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EXCRETA DISPOSAL  
FOR RURAL AREAS AND SMALL COMMUNITIES



# EXCRETA DISPOSAL FOR RURAL AREAS AND SMALL COMMUNITIES

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## Introduction

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*During the past several years there have been many developments in the field of disposal of human wastes, and many books have been written on this subject. The great majority of these books, however, deal almost exclusively with sewerage and sewage disposal as applicable to cities and large towns and communities. A survey of the relevant publications and of the few books devoted to rural sanitation reveals important shortcomings : in virtually all instances, they are confined to the study of one or a limited group of specific sanitation problems, such as latrines, wells, septic tanks, or a particular method of refuse disposal adequate for small communities. Very few publications deal comprehensively with the mechanics of getting sanitary excreta disposal facilities constructed and used properly, and with the factors involved in the process.*

*The persons primarily responsible for these aspects of rural sanitation are the public health administrators, the medical officers of health, the civil or sanitary engineers engaged in public health, and the sanitarians. It is to these that this monograph is addressed. They will find in it not only technical data relating to particular rural excreta disposal facilities, but also information on what is believed to be needed or to be done in order to achieve success in programmes of excreta disposal in rural areas and small communities. The role of the health department, the need for securing the active participation of the community and of the family, the planning of programmes, and the training of the necessary personnel are covered, as well as the latest accepted practices in excreta disposal for rural areas.*

*From their own experience and from their discussions with others of long experience and standing in rural sanitation work, the authors have formulated the following principles which appear to them to be essential in most countries to the success of sanitary excreta disposal programmes :*

- 1. The object of any privy programme should be to get the family to assume responsibility for, and to solve, its own excreta disposal problems.*

- 2. The health department should contribute funds for materials or labour or both in order to encourage the family to build the first latrine and thereby to take the first important step in learning a new habit.*

- 3. The health department must train sanitary inspectors to work with the families in the communities on the educational and technical aspects of latrine construction, use, and maintenance.*

4. *The sanitation work should be under the general direction of a well-trained sanitary engineer who must be able to understand the problem of excreta disposal in its most elementary terms and the processes involved in effecting improvement in this fundamental of rural sanitation.*

*This study is written largely on the basis of these four points. Although it is obvious that every problem is different and must be solved on the basis of each local situation, it is hoped that the information given herein will shed some new and helpful light on a problem which is very old, no matter in what part of the world it is found. An effort has been made to give enough detail to help those who are beginning in this work and, at the same time, to present some ideas and approaches which may be new to those with experience in rural sanitation.*

*It is hoped, too, that this monograph will serve as one of the links in the chain of efforts being pursued by the World Health Organization to stimulate environmental sanitation programmes at the local level in member countries.*

*A preliminary text covering certain aspects of excreta disposal without water carriage was first drafted by Mr E. G. Wagner, a short-term consultant to WHO, and was issued in 1955 as a mimeographed document. This text was circulated to forty experts in different parts of the world for their comments and suggestions. The thirty-eight replies received were much appreciated, and have greatly assisted in amending and revising the original text. (A list of the reviewers will be found in Annex 2, page 177.) The World Health Organization wishes to express its gratitude to these reviewers. Also, to the Serviço Especial de Saúde Pública of Brazil and the Institute of Inter-American Affairs, and to their staffs, the Organization gives sincere thanks for the use of their vast experience and for their frank and helpful criticism of the material.*

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# BASIC CONSIDERATIONS

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## PUBLIC HEALTH IMPORTANCE OF EXCRETA DISPOSAL

Excreta disposal is an important part of environmental sanitation. Its provision is listed by the WHO Expert Committee on Environmental Sanitation <sup>44</sup> among the first basic steps which should be taken towards assuring a safe environment in rural areas and small communities, the others being the provision of an adequate supply of safe drinking-water and the control of insect and animal vectors of disease in places where these are of significance. In large areas of the world, and indeed in parts of every country, proper excreta disposal is among the most pressing public health problems.

The inadequate and insanitary disposal of infected human faeces leads to the contamination of the ground and of sources of water supplies. It often affords an opportunity for certain species of flies to lay their eggs, to breed, to feed on the exposed material, and to carry infection. It also attracts domestic animals and rodents and other vermin which spread the faeces ; and it sometimes creates intolerable nuisances.

### Relationship to Health

Poor excreta disposal is often associated with the lack of adequate water supplies and of other sanitation facilities and with a low economic status of the rural population. These conditions, all of which affect health, make it difficult to assess the role played by each component in the transmission of disease. However, it is well known that there is a relationship between the disposal of excreta and the state of health of the population. The relationship is both direct and indirect in character.

The direct effect is exemplified by the reduced incidence of certain diseases when proper disposal of excreta is practised. This group of diseases includes cholera, typhoid and paratyphoid fevers, the dysenteries, infant diarrhoeas, hookworm disease, ascariasis, bilharziasis, and other similar intestinal infections and parasitic infestations. These diseases lay a heavy hand on infants, whose immunity is low and whose vigour is often not great enough to cope with an infection after it becomes established. Further

**TABLE I. INFANT MORTALITY AND MORTALITY FROM DIARRHOEA AND ENTERITIS FOR THE YEAR 1954 \***

Country	Infant mortality		Infant diarrhoea and enteritis	
	deaths, 0-1 year, total	rate per 1000 live-births	deaths <sup>a</sup>	deaths from diarrhoea and enteritis (%)
Egypt	81 407	179 <sup>b</sup>	43 517	54.7
Colombia	48 734	103	6 277	12.8
Guatemala	14 302	88	1 392	9.7
Portugal	16 898	86	5 126	30.3
Mexico	107 853	80	21 052	19.5
Costa Rica	3 820	79	772	20.2
Puerto Rico	4 482	58	1 088	24.3
Panama	1 745	53	241	13.8
Italy	46 104	53	5 168	11.2
Uruguay	2 428	51	440	18.1
Austria	5 023	48	391	7.8
Japan	78 944	45	5 669	7.2
Germany, Federal Republic	33 353	43	443	1.3
Israel	1 417	35	198	13.9
Union of South Africa (European population)	2 298	33	277	12.0
Canada	13 841	32	554	4.0
Finland	2 750	31	199	7.2
USA	106 791	27	3 590	3.3
Denmark	2 051	27	64	3.1
Switzerland	2 280	27	42	1.8
United Kingdom of Great Britain and Northern Ireland	17 160	25	428	2.5
Norway	1 343	21	37	2.7
New Zealand (exclusive of Maoris)	968	20	17	1.7
Sweden	1 966	19	21	1.0

\* Taken from *Annual Epidemiological and Vital Statistics, 1954*.<sup>41</sup>

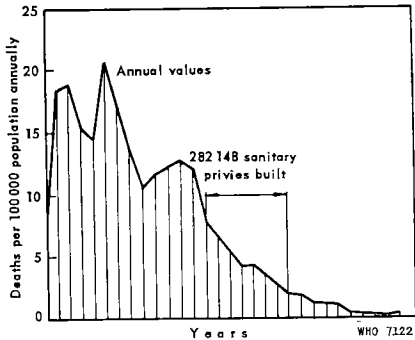
<sup>a</sup> Figures given in this column do not include deaths due to enteric infections in the newborn (babies less than four weeks old).

<sup>b</sup> Figure for 1953.

evidence of this direct relationship may be found in a comparison of figures for infant mortality from diarrhoeas and enteritis in various countries (see Table I).

A good example of the effect of sanitary excreta disposal on the incidence of typhoid and paratyphoid is given by Fair & Geyer:<sup>43</sup> In the State of West Virginia, USA, when a privy construction programme was undertaken, the death-rate attributable to these diseases was cut by two-thirds and eventually was reduced to nil (see Fig. 1). It is stated, however, that improvements in other sanitary conditions probably occurred at the same time.

FIG. 1. REDUCTION IN THE DEATH-RATE FROM TYPHOID BY SANITATION OF EXCRETA DISPOSAL



Reproduced from Fair, G. M. & Geyer, J. C. (1954) *Water supply and waste-water disposal*, p. 26, by kind permission of John Wiley & Sons, Inc., New York.

The indirect relationships of excreta disposal to health are many, but they are generally associated with other components of environmental sanitation. Here mention may be made of the following :

1. The improvement of hygienic conditions promotes a state of well-being in the population which is conducive to its social development.

2. There is considerable evidence that the diminished incidence of excremental and water-borne diseases which results from improvements in environmental sanitation is accompanied by a marked decrease in morbidity from other diseases the etiology of which is not directly related to either excreta or contaminated water-supplies.

3. Various economic benefits, such as those resulting from an increase in life expectancy, arise in connexion with the implementation of sanitation programmes.

