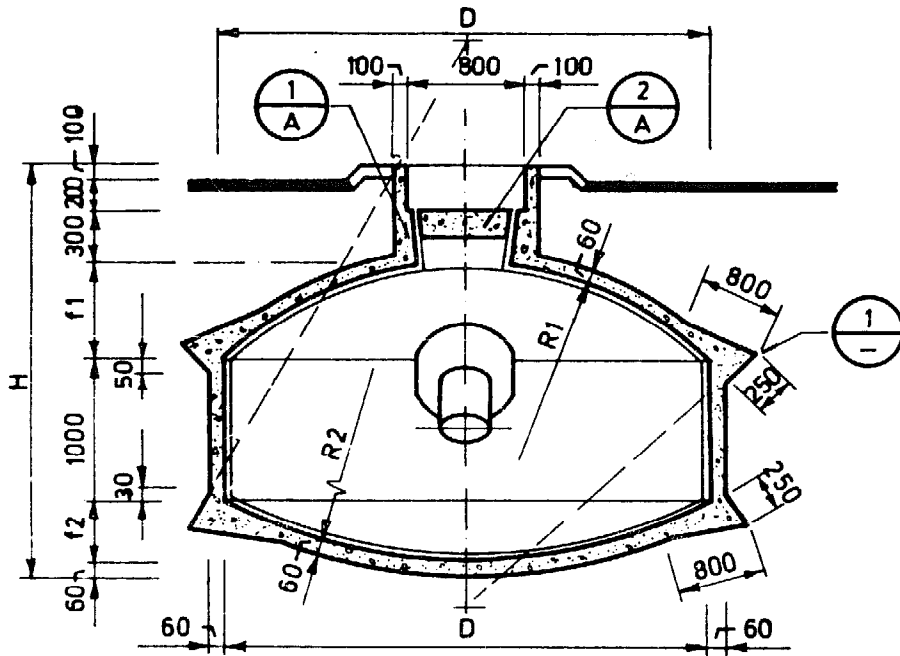
**LAYING-OUT**



**EXCAVATING OF BOTTOM  
ACC. TO NUMBERS**

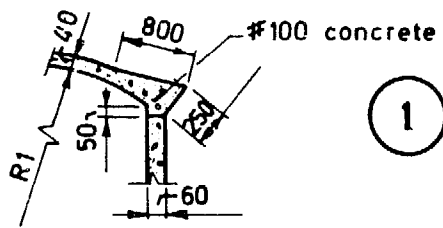


measurements in mm  
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2-2 section

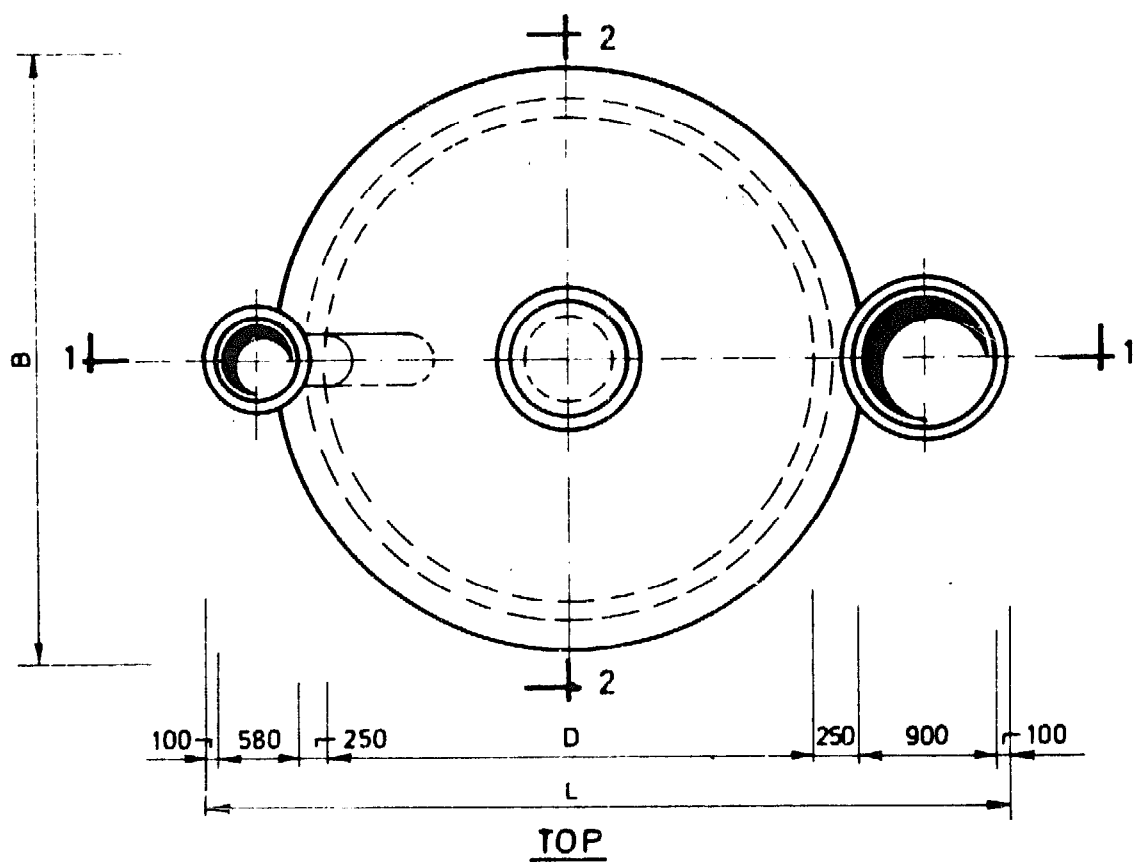
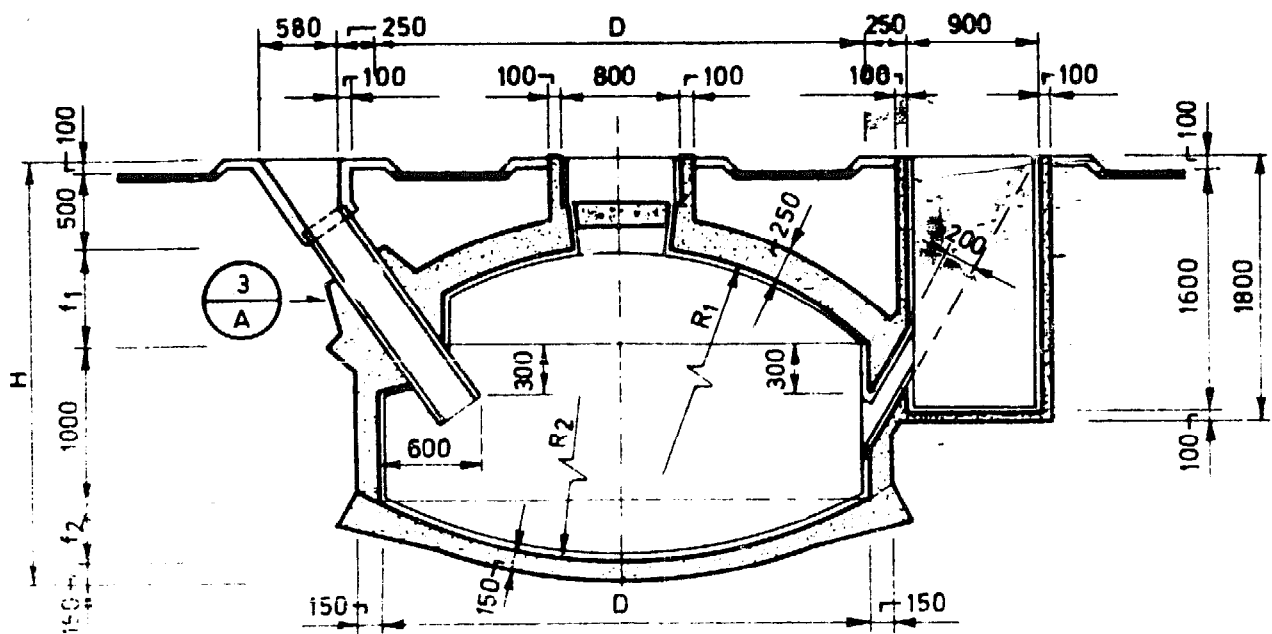
m <sup>3</sup>	L	B	H	D	R <sub>1</sub>	f <sub>1</sub>	R <sub>2</sub>	f <sub>2</sub>
6	4580	2880	2440	2400	1740	480	2550	300
8	4880	3180	2540	2700	1980	540	2860	340
10	5180	3480	2640	3000	2180	600	3180	380
12	5380	3780	2700	3200	2320	640	3400	400



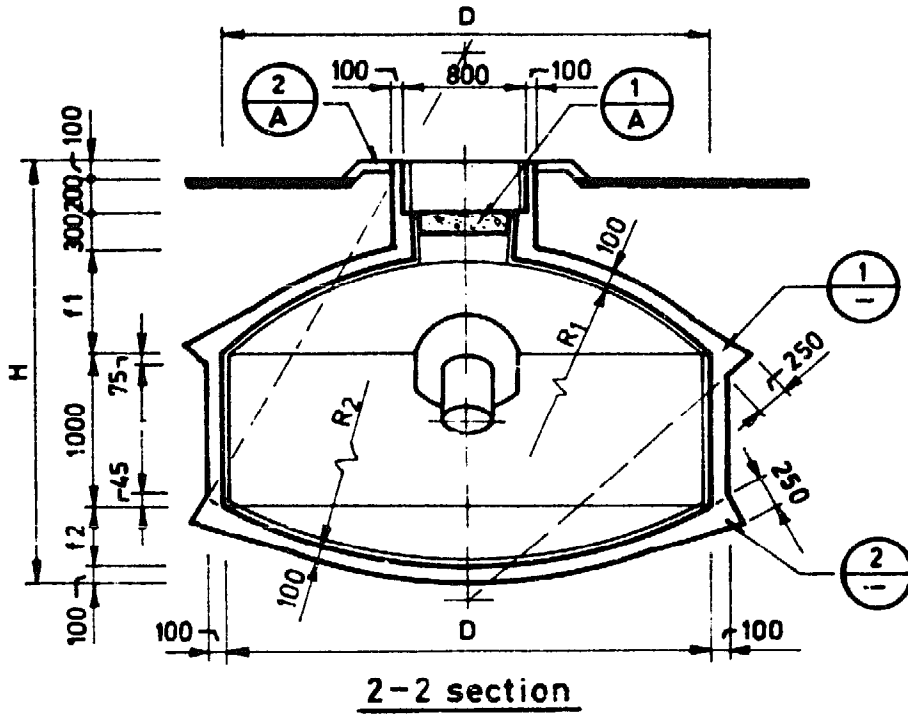
1

note: dome, wall and bottom are of # 30 concrete, when dome is made of # 100 concrete, see detail 1  
inlet and outlet are made of lime-clay.

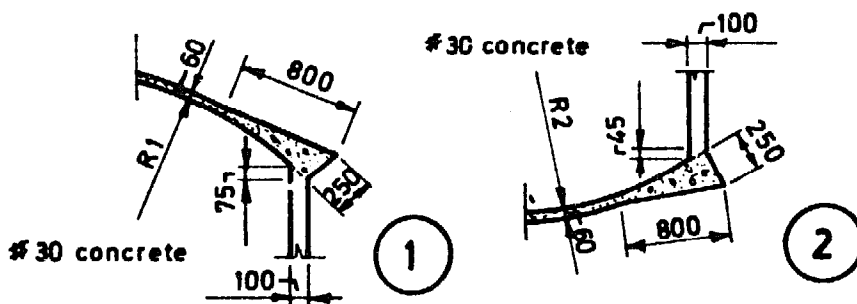
6, 8, 10 + 12 m<sup>3</sup> CONCRETE TANKS



measurements in mm  
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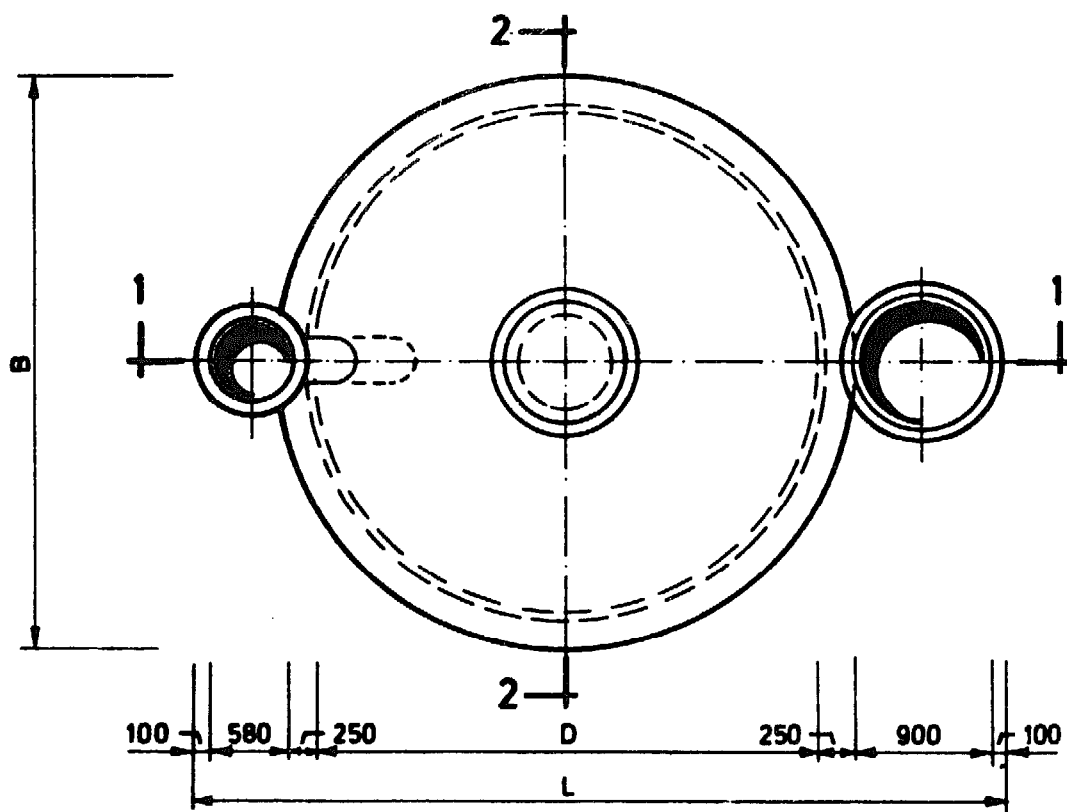
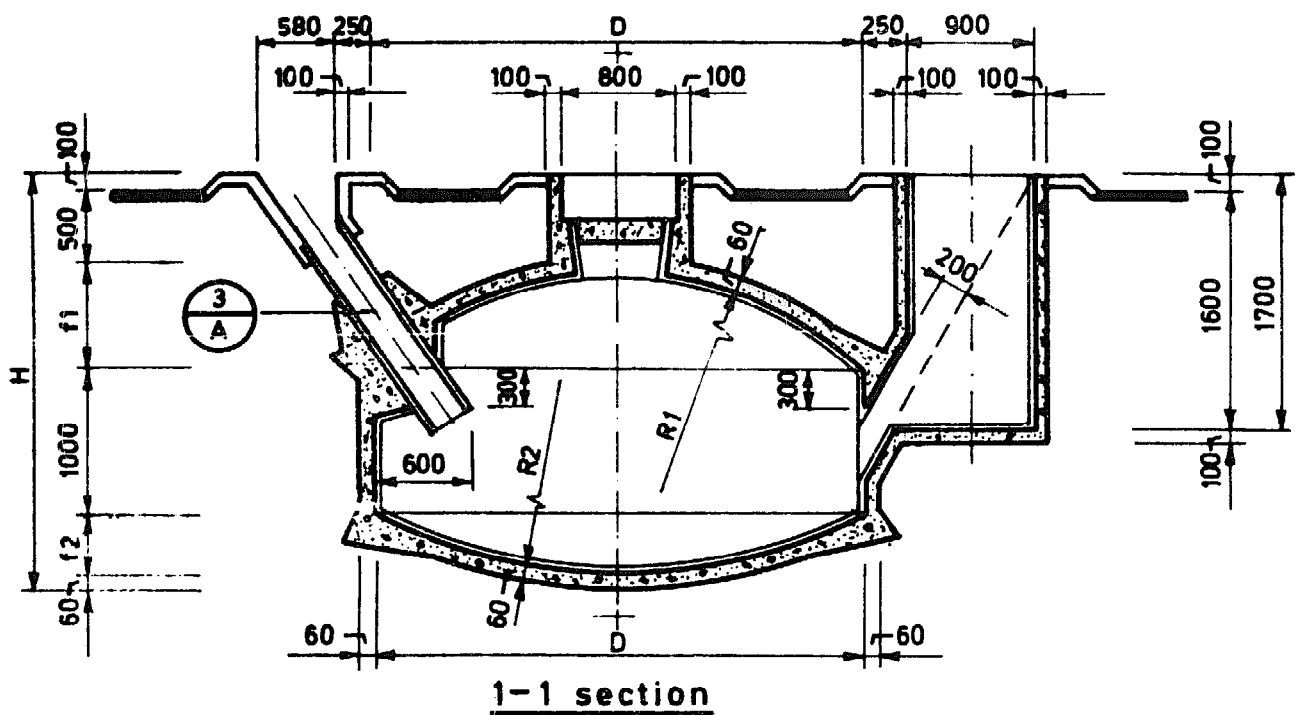
TYPE	L	B	H	R <sub>1</sub>	f <sub>1</sub>	D	H <sub>1</sub>	R <sub>2</sub>	f <sub>2</sub>
6	4580	2960	2480	1740	480	2400	1800	2550	300
8	4880	3260	2580	1960	540	2700	1000	2860	340
10	5180	3560	2680	2180	600	3000	1000	3180	380
12	5380	3760	2740	2320	640	3280	1000	3400	300