4. Morbidity resulting from lack of even the simplest sanitation facilities adversely affects deployment of labour. When they are healthy, unemployed persons who are unable to find work in one place may readily emigrate to another where work is available. The sick cannot do so.<sup>44</sup>

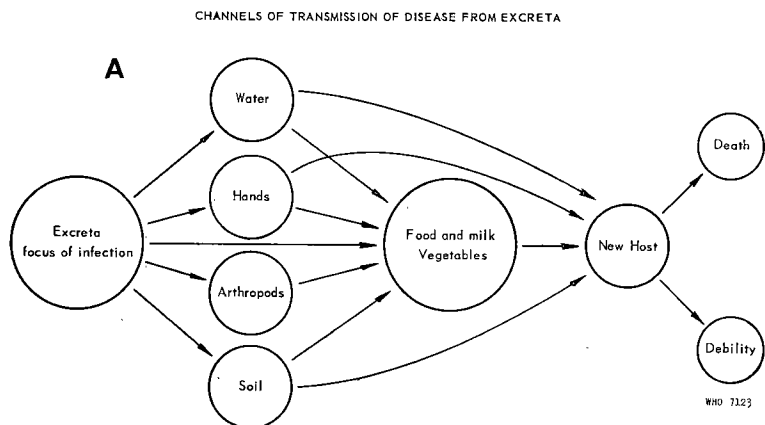
### How Disease is carried from Excreta

Man is the reservoir of most of the diseases that destroy or incapacitate him. The faecal-borne infections and infestations already mentioned are the cause of tremendous losses in death and debility. It is interesting to note that all these diseases are controllable through good sanitation, especially through sanitary excreta disposal.

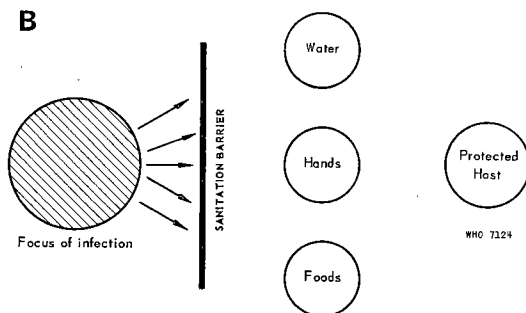
In the transmission of these diseases from the sick, or from carriers of disease, to the healthy, the chain of events, as shown in Fig. 2 A, is similar to that for many other communicable diseases. Anderson & Arnstein<sup>1</sup> state that, in order to transmit disease, the following factors are necessary :

- (1) a causative or etiological agent ;
- (2) a reservoir or source of infection of the causative agent ;

FIG. 2. TRANSMISSION OF DISEASE FROM EXCRETA



STOPPING THE TRANSMISSION OF FAECAL-BORNE DISEASES BY MEANS OF SANITATION



- (3) a mode of escape from the reservoir ;
- (4) a mode of transmission from the reservoir to the potential new host ;
- (5) a mode of entry into the new host ;
- (6) a susceptible host.

The absence of a single one of these six conditions makes the spread of disease impossible. As may be seen from the diagram in Fig. 2 A, there are many ways in which the causative agent of enteric disease reaches a new host. In different parts of the world, different modes of transmission may assume various degrees of importance: in some areas, water, food, and milk may be most important; in others, flies and other insects; and, in still others, direct contact may assume a major role. What is most probable is a combination of all, and the sanitary worker must assume that this

is the case and guard against all modes of transmission. The technical objective of sanitary excreta disposal is therefore to isolate faeces so that the infectious agents in them cannot possibly get to a new host. Fig. 2 B shows the place where the sanitation officer might choose to erect a barrier to break the chain of disease transmission from excreta.

### Extent of the Problem

A rapid investigation of sanitary conditions throughout the world would show how vast and important is the problem of excreta disposal. Even in countries such as Great Britain, France, and the USA, which by world standards may be considered prosperous and healthy, much remains to be done in this field. J. A. Scott<sup>32</sup> states that in Great Britain, where 20% of the population live in rural communities, 23% of households do not have the exclusive use of a water-closet. In France, of 38 000 local authorities (municipal authorities) only 80 have sewage-treatment plants, and fewer than 1500 have any kind of sewerage system or refuse-disposal organization. In the USA, it was conservatively estimated in 1943 that 4 000 000 sanitary privies were needed in rural areas to serve 16 000 000 people, who lacked these fundamental necessities and who, for the most part, resided in areas having the highest incidence of typhoid fever, dysentery, and hookworm.<sup>35</sup>

While similar figures are not available for other areas of the world, sanitary surveys and statistical data collected from a large number of countries give useful indications as to the extent of the problem. In India and Pakistan, faecal-borne diseases rank high among the most important communicable diseases. In the decade between 1940 and 1950 the record shows that 27 438 000 persons died in India from the enteric diseases. The incidence of hookworm was between 40% and 70% of the population, and it was estimated that more than 200 million people were infected. In Ceylon, it was estimated in 1943 by the health department that 70% of the population was infested with hookworm. In rural areas of North China, 81% of the population has been found positive for *Ascaris*, and 76% was estimated to be positive for *Entamoeba histolytica* (amoebiasis).<sup>33</sup> A similar situation prevails in British Honduras, in Central America, where the incidence among village schoolchildren was found to be over 60% for *Ascaris* and 50% for hookworm. Similarly, high incidences of enteric and helminthic diseases have been reported for large populations in countries of the Middle East, South-East Asia, the Western Pacific, Africa, and the Americas by J. C. Scott<sup>33</sup> and by Simmons et al.<sup>34</sup>

In 1951, Dr H. van Zile Hyde<sup>22</sup> wrote :

“ The dire effect of this upon a rural nation was clearly brought home to me by a statement recently made by an American medical observer who stated that the worms

TABLE II. ESTIMATED COST OF TYPHOID FEVER AND OF DIARRHOEA AND ENTERITIS PER 100 000 POPULATION IN CERTAIN COUNTRIES FOR THE YEAR 1949

Country	Income per caput (US \$)	Typhoid fever		Diarrhoea and enteritis		Total deaths	Total cases	Funeral ex- penses <sup>c</sup> (US \$)	Medical care <sup>c</sup> (US \$)	Value of lives lost <sup>c</sup> (US \$)	Value of working time lost <sup>c</sup> (US \$)	Total cost (US \$)
		deaths <sup>a</sup>	cases	deaths <sup>b</sup>	cases							
USA	1 452	0.1	1	5.7	285	5.8	286	1 160	21 450	17 795	14 635	55 040
France	450	2.0	20	21.4	1 070	23.4	1 090	1 450	25 800	28 500	17 250	73 000
Portugal	140	8.6	86	195.2	9 760	203.8	9 846	3 930	72 300	66 800	48 200	191 230
Japan	98	1.3	13	88.0	4 400	89.3	4 413	1 200	22 850	18 500	15 200	57 750
Colombia	200	12.4	124	128.1	6 405	140.5	6 529	3 875	68 900	76 800	46 200	195 775
Ceylon	83	12.0	120	69.5	3 475	81.5	3 595	930	15 700	22 000	10 500	49 130
Dominican Republic	94	13.5	135	118.2	5 910	131.7	6 045	1 700	29 900	35 350	19 950	86 900
India <sup>d</sup>	54	58.6	234	65.8	3 290	124.4	3 524	925	9 840	40 700	6 800	58 265

<sup>a</sup> Typhoid fever mortality rate assumed to be 10%.

<sup>b</sup> Diarrhoea and enteritis mortality rate assumed to be 2%.

<sup>c</sup> Funeral expenses based on \$200 in USA; <sup>19</sup> medical care costs based on \$75 per case in USA; <sup>19</sup> value of lives lost (ages 0-45) from typhoid and paratyphoid fevers estimated at \$15 500 and from diarrhoea and enteritis (ages 0-45) at \$2850 for USA. <sup>19</sup> Working time lost per case assumed to be two weeks, with a value of \$50 in USA. The estimated unit cost of funerals and medical care and the value of lives and working time lost for countries other than the USA were assumed to be in the same ratio to similar costs and values in the USA as the per caput income for those countries to that for the USA.

<sup>d</sup> Mortality rates for typhoid fever and for diarrhoea and enteritis are not available for India. The rates and values listed are those for cholera and for diarrhoea and dysentery.

**TABLE III. ESTIMATED PER CAPUT COST OF RURAL WATER SUPPLIES AND LATRINES AND COST OF TYPHOID FEVER AND OF DIARRHOEA AND ENTERITIS PER 100 000 POPULATION FOR CERTAIN COUNTRIES IN 1949**

Country	Cost per caput of water supplies (US \$) <sup>a</sup>		Cost per caput at latrines (US \$) <sup>a</sup>		Total cost per 100 000 population (US \$)	Cost of typhoid fever and of diarrhoea and enteritis per 100 000 population (US \$)	Approximate number of years required for amortization of water supply and sanitation facilities from savings
	capital cost	main-tenance	capital cost	main-tenance			
USA	17.00	0.55	14.00	5.57	3 730 000	55 720	68
France	5.25	0.17	4.35	1.80	1 157 000	73 000	16
Portugal	1.65	0.05	1.35	0.55	360 000	191 230	2
Japan	1.15	0.04	0.95	0.40	254 000	57 750	5
Colombia	2.35	0.08	1.95	0.80	518 000	195 775	3
Ceylon	0.98	0.03	0.80	0.33	214 000	49 130	4
Dominican Republic	1.10	0.04	0.94	0.38	246 000	86 900	3
India <sup>24</sup>	0.63	0.02	0.52	0.21	138 000	58 265	3

<sup>a</sup> This includes the cost of labour, materials, and equipment. These costs could be reduced considerably by the use of voluntary labour and materials available locally to the householder.

infesting the people of a certain semi-tropical country metabolize more of the produce of that country than do the inhabitants. Half the work of a sick peasantry, therefore, goes into the cultivation of food for the worms that make them sick.”

It should be noted that, in many countries, more than 80% of the population live in rural areas and small communities and, as a general rule, have a low income. In most cases, all the elements of rural sanitation are absent, and indiscriminate fouling of the soil with human excrement is common. Such conditions are also often found in rural areas near towns, and aggravate the urban sanitation problems. The menace of inadequate excreta disposal is present so long as sanitary privies are lacking in a community.

The economic losses resulting from insanitation often reach staggering proportions. Atkins,<sup>a</sup> analysing data available for several countries in 1949, found that infant mortality and mortality from typhoid fever, diarrhoea, and enteritis were in inverse proportion to the income *per caput*. He estimated the cost of these three diseases (see Table II) and the *per caput* cost of rural water-supplies and latrines (see Table III). He concluded that in each of the countries considered, except the USA and France, it would be possible to amortize within a period of five years

<sup>a</sup> Atkins, C. H. (1953) *Some economic aspects of sanitation programmes in rural areas and small communities* (Unpublished working document WHO/Env.San./56)

the cost of rural sanitation facilities from the savings which would accrue from the reductions in typhoid fever, diarrhoea, and enteritis. Other advantages would result from the control and reduction in incidence of cholera, the dysenteries, ascariasis, guinea-worm, hookworm, and other enteric and parasitic diseases. In addition, there would be several indirect benefits, such as the convenience and saving of time which the facilities would offer.

### **Collateral Benefits of Proper Excreta Disposal**

Certain public health programmes, when properly carried out, often yield important side benefits quite apart from those which they were expected to produce. Programmes of excreta disposal belong to this group. An example of this was given by Tisdale & Atkins<sup>35</sup> in 1943 :

“ The sanitary privy has a definite relationship to public health and in this connection the following points are significant :

“ 1. In areas [of the USA] where water carriage sewerage systems are impracticable the privy is the facility relied upon to break the transmission chain of intestinal diseases.

“ 2. Privy construction programs, originally undertaken in the hookworm and typhoid fever regions in the South thirty years ago, contributed substantially to the early development of full-time local health services. At present more than 1,800 counties in the United States have such services.

“ 3. The 3,000,000 sanitary privies constructed under the various work-relief programs have had an important effect in reducing the incidence of intestinal diseases.

“ 4. The close association of U.S. Public Health Service officials with state health departments in rural sanitation campaigns over a period of 30 years has been instrumental in developing the *esprit de corps* which now enables local, state, and federal health services to cope successfully with problems of sanitation, malaria, venereal disease, and industrial hygiene in critical war areas in America today.

“ 5. The fundamental principles of federal-state cooperation, successfully demonstrated in the rural sanitation programs, are now being applied throughout the field of public health. In addition, cooperative plans for public health work among selected population groups have been developed by the Public Health Service with other federal agencies. The Farm Security Administration's health and sanitation program is an example of federal cooperative health work.”

Similar examples may be drawn from the experiences of Scott<sup>33</sup> in China and the World Health Organization in Taiwan, where attempts at solving the excreta disposal problem have been found to be linked with the development of satisfactory composting procedures. In these countries, as well as in Latin America, programmes of excreta disposal have led to the recognition of the need for team-work between the medical officer, the public health engineer, and the public health inspector.

## SOCIAL AND PSYCHOLOGICAL IMPLICATIONS OF RURAL SANITATION PROGRAMMES

### Community Participation

Experience available from all parts of the world leads to the conclusion that a programme of rural sanitation, of which sanitary excreta disposal is an essential part, cannot be successful without the participation of the local community. To be truly effective, environmental sanitation, which is a basic function of every integrated health service, needs the understanding, the support, and the active participation of the people concerned. Mere technical improvement of the environment without public education in hygiene and sanitation, based on local customs, traditions, and beliefs, has again and again proved futile.

One measure of the success of a rural sanitation programme is its power to sustain itself and grow. In order to achieve this success, it is necessary to find ways of gaining popular support and of overcoming popular objection. In both, health education of the public plays a major role. In the former instance, attention must be given to the structure and organization of a programme which will fit into the local social and economic system. More important still is the desirability of bringing the people into the programme as partners. In the pursuit of the second objective, the assistance of a competent health educator may be required. It is very likely that, even before reaching the stage of overcoming popular objection, the sanitarian may have to undertake the task of disturbing the age-old apathy and inertia which grip the people. For example, the fact that a community is without adequate excreta disposal facilities immediately suggests to a health worker the need for providing latrines. However, the community may not be ready for, or interested in, such facilities, or may be even hostile to them. To insist upon the immediate introduction of latrines into a community under such circumstances is not a wise move on the part of the sanitarian, who should always remember that "doing things to people and for people is easier, though in the long run more costly, and less effective, than fostering greater individual and local initiative, responsibility, and self-reliance on a well-informed basis".<sup>a</sup>

This health education stage is admittedly the most difficult in the evolution of a privy scheme. Once it is successfully passed, the programme will move at a faster rate. For example, in the rural areas of several Latin American countries where community health programmes have been

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<sup>a</sup> Martikainen, A. H. (1956) *Co-operation for future progress in health education of the public*. In: *Report of the Third Conference of the International Union of Health Education of the Public*, Rome, vol. 1. (This paper also exists as a WHO unpublished document: WHO/MH/AS 124.56.)

going on for some time, privies are constructed almost exclusively by the families, with the health department supplying the necessary guidance and the concrete privy slab either at cost or gratis. In many places the demand for slabs is always greater than the supply.

Experience shows that the most important factor in getting the community to participate is to bring members from all its segments into the programme as partners. The people must, however, understand what the programme is all about. This may be achieved by working through the village council, if one exists, and if not, through a village committee set up at the planning stage and comprising prominent and respected leaders of the community. Further progress will come from the assimilation and use of scientific excreta disposal principles by the villagers themselves, and this can be realized only if they take part in the survey, planning, and conduct of the programme. One should expect that initial progress will be rather slow and that it may be necessary to plan the programme in successive stages stretched over a period of time.

The relation of health education of the public to the important subject of community participation in rural sanitation programmes has been studied by various authors, in particular by Foster,<sup>14</sup> Derryberry,<sup>8, 9</sup> and Ramakrishna.<sup>a</sup>

In recent years the expression "community development" has come into popular international usage to connote a complex of processes of which the two most important elements are the following :

"The participation by the people themselves in efforts to improve their level of living with as much reliance as possible on their own initiative ; and the provision of technical and other services in ways which encourage initiative, self-help and mutual help and make these more effective." <sup>36</sup>

As stressed earlier, the practical application of these principles is essential for lasting progress in rural sanitation. In addition, field experience shows that a specific local project or activity in sanitation initiated in response to a local demand can serve as a very practical basis for stimulating local interest and participation in attacking other basic problems, and thus act as an important spearhead for the promotion of community development.

### Family Participation

Since one of the ultimate objectives of a sanitation programme in a community is to get the family to solve its own excreta disposal problems (within reason, of course), it is important that each family unit participate

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<sup>a</sup> Ramakrishna, V. (1956) *Role of health education in environmental sanitation programmes* (Unpublished paper prepared for the WHO Seminar on Environmental Sanitation, Beirut, Oct.-Nov. 1956)

in some way in its execution. Whatever the nature of the sanitation needs and related health problems, health workers can gain the interest of people by a sympathetic and practical approach to their problems. People who come to a health centre or dispensary (mobile or stationary) seeking treatment of intestinal disorders are usually receptive to suggestions as to how to avoid dysentery and diarrhoea. Full advantage should be taken of such opportunities to help make the people aware of the measures which can be applied at home and in the community to prevent these conditions. Practical demonstrations and discussions of latrine construction, aided by the use of visual media based on local situations—e.g., photographs, slides, posters, film strips, film exhibits, and others—may be particularly rewarding.

Once the family is willing to participate in the scheme and to learn a new habit, the public health inspector must be ready to offer a solution which is acceptable and as simple and economical as possible. When sanitation and personal hygiene become habits, the health programme will have made tremendous progress.

The sanitation work cannot be considered completed, however, after the construction of the first privy or latrine; in fact, it has just begun. The public health inspectors or public health nurses, as the case may be, must remain continuously in touch with the family to stimulate and educate its members into using and maintaining this facility, which often has been constructed after hard and time-consuming labour. The continued educational process involved requires the co-operation of the whole health department staff, which can consider that success has been achieved only when the family has accepted the privy as a part of its way of life, and is willing to maintain it, to rebuild it, and to move it to a new location, as necessity demands, and even to become a disciple in teaching the neighbours. It will be noted that time and continuity of staff and organization are essential for successful rural sanitation development.