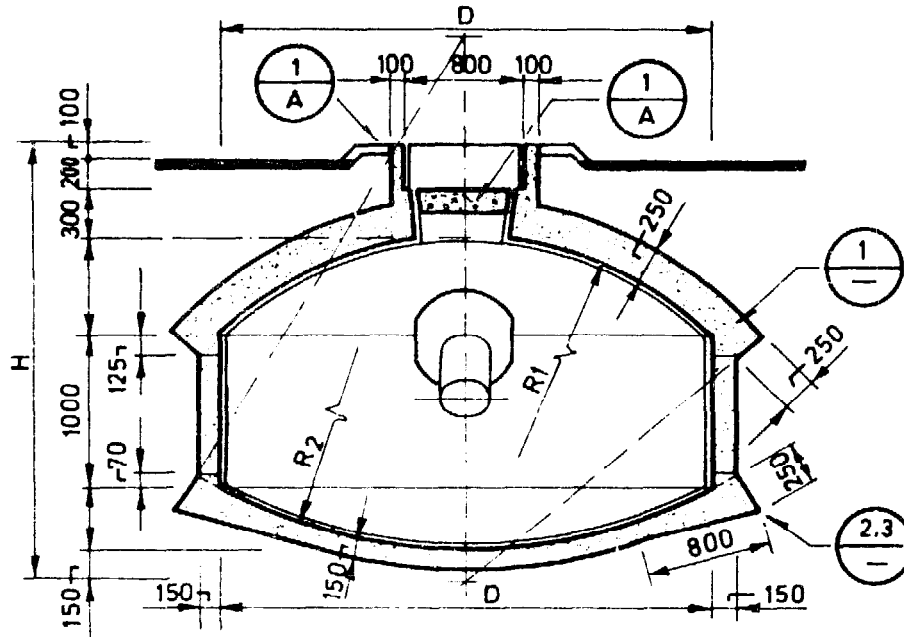
note: all parts are of lime concrete if the bottom and dome are made of other materials, see details 1,2

**6, 8, 10, 12 m<sup>3</sup> LIME CONCRETE TANKS**



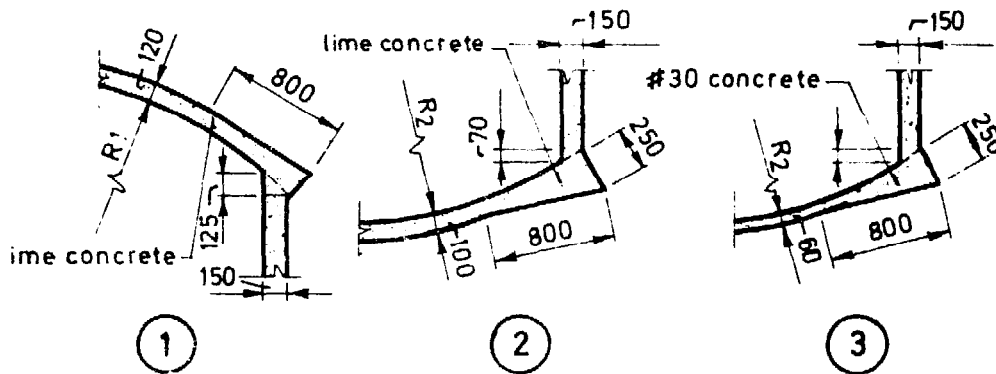


measurements in mm  
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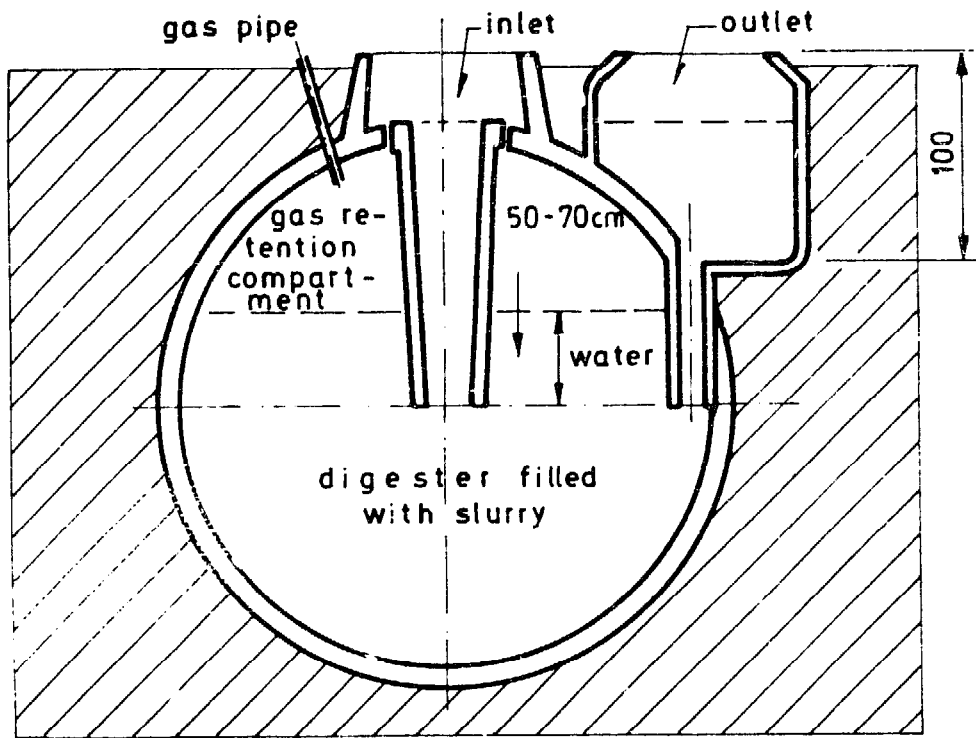
2-2 SECTION

m <sup>3</sup>	L	B	H	R <sub>1</sub>	f <sub>1</sub>	D	H <sub>1</sub>	R	f <sub>2</sub>
6	4580	3060	2530	1740	480	2400	1000	2550	300
8	4880	3360	2630	1960	540	2700	1000	2860	340
10	5180	3660	2730	2180	600	3000	1000	3180	380
12	5380	3860	2790	2320	640	3200	1000	3400	400