Mention has been made of simple and economical solutions to the family's excreta disposal problems. Finding reasonable solutions is considered to be one of the keys to active family participation. These are not always easy to find. Undoubtedly there are places where nature, aided perhaps by man, makes it very difficult, if not impossible, to devise simple and economical facilities. In these situations, the sanitarian's ingenuity and ability are taxed to the limit. He must be resourceful in making use of available materials and in organizing the people of the community for the difficult tasks at hand. In some instances extra technical and financial assistance may be required from the health department. The family cannot be expected to perform difficult and complicated construction operations. Sanitarians and public health officers should strive to propose and design solutions that are within the means and ability of the people to operate, maintain, and replace. This is true of a simple

family privy, a village well, a public water-supply system, or large water-and sewage-treatment works.

As to actual modes of obtaining family participation, several systems have been tried in different countries with varying degrees of success. The best methods are those in which initial work and expenses are shared by the family and the health authorities or other agencies. Family contribution either may be financial in character or may take the form of labour and materials. Although financial contribution by the villagers, or by the local authorities, is highly desirable, it will be found advantageous in the early stages of a programme to secure the actual participation of the people in the work, which is being executed for their own benefit. People are more likely to put into daily practice those learning experiences in which self-initiative and self-help have played a part. The psychological advantages of self-help are considerable, even if the extent of the self-help is limited to the provision of manpower and locally available material.

In an effort to give proper importance to the construction of privies, use has been made in Latin America, with remarkable success, of simple contracts between the health department and the head of the family. The contracts state in simple, direct terms the obligations of each party, so that no misunderstanding can arise. This impresses on the family the importance which both parties attach to the privy as a vital element in household health. The application of this technique depends on a patient and enthusiastic health department representative, for it takes time to talk to each family and explain over and over the need for a sanitary privy and the benefits which can be derived from its daily use.

Another technique used with success in some countries in South-East Asia consists of "selling" the programme to respected leaders of the community and helping them, first, to install their latrines. The possession of a sanitary latrine thus becomes associated with a position of prestige in the community.

### **Role of the Health Department and Other Agencies**

It is accepted as axiomatic in environmental sanitation that governments should take the initiative both in stimulating action and in providing the essential technical guidance.<sup>44</sup> For excreta disposal programmes the primary responsibility and authority for surveying, planning, organizing, and implementing wide-scale measures obviously rest with the health department. To do this job with any chance of success, however, the health department must secure the understanding, the support, and the participation of the villagers, as previously mentioned. It is also the responsibility of the health department to seek the co-operation of various interested government or private agencies, such as agriculture, education,

and public works departments, or large plantation estates, and to co-ordinate their activities in this field in order to ensure proper integration of their activities into the general health and community development programme planned for the area concerned.

When excreta disposal programmes are contemplated for the first time in a community, the health department should be prepared to spend more than the mere cost of required staff. The sum to be spent need not be large but will make it possible for the department to win the co-operation of individual families for the construction of the initial facilities. Experience shows that, if the health department does not enter into the programme with adequate funds, it may take many years to get to a point of complete community participation. On the other hand, by giving the sanitation work a good start in the form of partial financial assistance, the time can be greatly reduced. The funds spent in this manner will pay great dividends in the future. With money to buy materials, especially the types of materials unavailable locally, the public health inspector is in a position to offer something concrete, beside technical advice, to the family. He may then say: "If you will provide the labour for your privy, I will provide materials." Or he may offer part of the labour and part of the materials.

The health department is also responsible for organizing demonstration or pilot schemes of excreta disposal. Such demonstrations should be carried out first in health and welfare centres, in schools, and in residences of local health and sanitation officials. A demonstration plot of land suitably located and provided with sanitary excreta disposal units in various stages of completion is a desirable item in a planned sanitation improvement and training programme. The health department should also prepare and make available to the people and their leaders leaflets and manuals covering the design, construction, and operation of excreta disposal facilities that fit the conditions encountered in the areas concerned.

"Wherever bad construction, poor ventilation and lighting, lack of washing facilities, insanitary toilets, or similar deficiencies exist [in schools], children will be absorbing wrong ideas and learning harmful habits which may never be eradicated . . . Similarly, a well-built and well-kept latrine may be far safer as well as of greater fundamental education value than a porcelain and tile toilet which is allowed to become dirty and a nuisance." <sup>45</sup>

Mere classroom teaching of sanitation, unaccompanied by actual demonstration, will have little—if any—effect on children; but this is, unfortunately, common in many parts of the world. It is well known that children learn by doing and through example, two facts which can be used to advantage in leading schoolchildren into the practice of a sanitary way of living. It goes without saying that health workers should lead the way and give the proper example to the people by living and working in sanitary surroundings.

Under certain circumstances which require the use of community-controlled latrine construction services, the role of the health department may assume increased scope and importance. Such situations would arise, for example, in areas where crowding of houses or hard ground conditions make it necessary to put in some kind of collective sanitation facility, deep-bored holes inside houses, precast hand-flush installations in houses, or other types of excreta disposal systems which, because of physical circumstances, cannot be erected by the families themselves. In these cases a government, through its health department, may need to set up and maintain an efficient organization to carry out excreta disposal construction work. Here also the active participation and contribution of the local populations in the form of labour, materials, and money are absolutely required for the ultimate success of the excreta disposal programme. The people should never be led to rely entirely on the health department for the provision, maintenance, or renewal of their sanitary facilities, even when these must be built for them for special reasons, as explained above. An alternative solution which may sometimes be used involves the formation of construction co-operatives or health leagues by the people themselves under the sponsorship of the health department, which may supply financial and material assistance in addition to providing technical guidance.

### **Campaigns**

In order to achieve efficiency and rapidity of execution, it is often tempting to carry out latrine construction work on the basis of campaigns. This method has a definite place in health programmes, and experience has shown that it can be successful under certain conditions. Campaigns will prove useful, however, only when there is good follow-up and continued health education and sanitary inspection. Under these conditions, the health department still has an opportunity to convince the families of the worth of the latrine and to persuade them to maintain it and replace it when the need arises.

In areas where there is a lack of organized community services in addition to a low economic level, there will be no follow-up inspection or health education, and the programme is likely to be a complete failure. It is uneconomical to spend money on latrine campaigns under such conditions, for rarely do the people use the privies in sufficient numbers, and even more rarely do they maintain or replace them. It has been reported, for example, that even where public acceptance of privy campaigns in areas of Latin America has been good, the privies have frequently been used as chicken-coops or grain silos. Experience after experience can be recounted in which a great deal of money and effort was expended only to have the situation return to its original unhygienic status after a rela-

tively short time because of the lack of continued health education and inspection by a well-organized and integrated sanitation service of a health organization.

One important aspect of latrine campaigns is the community interest and attention that are focused on the excreta disposal problem. Parallel situations exist in connexion with other health campaigns, such as malaria control and yaws campaigns. If advantage can be taken of this interest and if an adequate and permanent follow-up organization can be set up, the campaign technique can be a very successful method of getting latrines built and used. Under most conditions, however, the education and family participation method, although slow, is best.

### **Public Versus Individual Latrines**

Public latrines, or "multiple units" types, are usually constructed in markets, camps, schools, factories, slum districts, and similar localities. They are also useful in other places where large numbers of persons congregate occasionally, provided that permanent and close attention is available to ensure cleanliness and proper operation.

Experience in all parts of the world indicates that, except in unusual circumstances, multiple units should never be substituted for the individual family latrine. True, it is cheaper and less troublesome to construct a few communal latrines in a community than to build a large number of individual latrines at the rate of one unit per family. In addition, a good solution to each family's excreta disposal problem is not always easy to find. For such reasons the construction of the communal type of excreta disposal facility was accepted in the past, even in urban communities. However, it was discovered after a few years' use that these public latrines were employed by only a portion of the population for which they were intended, the remaining group continuing the original practice of defaecating anywhere. It was then believed that two reasons for this situation were inadequate design and the lack of cleanliness. Attempts were made to improve these elements; but, in most instances, communal latrines, irrespective of the type of design, proved to be failures.

It should be pointed out that the community is generally made responsible for the maintenance of public units. Usually communal administrations are notoriously poor and ineffective at maintaining even the utilities that offer great convenience, such as water works and electric light systems, let alone a communal privy which many do not consider essential in any case. This does not mean that the construction of public latrines should be disregarded; but one should be warned against their limitations and the illusion that they will be automatically and efficiently maintained by the community. The truth is that the communal authorities

must be prodded on this important matter of maintenance as much as, or more than, the family. So long as the effort to ensure good maintenance must be made, it is decidedly better to spend it on the family, on whom there is hope of its eventually having the desired effect. Families will usually keep their own latrines clean and in proper operation with only occasional guidance from the public health inspector.

Public latrines, therefore, should be built only where absolutely necessary and should be designed to facilitate maintenance and constructed for permanence, as far as possible. They must be kept clean at all times, for, unless cleanliness is observed, they will not be used. Water and other materials must be available for use in keeping the latrines clean.

Since the objective of this monograph is the promotion of rural excreta disposal by the individual family, no attempt will be made to describe types of public latrines or urinals which are usually associated with them.