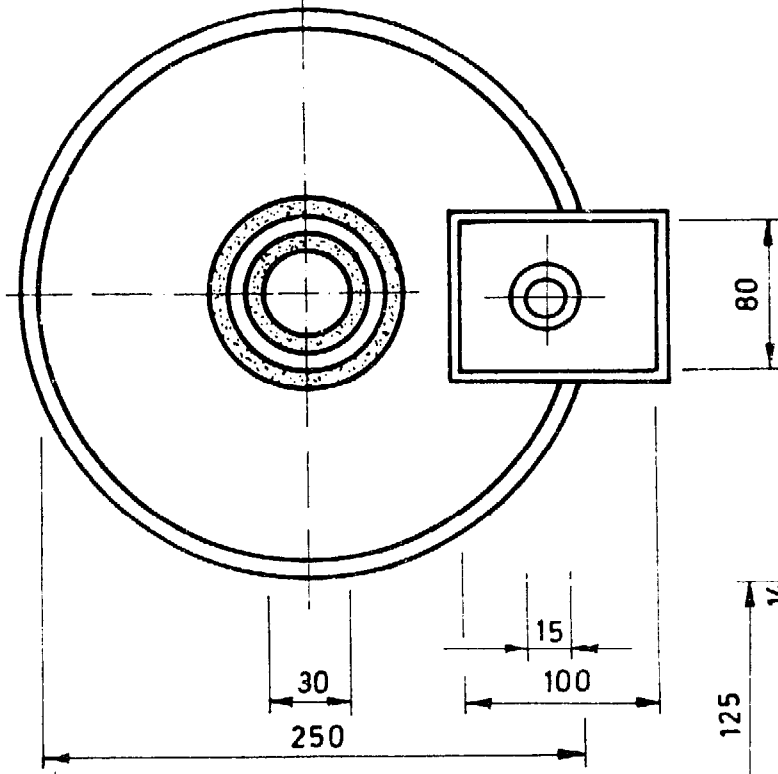


note: all parts of tank are of lime clay. If the bottom and dome are made of other materials, see details, ①.②.③

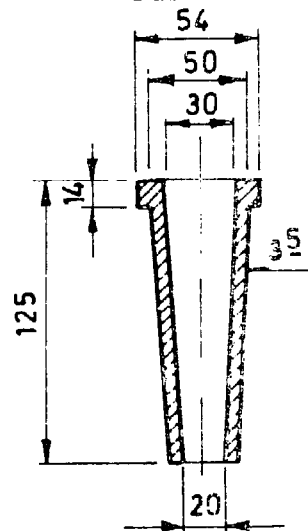
6, 8, 10 + 12 m<sup>3</sup> LIME - CLAY TANKS



top

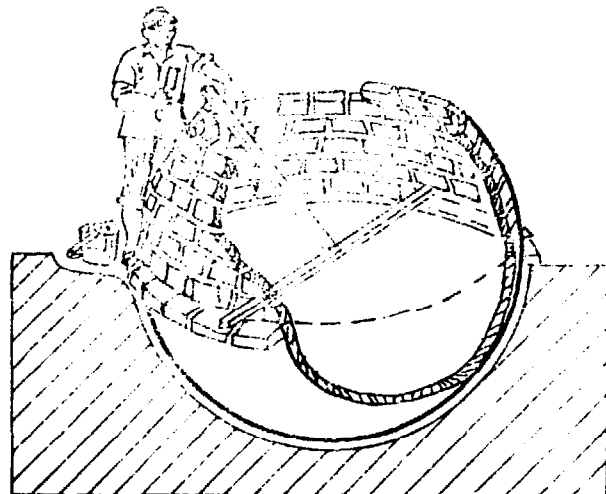
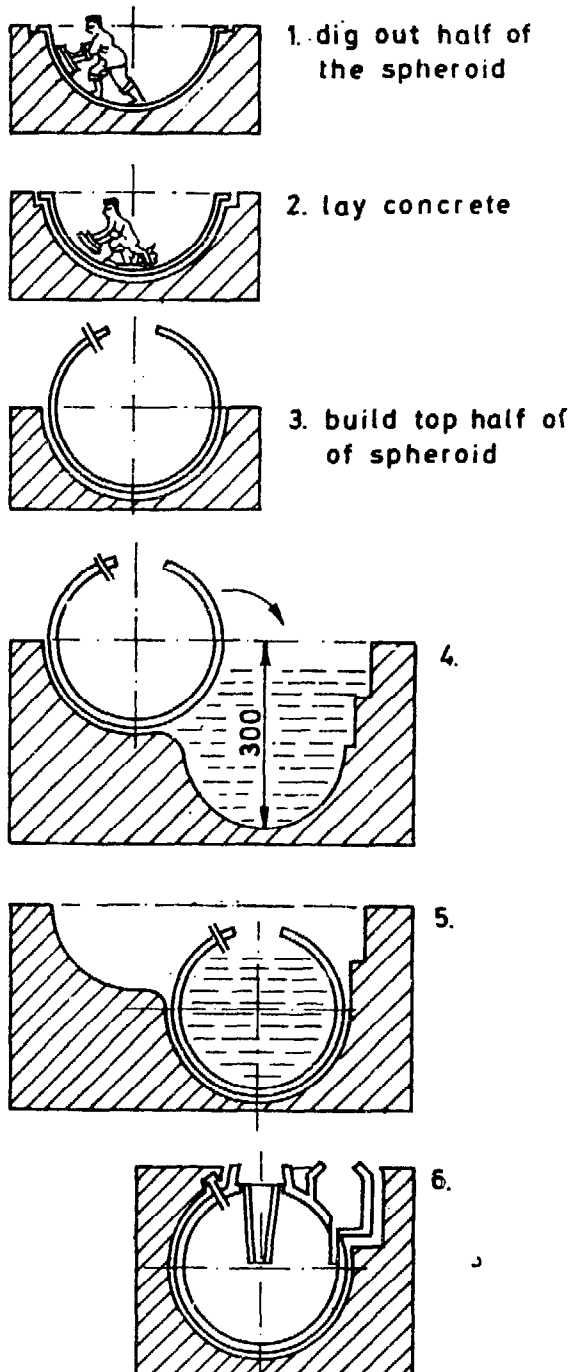


DETAIL



measurements in cm!  
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moveable inlet pipe