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# THE PRIVY METHOD OF EXCRETA DISPOSAL

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## FACTORS INFLUENCING PRIVY DESIGN

A rational approach to the problem of collecting and disposing of human excreta in rural areas assumes that the engineering aspects, while not as extensive as those associated with urban engineering schemes, still require the same careful marshalling of facts and application of painstaking analyses for their solution. There are several factors which influence the choice and the design of a system applicable to a particular community. Some are biological in character ; others are of an engineering nature ; and still others, which are of no less importance, involve careful consideration of human behaviour.

## Decomposition of Excreta

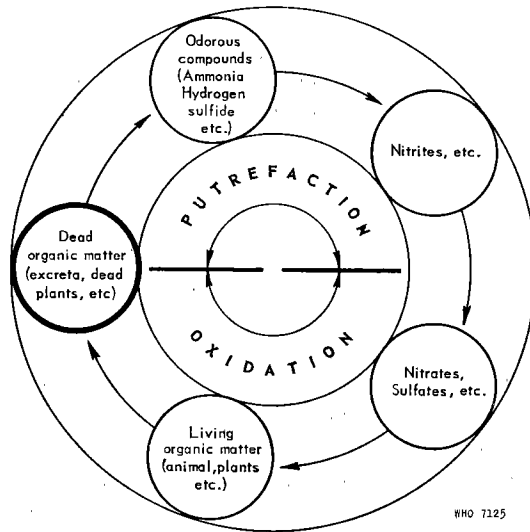
Excreta, wherever deposited, immediately start to decompose, and are ultimately converted to an inodorous, inoffensive, and stable product. In the design of excreta disposal facilities it is important for the health worker to know and understand how this process takes place and how it affects the material itself and the harmful organisms such material may contain. The sanitarian, in particular, is often called upon to explain in simple terms what actually happens to faeces and the health hazards involved in inadequate disposal systems.

The main actions of decomposition are to break down the complex organic compounds, such as proteins and urea, into simpler and more stable forms ; to reduce the volume and mass (sometimes as much as 80 %) of the decomposing material by the production of such gases as methane, carbon dioxide, ammonia, and nitrogen, which are dissipated into the atmosphere, and by the production of soluble materials which, under some circumstances, leach away into the underlying soil ; and to destroy pathogenic organisms which in some instances are unable to survive the processes of decomposition or attack by the rich biological life of the decomposing mass.

Bacteria play the major role in decomposition ; and bacterial action may either be aerobic—i.e., carried out in the presence of air—or anaerobic

—i.e., carried out in the absence of oxygen, generally in a fluid or saturated environment. The process may be entirely anaerobic, as it is in aqua privies, septic tanks, or at the bottom of deep pits, or entirely aerobic, as it is in certain composting operations. On the other hand, decomposition may consist of more than one stage, some anaerobic and some aerobic, depending upon the physical conditions encountered. For example, anaerobic processes may take place in a septic tank; but, as the liquid effluent is discharged into an underground tile distribution system, the water drains away, leaving much organic matter in the upper layers of the soil to be decomposed by aerobic saprophytic bacteria, which thrive in the top 60 cm of the soil.

FIG. 3. CYCLE OF NITROGEN



The process of decomposition applies to all dead organic matter of vegetable or animal origin, and particularly to their nitrogenous, sulphurous, or carbonaceous constituents. In the case of human wastes, a mixture of faeces and urine, which are relatively rich in nitrogenous compounds, the decomposition process is typically represented by the nitrogen cycle, which is shown in Fig. 3. In this cycle compounds are broken down first into ammonia and other simple products, and are then converted by nitrifying bacteria into nitrites and nitrates. The strong smell noted during the decomposition of urine is due to ammonia, which escapes before it has been converted into a more stable form. Decomposition may proceed very rapidly, the period varying from a few days in the case

of very carefully controlled mechanical composting to several months, perhaps up to nearly a year, under average conditions in a pit privy.

Conditions prevailing in decomposing faeces are generally unfavourable to the survival of pathogenic organisms. Not only do the temperature and moisture conditions inhibit the growth of pathogens, but also the competing bacterial flora and protozoa are predatory and destructive. Pathogens tend to die quickly when the humus-like end product of decomposition is spread out and dries. The bacterial pathogens probably do not survive more than two months in undisturbed privy contents. The ova of hookworm will remain viable for much longer periods, depending on moisture and air temperature : they may live up to five months in cool climates, much less long under tropical conditions. They will eventually hatch in the presence of air, and will produce larvae which may survive for several weeks in moist, sandy soils. *Ascaris* ova may live for two or three months in pit-privy material.

The final products of decomposition contain valuable soil nutrients and may profitably be used as fertilizers. Sometimes farmers complain of the small nitrogenous content of digested or composted night-soil. Indeed, fresh excreta do contain more nitrogenous matter which, however, cannot be used by plants in their original composition. Plants can utilize nitrogen only as ammonia or as nitrites or nitrates, which are only produced during later stages of decomposition. When raw excreta are spread on the land, much of the nitrogen is transformed into volatile matter, which evaporates into the air instead of being used by plants.

### Quantities of Human Faeces

The public health engineer or inspector is interested in the amount of the raw material which must be processed. Most studies on quantities of human waste have been made chiefly on a physiological basis and have given some information on the ranges and mean values of the quantities of excreta produced by individuals. A small amount of information based on actual field observations is also available but is of varying reliability. It is recognized that the quantities of human excreta produced may be influenced by local conditions, not only physiological, but also cultural and religious. An example may be the use of ablution water or other personal cleansing materials.

A review of published data shows that in Asia the amount of faeces is about 200-400 g (7-14 oz.) per person per day (wet weight), as compared to 100-150 g (3.5-5.3 oz.) per day for European and American countries. In North America a figure for pit-privy design is based on 1.5 cu. ft (42.4 l) per person per year where urine may leach away, and a figure of 19.5 cu. ft (552 l) per person per year for water-tight containers such as the vault

privy. In India, according to the *Manual of hygiene for the armed forces, 1953*,<sup>25</sup> the amount per person per day is 400 g (14 oz.) for faeces and 2300 g (81 oz.) for urine and cleansing water. According to O. J. S. MacDonald,<sup>19</sup> in the tropics faeces will range from 280 g to 530 g (10-19 oz.) per person per day, and urine, depending upon temperature and humidity, from 600 g to 1130 g (1.3-2.5 lb.).

H. B. Gotaas,<sup>18</sup> in a worldwide summary, gives the following data collected from various sources :

	Grams/person/day	
	wet weight	dry weight
Faeces . . . . .	135-270	35-70
Urine . . . . .	1000-1300	50-70
Total . . . . .	1135-1570	85-140

A study in the Philippines indicated an average production of 665 g (1.5 lb.) of total excreta per person per day. It was noted that probably only a fraction of the urine was included in this figure.

It has been recommended that controlled observations be made in each country or portion of a country where there is reason to believe that deviation from the established norm may occur. These observations should be of such duration as to allow the measurement of possible seasonal variations, should include an adequate sample, and should be carried on under the direction of a responsible officer.

The available data being admittedly meagre, it has been suggested for design purposes that for total excreta the figure of 1 kg (2.2 lb.) (wet weight) per person per day should be used.

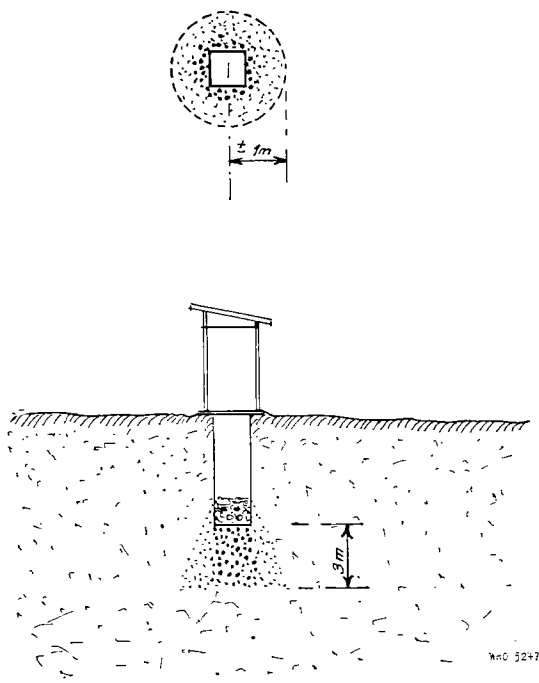
### Soil and Ground-Water Pollution

The study of methods of pollution of the soil and water by excreta also provides useful information concerning the design of disposal facilities, especially their location with respect to sources of drinking-water supplies. After excreta are deposited on the ground or in pits, the bacteria, unable to move much by themselves, may be transported horizontally and downward into the ground by leaching liquids or urine, or by rain water. The distance of travel of bacteria in this way varies with several factors, the most important of which is the porosity of the soil (see Fig. 4, 5, 6). Their horizontal travel through soil in this manner is usually less than 90 cm (3 ft) and the downward travel less than 3 m (10 ft) in pits open to heavy rains, and not more than 60 cm (2 ft) normally in porous soils.<sup>27</sup>

Gotaas and his co-workers,<sup>6</sup> studying the artificial recharge of aquifers with reclaimed sewage and other waste waters in the State of California,

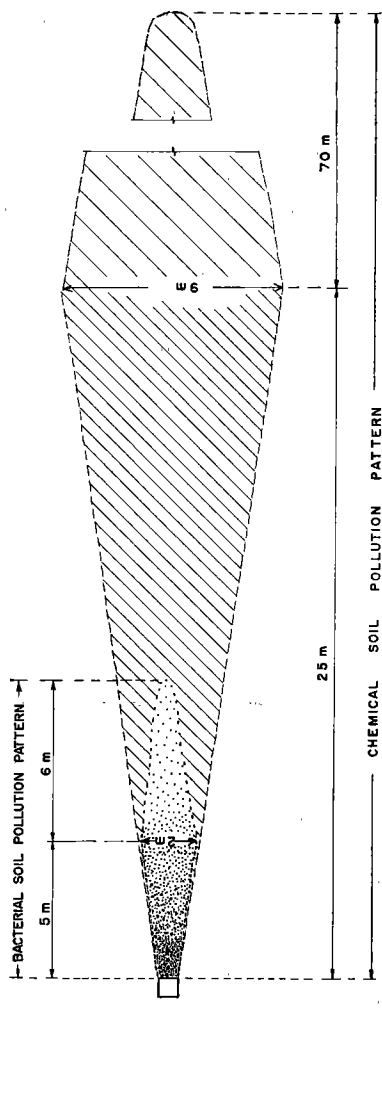
USA, found that bacteria were transported to a distance of up to 30 m (100 ft) from the recharge well in 33 hours, and that there was a rapid regression of bacterial count over this distance due to effective filtration and to bacterial die-off. They also found that chemical pollution travelled twice as fast. Recently, other workers,<sup>15</sup> studying ground-water pollution in Alaska, noted that bacteria were traced to a distance of 15 m (50 ft) from the dosing well into which test bacteria were introduced. The width of the path of bacterial travel varied between 45 cm and 120 cm (1.5 ft and 4 ft). Regression then took place and, after a year, only the dosing well remained positive for the test organism. These investigations confirm the findings of other workers<sup>27</sup> to the effect that the contamination from excreta disposal systems tends to travel downward until it reaches the water table, then moves along with the ground-water flow across a path which increases in width to a limited extent before gradual disappearance.

FIG. 4. MOVEMENT OF POLLUTION IN DRY SOIL



In dry soil there is relatively little migration of chemical and bacterial substances. Laterally there is practically no movement; and with excessive washing (not common in privies or septic tanks) the vertical penetration is only about 3 m (10 ft). Where the contamination does not enter the ground water, there is practically no danger of contaminating water supplies.

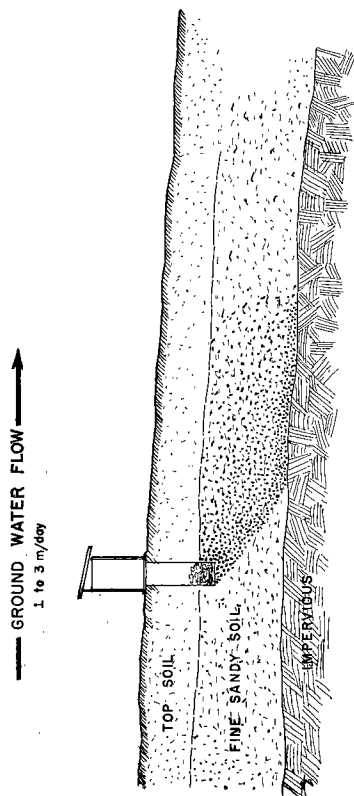
FIG. 5. BACTERIAL AND CHEMICAL SOIL POLLUTION PATTERNS AND MAXIMUM MIGRATIONS \*



The source of contamination in these studies was human excreta placed in a hole which penetrated the ground-water table. Samples positive for coliform organisms were picked up quite soon between 4 m and 6 m (13 ft and 19 ft) from the source of contamination. The area of contamination widened out to a width of approximately 2 m (7 ft) at a point about 5 m (16 ft) from the privy and tapered off at about 11 m (36 ft). Contamination did not move "upstream" or against the direction of flow of the ground water. After a few months the soil around the privy became clogged, and positive samples could be picked up at only 2 m to 3 m (7 ft to 10 ft) from the pit. In other words, the area of soil contamination had shrunk.

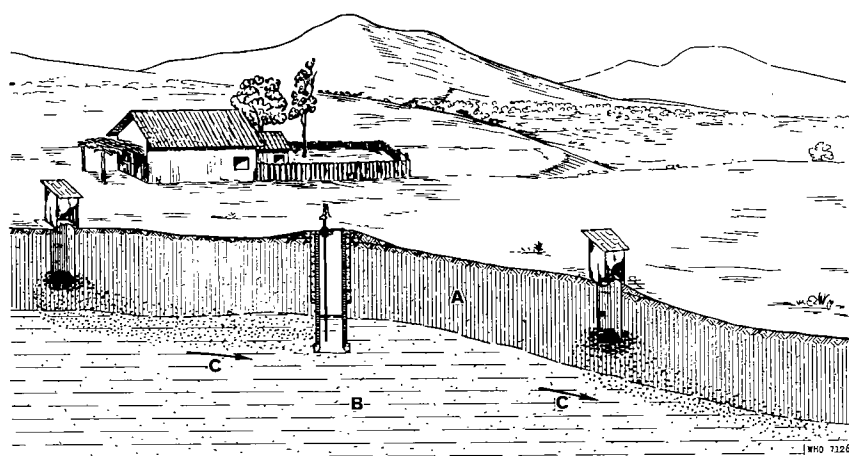
The chemical pollution pattern is similar in shape to that of bacterial pollution but extends to much greater distances.

From the point of view of sanitation, the interest is in the maximum migrations and the fact that the direction of migration is always that of the flow of ground water. In locating wells, it must be remembered that the water within the circle of influence of the well flows towards the well. No part of the area of chemical or bacterial contamination may be within reach of the circle of influence of the well.



\* Based on data from Caldwell & Parr <sup>4</sup>, <sup>5</sup> and Dyer, Bhaskaran & Sekar <sup>10</sup>, <sup>11</sup>

FIG. 6. MOVEMENT OF POLLUTION IN UNDERGROUND WATER



A = Top soil

B = Water-bearing formation

C = Direction of ground-water flow

In the Netherlands, Baars<sup>2</sup> found that, unless accompanied by a considerable amount of water, bacterial contamination did not travel more than 7.5 m (25 ft) through fine sand.

On the surface of the ground, only the earth immediately surrounding the faeces is likely to be contaminated, unless it is carried further by surface water such as rain and irrigation water, blown away by the wind, or picked up by the hair and feet of flies or other insects and animals. It has been observed in pit latrines, however, that hookworm larvae, although unable to move sideways to any appreciable extent, are likely to climb upwards along the pit walls and reach the top surface of defective wooden or earthen floors, where they lie in wait for a person with bare feet.

Depending upon conditions of humidity and temperature, pathogenic bacteria and ova of parasitic worms will survive varying lengths of time in the ground. Pathogenic bacteria do not usually find in the soil a suitable environment for their multiplication, and will die within a few days. On the other hand, hookworm eggs will survive as many as five months in wet, sandy soil, and three months in sewage. Hookworm disease is transmitted through contact of the skin, usually bare feet, with soil containing hookworm larvae. Other parasitic diseases are also transmitted when fresh faeces or sewage is used, during the growing season, to fertilize vegetable crops which are eaten raw.

If ground water is located near a source of infection within the distances mentioned above, it may become contaminated by harmful bacteria and by putrid chemical substances originating in faecal decomposition. A

source of infection may be some excreta deposited on the ground near by, a pit latrine, a cesspool, or a leaky sewer or sewage disposal pipe. The contaminated ground-water, which is usually shallow, may be tapped by a well used for drinking-water and other domestic purposes and may lead to further human infection and diseases such as diarrhoeas, typhoid and paratyphoid fevers, cholera, and the dysenteries.

The effects of proximity of wells to latrines and the travel of faecal pollution through ground water have been investigated by various scientists. The studies of Caldwell & Parr<sup>4, 5</sup> and of Dyer, Bhaskaran & Sekar<sup>10, 11</sup> are classics which should be studied by all interested public health workers.

### **Location of Latrines and Other Excreta Disposal Facilities**

Regarding the location of latrines with respect to sources of water supply, the following conclusions may be drawn from up-to-date information.

1. There can be no arbitrary rule governing the distance that is necessary for safety between a privy and a source of water supply. Many factors, such as slope and level of ground water and soil-permeability, affect the removal of bacteria in ground water. It is of the greatest importance to locate the privy or cesspool downhill, or at least on some level piece of land, and to avoid, if possible, placing it directly uphill from a well. Where uphill locations cannot be avoided, a distance of 15 m (50 ft) will prevent bacterial pollution of the well. Setting the privy off to either the right or the left would considerably lessen the possibility of contaminating the ground water reaching the well. In sandy soil a privy may be located as close as 7.5 m (25 ft) from a properly constructed household well if it is impossible to place it at a greater distance. In the case of a higher-yielding well, not less than 15 m (50 ft) should separate the well from a latrine.