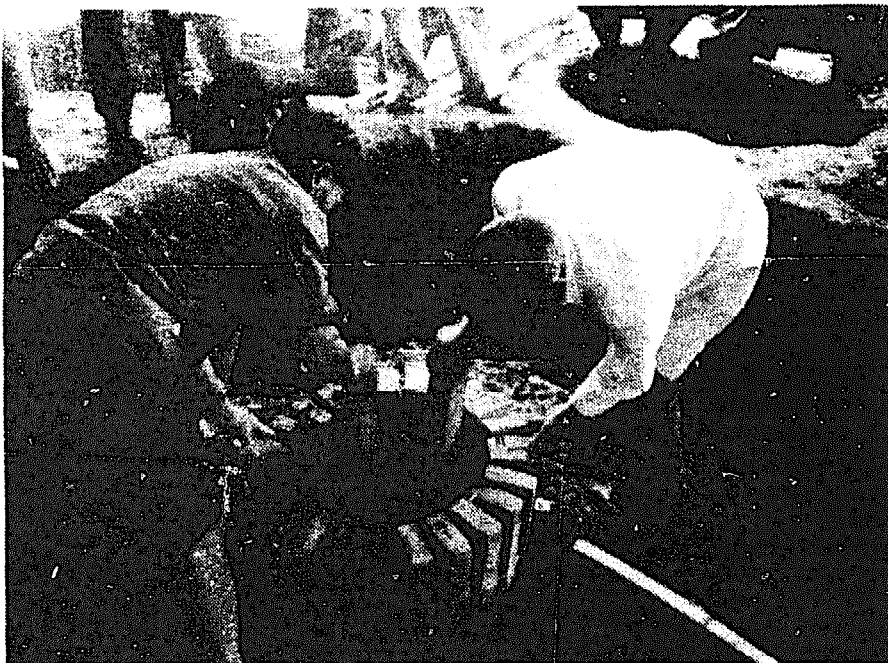
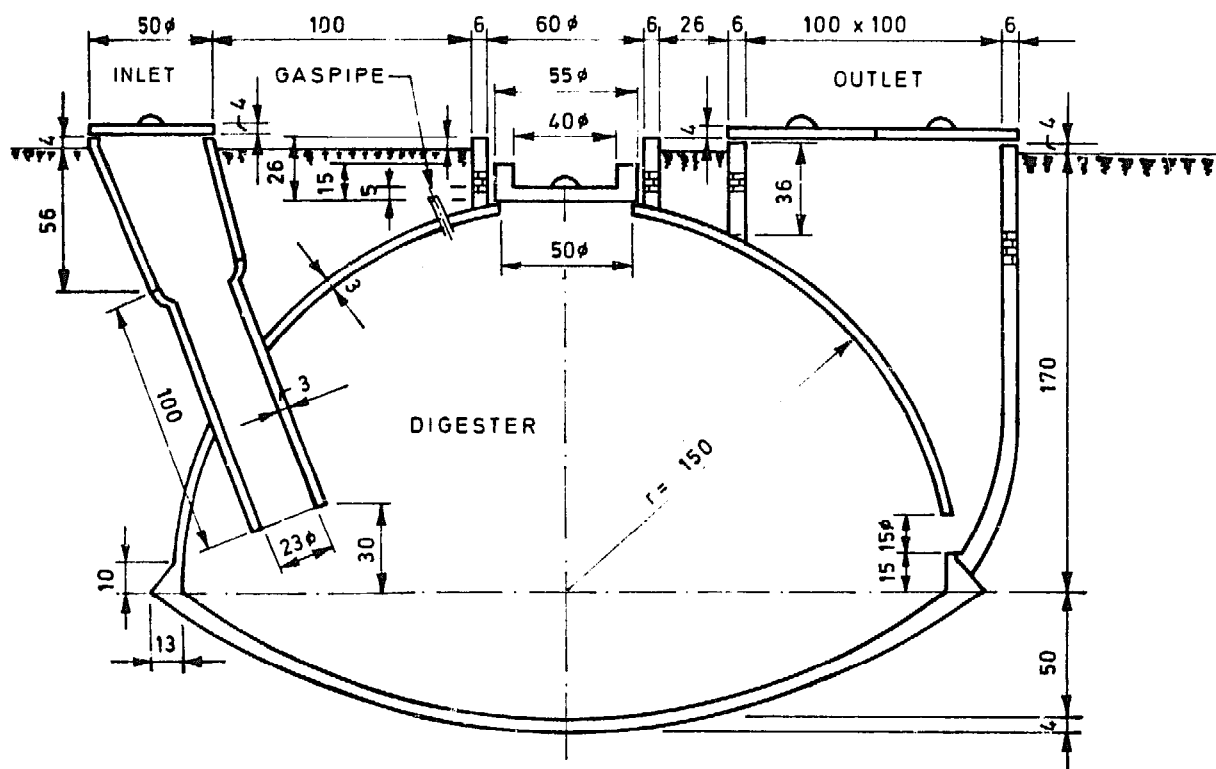


build top of sphere without wooden frame

construction procedure of the spheroid

1. lower half of sphere  
1:2:4 cement, sand, gravel.  
gravel to be of 10-15 mm  $\phi$ .  
concrete thickness 4 mm
2. top of sphere  
is brick work, with a coat of cement  
and sand.  
if no bricks are used:  
1:2:5 cement, sand plaster  
8-10 mm thickness outside
3. inside  
to coat three times:  
1st. 1:2.5 cement+ sand, 8 mm thick  
2nd. 1:1 cement+lime, 3 mm thick  
3rd. coating 3 mm thick
4. dig out another deeper pit, fill this  
with water, and float the spheroid  
into right position.
5. fill spheroid with water; when in  
its position empty both, spheroid  
and the pit
6. fit inlet pipe and outlet chamber.

THE CHINESE  
BALL - DIGESTER



A "Cast-in-place" digester. A trench 200 cm deep x 6 cm wide is dug with special tools. Concrete is poured in and tamped down to make digester wall. Digester top center is dome shaped with mud. Concrete is cast over this. When hard, the mud of dome support and of hole pit is removed through manhole. Picture shows manhole construction.

(Photo: Mrs. S.L.Maskey)

## A NEPALESE-MADE "CHINESE" GAS PLANT

Producing 100 cft of gas per day

This is a local modification of the Chinese design. It eliminates the manhole in the centre of the dome. This certainly abolishes the need for a gastight seal that has to be checked every time the manhole is opened for cleaning or repairing the pit. The dome is completely cast and plastered and rendered gastight once at for all. So far so good. But when cleaning has to be done, unless a forced draught is provided with a fan or air pump, the fumes in such a confined space might be overpowering.