2. In homogeneous soils the chance of ground-water pollution is virtually nil if the bottom of a latrine is more than 1.5 m (5 ft) above the ground-water table. The same may be said if the bottom of a cesspool is more than 3 m (10 ft) above the level of the ground water.

3. A careful investigation should be made before building pit privies, bored-hole latrines, cesspools, and seepage pits in areas containing fissured rocks or limestone formations, since pollution may be carried directly through solution channels and without natural filtration to distant wells or other sources of drinking-water supplies.

Regarding the location of latrines with respect to dwellings, experience shows that the distance between the two is an important consideration in the acceptability of the sanitary facilities. The location of latrines,

private or communal, at a considerable distance or away and uphill from dwellings has been observed to mitigate against their regular use and proper maintenance. A latrine will more likely be kept clean if it is close to the house or other building which it serves. Fig. 7 gives an example of proper location of latrines with respect to wells and dwellings.

FIG. 7. WELL AND PRIVY LOCATION IN A RURAL COMMUNITY



Other considerations are as follows :

1. The site should be dry, well drained, and above flood level.
2. The immediate surroundings of the latrine—i.e., an area 2 m (6.5 ft) wide around the structure—should be cleared of all vegetation, wastes, and other debris. This recommendation may be ignored, however, in the initial stages of sanitary development of rural areas where it is necessary, for example, in order to secure acceptability of the latrine by the local population, to avoid disturbing the natural bush-type surroundings which were previously used for defaecation.

### Fly Breeding in Excreta

The role of flies in the transmission of faecal-borne diseases has already been mentioned. The common housefly lays its eggs preferably in horse and stable manure, but will also do so in exposed human excrement and any other decaying organic matter. It crawls and feeds on this material, picking up filth and live organisms on its hairy body, as well as bacteria which pass unharmed through its alimentary tract and are often deposited later on human food. Besides the housefly, various other flies (bluebottle fly, greenbottle fly) may also breed in human excrement and decaying matter. In temperate climates, excreta-borne diseases are usually more

prevalent during the warmer months when flies are most numerous and most active.

In designing a latrine, attention must be paid to means of preventing fly breeding. In so doing advantage may be taken of the fact that flies have a positive phototropism and, therefore, are attracted by light and shun darkness and dark surfaces. The best latrine is one in which the excreta are promptly flushed away into a closed pit or tank underground. Other types of latrine would also be effective in this respect if all openings leading to the excreta, including the seat, were kept clean and closed when not in actual use. This is not usually the case.

Attempts have been made to attract and trap flies which have hatched in latrine pits. These attempts have apparently not been successful, as the mechanisms involved (inverted glass bottle, perforated cans, or others) do not seem to last or stay in place very long.

Disinfectants are of little use in pit latrines because they are quickly neutralized by the organic matter. They also have the disadvantage of interfering with bacterial decomposition and reduction of excreta.

Certain inorganic chemicals may be added to latrines as larvicides to control fly breeding—namely, sodium fluosilicate, sodium arsenite, or borax (sodium tetraborate). A 2.5-cm (1-in.) surface layer of 10% borax in each latrine has proved highly effective in India.

Among the organic chemicals, either PDB (paradichlorobenzene) or ODB (orthodichlorobenzene) has proved an effective larvicide and ovicide; the latter is used in home latrines in Japan. The use of aldrin, dieldrin, chlordane, BHC, or DDT in faecal matter leads rapidly to the development of resistance to these chlorinated hydrocarbon insecticides by the larval and adult houseflies. Spraying of inside walls of latrine superstructures with aldrin and dieldrin has been found to increase housefly production by as much as fifty times.<sup>26</sup>

### Hole Covers

The subject of a cover for a hole or seat is an interesting but controversial point in the design of latrines. There is no doubt that a cover is desirable, and in some places necessary, to prevent ingress of flies and other vermin and, also, to reduce odours. However, in all the literature on public health subjects, and on excreta disposal in particular, no case has been reported where covers have been successfully used and kept in place over a period of months or years. Even in countries, such as the USA, where people in general are highly conscious of sanitation, the problem of seat covers has not been solved.

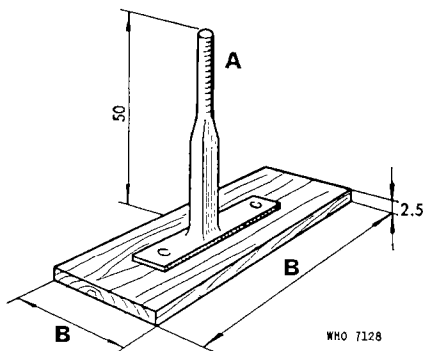
Self-closing covers have not been successful because the condensation which takes place on the under-side of a closed seat is objectionable to the users. Covers that are hinged to the slab or riser are usually left in the

open position. Covers not hinged to the slab are seldom replaced on the hole and are soon carried away by children. Hinges of even the most rugged design soon become broken. More complicated types of cover have been tried, the principle being that the door of the privy will not open to let the user out if the cover is not closed. This type has failed because it is too complicated for the people and discourages them from using the privy, or they soon learn to get rid of the cover in some way.

In view of the above, the drawings in this document do not include seat or hole covers, except for Fig. 8, which shows a simple type of cover. This problem is left to each health department to weigh and try to solve in the light of the local situation. In the Amazon Valley of Brazil some 20 000 installations have been constructed ; and, because the fly population is not too great, no attempt has been made to put hole covers on the squat type of privy slabs. But where there are many flies, some attempt should be made to cover the holes and prevent the flies entering and breeding in the pits.

The successful use of hole covers will probably result only from a long and concentrated educational programme.

FIG. 8. SIMPLE HOLE COVER



- A = Long handle is a special feature. Top part is likely to remain clean.  
 B = Width and length to suit size and shape of hole, which will be covered, not plugged.

### Engineering Factors

The selection, design, location, and construction of excreta disposal installations require the application of some engineering knowledge. Such knowledge may assume major importance in certain areas because of peculiar physical factors and difficulties. The nature of ground formations is often the governing factor in the selection of a type of installation. In areas containing rocks, boulders, or fissured limestone and, also, where ground water is high or caving of pits occurs, the public health officer and the sanitarian may require the assistance of the engineer to find adequate and economical solutions to these engineering problems.

The selection and proper use of local materials are also of engineering significance in the construction and cost of privies on a mass scale. The use of bamboo for pit curbing and for the reinforcement of concrete

slabs<sup>17</sup> and the use of sand-stabilized earth<sup>a</sup> are examples in point. In every area it is desirable that field research and experiments be carried out to discover the best possible use of cheap, locally available materials. Finally, the selection of design features which can be handled by local labour is an important engineering consideration. Local skills should be utilized to the greatest possible extent. It is fairly obvious that, if the type of installation selected cannot be built by the villagers themselves, the privy scheme will be limited to the construction of a very few installations by imported labour.

This brief outline of the engineering problems which are likely to be faced by most health departments in the execution of large-scale privy campaigns and other sanitary installations points to the need to have a few full-time public health engineers on the health department staff. These engineers may be detailed from the centre as required to assist rural health units in solving such problems.

### Human Factors

In all matters of excreta disposal, human factors are as important as technical features. People, especially inhabitants of rural areas, will not use a latrine of a type which they dislike, or which does not afford adequate privacy or, finally, which cannot be kept clean.

Regarding the type of latrine which should be selected, the preliminary sanitation and sociological survey will indicate the types of facilities, if any, in use in the area. The first step in design will therefore be to try to improve the existing system, retaining as many as possible of its "sociological" features. Two examples may be cited to illustrate this important point. Water-flush-type latrines with risers and seats, though best from the sanitary standpoint, have not normally been found acceptable by people who are used to defaecating in the bush in a squatting position. In another instance, people readily accepted pit privies which were built within a thatch and bamboo enclosure without a roof, as they preferred to squat in the open air. Everywhere in the world people have certain taboos with respect to the collection and disposal of human faeces. While it is impossible in one document or textbook to study them all, the health worker should pay much attention to them and should avail himself at all times of the assistance of experienced health educators, social anthropologists, or sociologists to discover the right approach to the solution of the excreta disposal problem of rural communities.