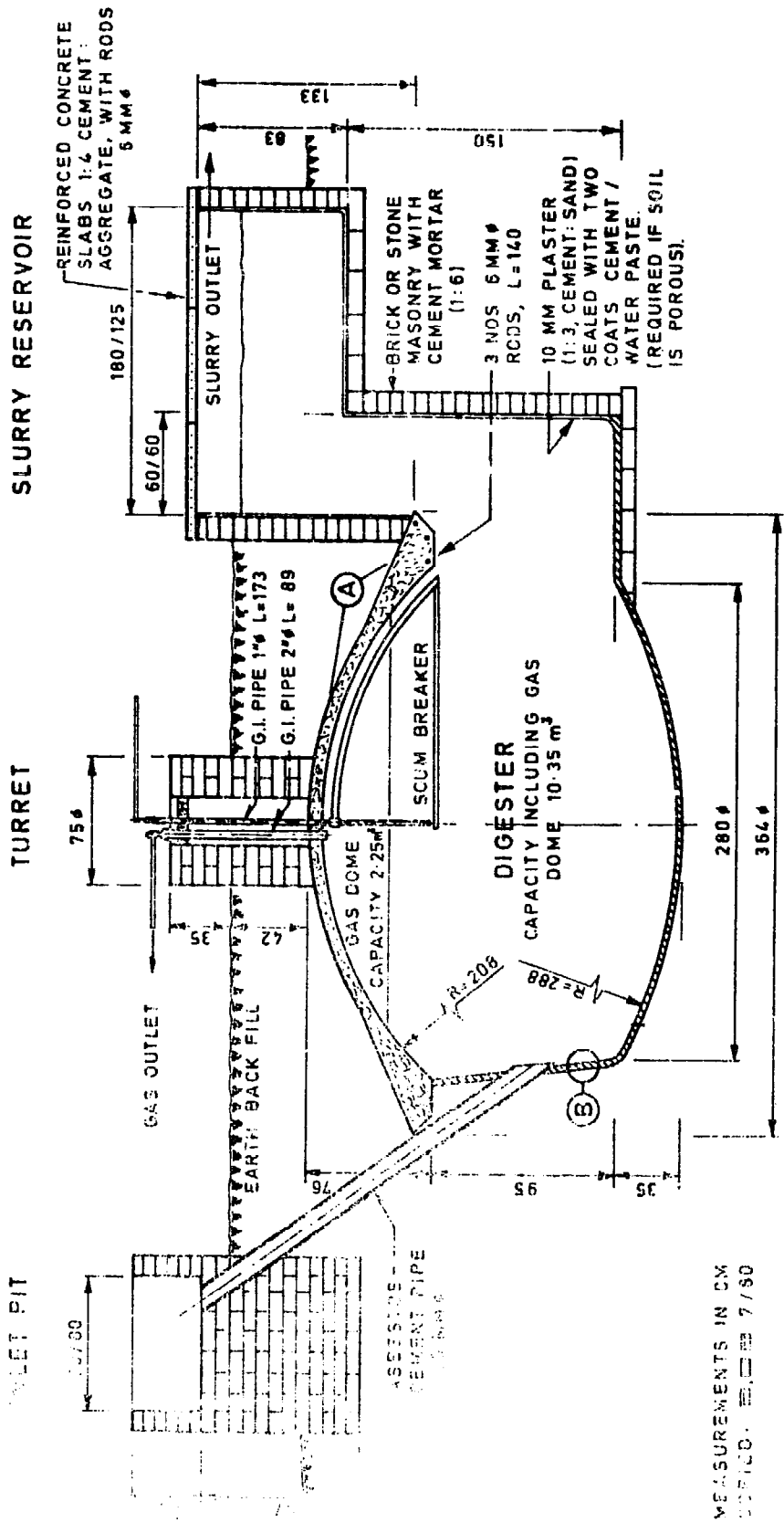
The technique of making this version of the Chinese design depends on making the gas dome of concrete spread over a mould. The digester pit is dug from under the dome, once it is dry. This technique, although it costs slightly more in labour charges than other versions, saves the need for heavy wood or metal form work that would otherwise need to be carried to the plant site. This version of the Chinese design is therefore considered to be easier to make in the hilly regions of Nepal, where transport is difficult.

### CONSTRUCTION PROCEDURE

1. Dig a hole, 2 m deep by 2 m diameter
2. Cover hole with boards or branches and form a mud mould for the cement dome -top at ground level- shaped with a jig. Dig trench and fit cement asbestos pipe, fit gas outlet pipe and scum breaker support pipe.
3. Pour dome. The thicker edge forms a collar that supports the dome on undug earth.
4. Build slurry inlet pit.

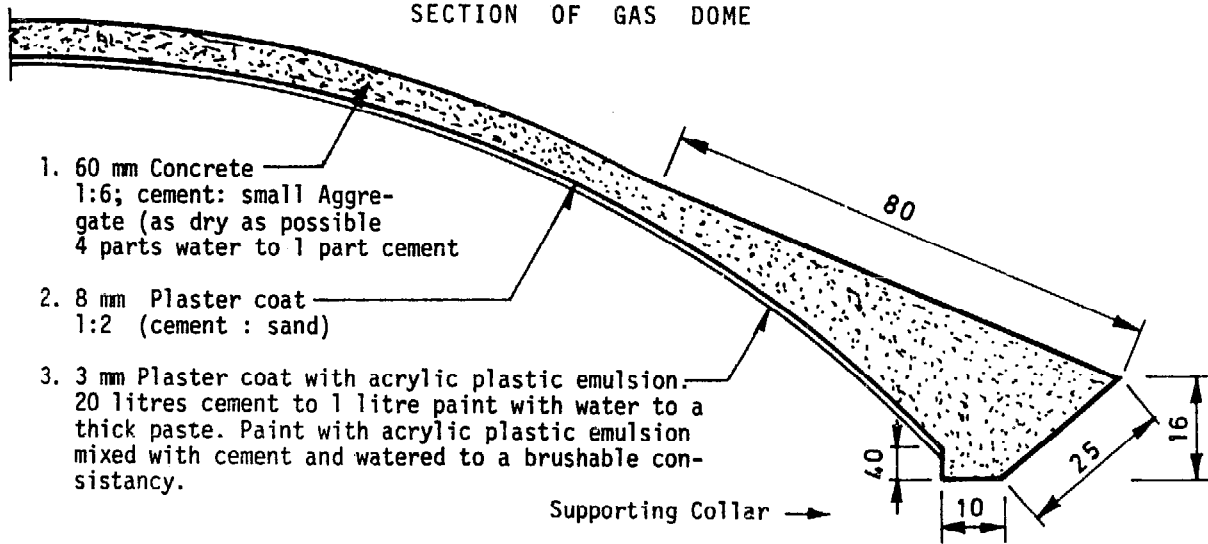
5. Dig access hole beside position of slurry outlet arch.
6. While concrete is hardening, do pipe fitting.
7. Build masonry turret on dome to support gas outlet and scum breaker pipes.
8. Dig under dome to form digester and pit and plaster against wall.
9. Clean underside of dome carefully and plaster, the whole plaster coat must be applied at one time, without stopping.
10. Plaster second coat under dome -using cement mixed with acrylic plastic emulsion paint (20 litres cement to 1 liter paint, with water to give stiff paste).
11. Plaster second coat on digester floor and walls.
12. Paint inside of dome with mixture of acrylic plastic emulsion and cement with water to give a brushable consistency.
13. Build slurry reservoir tank of brick or stone masonry. Plaster inside of tank if soil is porous. Cover dome with soil to depth of 42 cm.
14. Fit scum breaker, fill with slurry of 1:1 cowdung and water and wait for gas production to start (about 15 days). Let the first drum-full of gas escape. Once the plant is producing gas add 60 kg of dung per day mixed 1:1 with water, cleaned of all straw and vegetable matter.

*(Ref: Biogas Newsletter, No. 10, D. Fulford, DCS)*





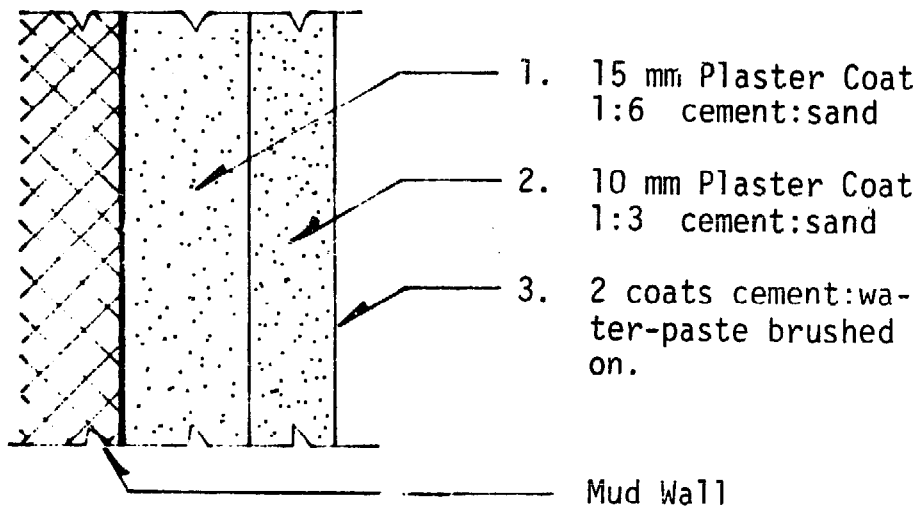
DETAIL A  
SECTION OF GAS DOME



1. 60 mm Concrete  
1:6; cement: small Aggregate (as dry as possible)  
4 parts water to 1 part cement
2. 8 mm Plaster coat  
1:2 (cement : sand)
3. 3 mm Plaster coat with acrylic plastic emulsion.  
20 litres cement to 1 litre paint with water to a thick paste. Paint with acrylic plastic emulsion mixed with cement and watered to a brushable consistency.

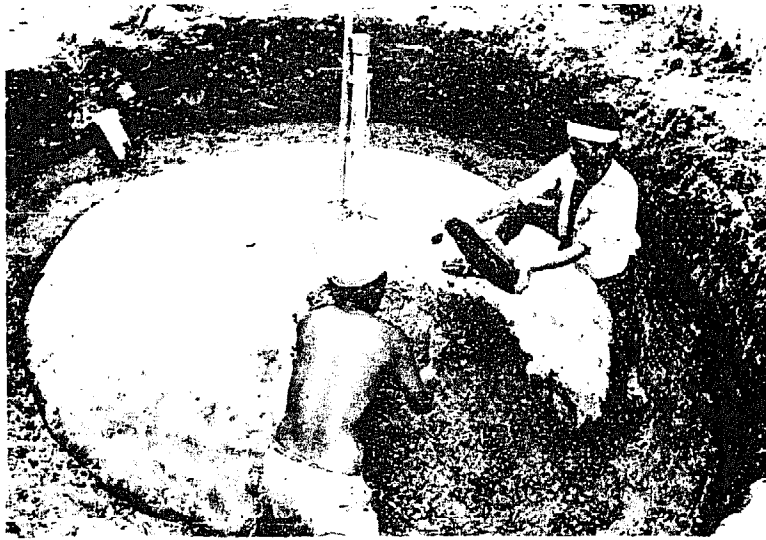
Supporting Collar →

DETAIL B  
SECTION OF DIGESTER PIT WALLS AND FLOOR



1. 15 mm Plaster Coat  
1:6 cement:sand
2. 10 mm Plaster Coat  
1:3 cement:sand
3. 2 coats cement:water-paste brushed on.

Mud Wall



9 Pouring concrete on dome



Pounding the mud mould for the dome

*(Photos: Kunda Dixit)*

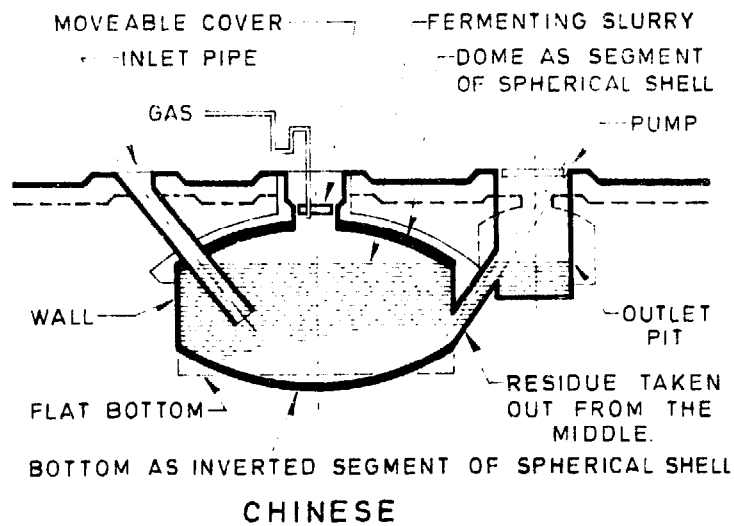
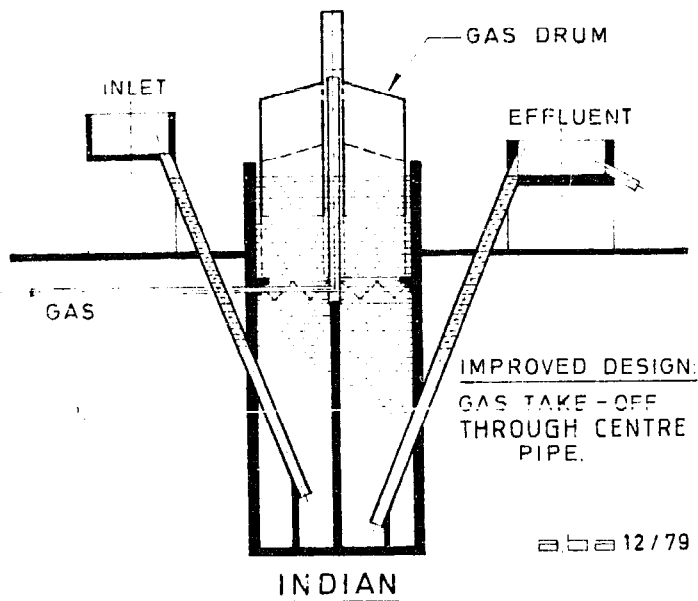
## A COMPARISON

We are often asked questions like "What do you think of Chinese technology?" or "Which gas plant is better, the Indian or the Chinese?" To this we can only answer that both are better. The Indian is better in some respects and the Chinese is better in others. Both have definitive advantages, and both have snags. Nothing in this world is perfect. We list for you some of the good and some of the bad points of both technologies. More could be said for and against both sides, but we hope we have touched on the main differences. Your choice of the plant may often be guided by local conditions, materials available, the skill of the builder, and other similar circumstances. But whichever plant you build, if it is properly installed and operated, will give you excellent service.

### EFFICIENCY:

INDIAN: The Indian gas plants are very satisfactory and serviceable. They are simple to build and maintain, and if intelligently operated are virtually trouble-free. They are highly recommended, especially for beginners.

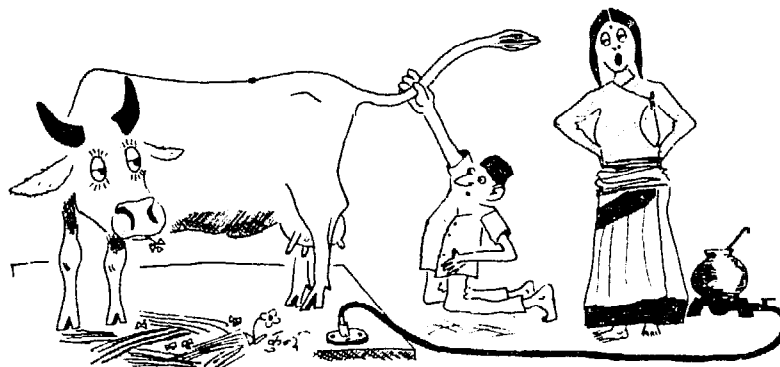
CHINESE: The Chinese plants too give perfect satisfaction. Require experienced builders. The high gas pressure in the digester poses the biggest problem if construction is not perfect (gas leaks, cracks in cover and walls.) Somewhat wasteful of gas: gas formed in side chambers is lost, excess pressure is reduced by releasing gas to atmosphere. So relatively larger plants are needed. The exhausted slurry and sludge of each batch makes richer and more abundant soil conditioner than that of Indian pit. The digester, because totally underground, is better insulated against winter cold.



	INDIAN	CHINESE
PURPOSE	Primary: gas Secondary: fertilizer	Primary: fertilizer Secondary: gas
CONSTRUCTION	simple masonry pit, easy to build but hard to install where drum cannot be made or easily be carried	closed underground tank or concrete tank with adjacent effluent chamber. Requires skill to render gastight. Can be built anywhere.
INPUT	virtually only cattle dung slurry may serve as septic tank	mostly mixed organic matter (veg., dung faeces) many plants exclusively night soil.
OUTPUT	automatic gravity flow	by pump or by bucket
OPERATION	- mostly flow fed - batch loaded (almost ever) - virtually no attention beyond mixing and feeding slurry	- batch loaded (generally) - can also work flow fed with dung slurry - labour intensive: for batch loading and emptying, and for removing effluent
GAS COLLECTION	in floating drum: - height of float shows gas volume - drum needs regular painting against corrosion	no drum; gas in sealed digester: - gas volume and pressure shown by slurry height in outlet.
GAS PRESSURE	- low: 70 - 150 mm water col. - steady, due to floating drum	- high: up to 1000 mm water-column maximum - constantly varying
COST	high because of metal drum and its fixture	lower cost because no metal
APPEARANCE	presentable, neat	neat, clean, unobstrusive.

## POSSIBLE TROUBLES

DEFECT	MAY BE CAUSED BY	REMEDY
No gas. Drum won't rise.	a) no bacteria	Add some.
	b) lack of time	Patience! Without bacteria it may take four to five weeks.
	c) slurry is too cold	Use warm water. Cover plant with plastic tent or use heating coil.
	d) insufficient input	Add right amount of slurry daily
	e) leak in drum or pipe	Check seams, joints, taps with soap water.
	f) hard scum on slurry blocks gas.	Remove drum; clean slurry surface. With sliding-drum plants turning drum slightly breaks crust.
No gas at stove; plenty in drum.	a) gas pipe is blocked. by condensed water.	Open escape cock.
	b) insufficient pressure	Increase weights on drum.
	c) gas inlet blocked by scum	Remove drum and clean inlet. Close all gas-taps; fill the gas line with water; apply pressure through moisture escape. Drain water out.
Gas won't burn.	wrong kind is being formed.	Slurry too thick or too thin. Measure accurately. Have patience.
Flame soon dies.	insufficient pressure	increase.
Flame begins far from burner	pressure too high	a) Remove weights from drum. Counterbalance
		b) Choke gas inlet at stove to 2 mm diameter. (thickness of 1" nail).



Kunda Dixit

"MAY BE THE CARBURETTOR IS JAMMED..."

## TEMPERATURE TABLE

°F	°C	°F	°C	°F	°C
50	10.4				
51	10.6	71	21.7	91	32.8
52	11.1	72	22.2	92	33.3
53	11.7	73	22.8	93	33.9
54	12.2	74	23.3	94	34.4
55	12.8	75	23.9	95	35.0
56	13.3	76	24.4	96	35.6
57	13.9	77	25.0	97	36.1
58	14.4	78	25.6	98	36.7
59	15.0	79	26.1	99	37.2
60	15.6	80	26.7	100	37.8
61	16.1	81	27.2	105	40.5
62	16.7	82	27.8	110	43.3
63	17.2	83	28.3	115	46.1
64	17.8	84	28.8	120	48.9
65	18.3	85	29.4	125	51.6
66	18.9	86	30.0	130	54.4
67	19.4	87	30.6	135	57.2
68	20.0	88	31.1	140	60.0
69	20.6	89	31.7	145	62.7
70	21.1	90	32.2	150	65.5

$$^{\circ}\text{C} = (^{\circ}\text{F} - 32) \times 0.5556$$

$$^{\circ}\text{F} = (^{\circ}\text{C} \times 1.8) + 32$$

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INFORMATION AVAILABLE ON APPROPRIATE TECHNOLOGY

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MINI TECHNOLOGY - VOLUME I / Second Edition  
by B.R. Saubolle and A. Bachmann

Contains 36 low-key projects to make life more livable: solar water heaters, biogas, sawdust stoves, room heating and cooling, corn sheller, crow trap, fly trap, and much more. Abundantly illustrated. A real jewel!

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MINI TECHNOLOGY - VOLUME II  
by A. Bachmann and B.R. Saubolle

This second volume continues the information on technology for rural areas and developing countries, where electricity is not yet available from the power grid. It gives suggestions based on experience on fuel efficient stoves, smokeless kitchens, energy from water. Explains also methods of rat disposal, etc. A welcome addition to the literature in this field!

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BEEKEEPING, by B.R. Saubolle and A. Bachmann

An introduction to modern beekeeping in Nepal. Written expressly for the Apia indica, this booklet will render great service all over South-East Asia. Clear, to the point, practical. Treats also of wall and log hives and of the African Top-Bar Hive. A treasure!

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MULTI-PURPOSE POWER-UNIT - With horizontal water wheel  
by A.M. Nakarmi and A. Bachmann

This booklet explains in a few words, but with many diagrams and photographs, one of the latest developments in the field of micro hydro-power in Nepal. In essence it is based on traditional technology and can provide from two to five or ten horse power.

The modular design comes in standard sizes that are manufactured in porterable loads, so that it can be easily transported even to remote areas. This device has aroused considerable interest in many places. The booklet provides useful information of alternative and renewable energy resources in rural areas.

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Published by:  
Sahayogi Press, Tripureshwar, Kathmandu

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FROM THE SAME PUBLISHER

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SMALL SCALE RENEWABLE ENERGY RESOURCES AND LOCALLY-FEASIBLE TECHNOLOGY IN NEPAL

by A. Bachmann and G.R. Shakya

This booklet provides a collection of the recent achievements in the field of locally-feasible technology and also some of the traditional technology in Nepal. The combination of the booklet, that of the article, the photographs and the directory will prove to be a useful tool for people actively involved in improvement of rural living.

A good pathfinder!

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HOME BREW, by B. Remi

A delightful booklet, explaining how to make beers and wines. Written in a light vein, it is profusely and humorously illustrated. Advocates only low-alcohol beverages: no distillation.

A charming production!

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DRINKING WATER INSTALLATIONS AND DRAINAGE REQUIREMENTS IN BUILDINGS IN NEPAL, by A. Bachmann

This book is based on many years of experience in sanitary engineering. The collection includes installations of low- and medium-pressure water supply, waste water and gas. Included also is valuable experiences of locally produced solar water heaters. The presentation is clear and has many technical drawings and is made for architects and planners as well as for technicians working at building sites; all with reference to conditions to Nepal and useful to many other countries.

Several times reprinted, revised edition.

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MOUNTAIN ENVIRONMENT AND DEVELOPMENT

A collection of papers published on the occasion of the 20th anniversary of the Swiss Association for Technical Assistance in Nepal, 1976. This booklet has been reprinted several times and found worldwide distribution!

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RENEWABLE ENERGY RESOURCES IN NEPAL

Proceedings of the Workshop-Seminar, Kathmandu 1-4 April 1981, published by Sahayogi Press and Recast, Tribhuvan University.

This collection provides a good overall view of problems and possible solutions for urban and rural populations in Nepal.

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## BOOK REVIEW

### FUEL GAS FROM COWDUNG

This booklet is directed to people who wish to build a biogas plant for supplying gas for cooking, lighting and other household purposes. Detailed constructions are given for constructing plants of several sizes. Two general designs are presented. The first design is that commonly used in India, which is based on the use of a metal drum for gas collection. The second design, used by the Chinese (who do not have easy access to metal drums) is based on the use of pressure-tight enclosures for gas collection, the space needed for the gas being provided by an auxiliary chamber being connected to the bottom of the main pit, into which part of the slurry flows as gas is accumulated in the top of the main enclosure.

While the main thrust of the booklet deals with cowdung, the use of manure from other animals is also dealt with, and also the possible use of sanitary wastes from dwellings. It is noted that the chief emphasis in India and in Nepal, where the book was written, is on the production of gas as a fuel. Besides the gas production, the slurry effluent from the plant is an excellent fertilizer, which retains most of the value of the original cowdung for this purpose. This is a secondary usage of the plant. By contrast, it is noted that the primary purpose of the Chinese biogas units is for the production of fertilizer, with the production of gas as a secondary objective.

In summary, this book should be most helpful to those readers who wish to design and install practical small-scale systems for producing gas and fertilizer. The instructions given are sufficiently detailed to provide guidance in the planning and construction of such plants for specific capacities.

FUEL GAS FROM COWDUNG

Third Edition

by

B.R. Saubolle and A. Bachmann

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An excellent, succinct, clear exposure in simple language of the principles of methane gas production from animal dung - abundant, clear diagrams with measurements in metric and British systems. This booklet has already gained worldwide distribution and has proved very practical and helpful in several developing countries. It has received much praise!

**Booklets available from:**

**UNICEF**

**P. O. Box 1187**

**Kathmandu / Nepal**



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