The next important human factors to be considered are the matters of privacy and of separation of the facilities provided for men and for

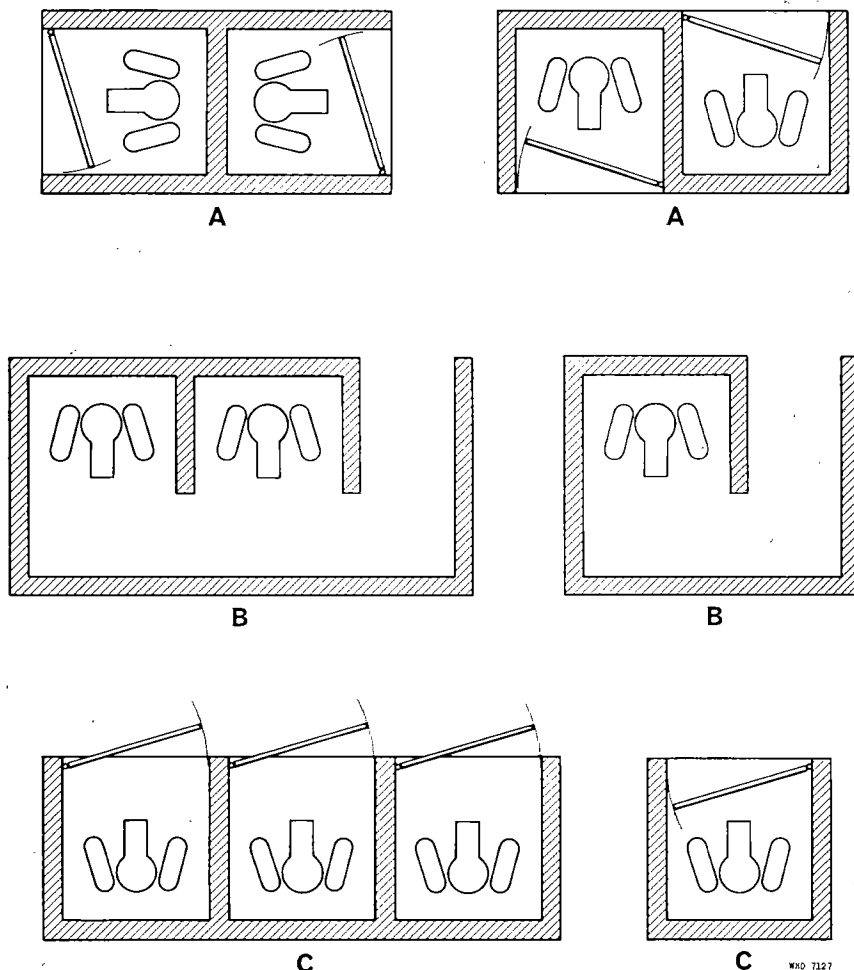
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<sup>a</sup> Youssef, M. S. (1953) *Suggestions for improving building materials used by Egyptian farmers* (Unpublished paper prepared for the Egyptian Government)

women. Various systems have been designed to provide privacy; they are shown in Fig. 9, together with those for separating the sexes. It will be noted that latrine doors should preferably open inwards.

A latrine, whether of the family or communal type, the design of which does not allow easy cleaning will also not be acceptable to most people.

FIG. 9. PRIVY DESIGNS ENSURING PRIVACY AND SEPARATION OF THE SEXES



A = These two layouts ensure complete separation of the sexes.

B = Semi-private installation. Snail-type entrance. Defaecation may take place in corridor passage when latrine floor is dirty.

C = Preferred types, ensuring complete privacy.

In this respect, smooth, hard-surface floors of concrete, cement, brick, or similar material are best because it is easy to flush them with water.

A latrine which is designed for too large a number of people will probably get dirty quickly and remain so, with the result that late callers will prefer to go and defaecate around the latrine building or in a neighbouring bush. A one-hole latrine is adequate for a family of five or six persons. For communal latrines in camps, markets, and similar places, one hole should be provided for every 15 persons; and in schools, one hole for every 15 girls and one hole plus a urinal for every 25 boys.

### **Cost Factors**

As pointed out before, the type of latrine to be recommended to a community or to a family should be simple, acceptable, and economical to build, to maintain, and to replace when the need arises. While there are simple and acceptable types of latrines fulfilling the three conditions mentioned, there are none which are at the same time cheap to build, to maintain, and to replace. Oddly enough, the systems which are most expensive to build (water-flush latrines) are the cheapest in the long run, because of their long life, and are the easiest and most economical from the maintenance standpoint.

General experience reveals one very important fact: in selecting or designing a type of latrine, cost should not be the dominant factor. It is necessary to strike a middle way after careful consideration of all the elements involved, giving preference to those factors which are conducive to a sanitary environment and to acceptability by the family.

## **EVALUATION AND SELECTION OF VARIOUS EXCRETA DISPOSAL SYSTEMS**

### **Criteria for Selection**

The problems of selecting a type of sanitary installation for a particular rural community are manifold and without a clear and simple answer. It has become evident that, in planning a permanent solution to an excreta disposal problem, many inter-related factors must be considered, among them cultural patterns, religious customs, climatological and geological conditions, economic standards, political and social organization of rural communities, general and health education, skills of local populations, and the availability of construction materials and personnel for technical supervision. What originally may appear on the surface to be a simple

problem has often, upon more careful examination, been found to be a relatively complex one.

The selection of the type of installation best suited to local needs must take into account the element of cost. Water-carried sewerage systems with flush toilets are very expensive and far beyond the economic possibilities of most rural areas. At the other extreme, it is possible for everyone to relieve himself in the most primitive manner at no cost whatsoever; but this method is disastrous in terms of sickness and death and resulting economic loss. Therefore, between these two extremes a solution should be found that will give the most in health protection and, at the same time, will be within the economic possibilities of the people to construct and maintain. Every sanitation worker should carefully consider this aspect of the problem, not only as it applies to privies, but also as it relates to every other type of sanitary improvement. The health department, through its staff, should assist each family in finding the proper solution, by painstaking efforts where necessary. Of course, it is relatively easy to decide on a privy campaign for a rural area from a health department office situated far away in the state or provincial capital simply by choosing a design that appears to be satisfactory because it has been used somewhere in the world. This is the kind of privy programme which has resulted in empty, abandoned, and unused installations in so many places.

As might be expected, a review of the literature reveals that a great variety of excreta disposal methods are in use in the world. Latrine characteristics are often very different. However, from a purely technical standpoint, it is generally agreed that a latrine or other disposal method should satisfy the following seven requirements (adapted from Ehlers & Steel<sup>12</sup>):

1. The surface soil should not be contaminated.
2. There should be no contamination of ground water that may enter springs or wells.
3. There should be no contamination of surface water.
4. Excreta should not be accessible to flies or animals.
5. There should be no handling of fresh excreta; or, when this is indispensable, it should be kept to a strict minimum.
6. There should be freedom from odours or unsightly conditions.
7. The method used should be simple and inexpensive in construction and operation.

### **Main Types of Installation**

The two types of installation which come closest to fulfilling the above seven requirements are the pit privy and the aqua privy.

The pit privy is used almost exclusively throughout the Western hemisphere and Europe and is common in parts of Africa and the Middle East. With a minimum of attention to location and construction, there will be no soil pollution and no surface- or ground-water contamination. The excreta will not be accessible to flies if the hole is kept covered; but, even when the hole is left open, the fly problem will not be very great since flies are not attracted to dark holes and surfaces. A good superstructure helps to keep the sun's rays and light from shining into the pit. There is no handling of the material. Odours are negligible, and faeces are normally out of sight. The pit privy is simple in design and easy to use, and does not require operation. Its life span will vary from five to fifteen years, depending upon the capacity of the pit and the use and abuse to which it is put. Its chief advantage is that it can be built cheaply, in any part of the world, by the family with little or no outside help and from locally available materials. It has few disadvantages, and it can play a major role in the prevention of filth-borne diseases.

The aqua privy is a modification of the "septic privy", which originated in the USA about fifty years ago. It is being used in increasing numbers in countries in Africa, the Middle East, and South-East Asia. If the tank is water-tight, the soil as well as the surface- and ground-water cannot be contaminated. Flies are not attracted to the tank's contents, and there are no odours or unsightly conditions. It may be located close to the house. Faeces and sludge, together with stones, sticks, rags, and other debris which may be thrown in, accumulate in the tank and must, of course, be removed at intervals. If the tank's capacity is sufficient, however, handling of its contents can be kept to a minimum. The aqua privy requires daily additions of water to keep it operating properly. The small amount of water needed is normally supplied by the water used for anal cleansing and for cleaning the slab and the drop pipe or funnel. This privy needs a little maintenance, but it is a permanent type of installation. It is more expensive to construct than the pit privy.

Mention may be made here of the water-seal slab which gives its name to a latrine called "water-seal" or sometimes "pour flush" latrine. In actual fact, it is not a separate type of excreta-disposal installation but is rather an interesting modification of the usual latrine slab or floor. The water-seal slab may be installed over a pit (such as that of a pit privy) or a water tank (such as that of an aqua privy). With proper operation and maintenance, the water seal will keep both flies and odours away. For this reason it may be installed advantageously as a part of the dwelling, preferably near the back of the house and with an outside entrance. It is obvious that its small trap will not withstand abuse. The water-seal slab is extensively used in the South-East Asia region, where anal cleansing with water is widely practised.

### Less Desirable Types of Installation

The bored-hole latrine is a variation of the pit privy. The pit is smaller in cross-section but deeper. Its capacity, however, is much less than that of the usual pit privy, and this results in a shorter useful life. Because of its depth—as much as 6 m (20 ft)—the pit often penetrates the ground water, which it contaminates easily. There is no soil or surface-water pollution, however; and no handling of excreta is involved. The fly hazard is increased because of the chances of pollution of the upper walls of the hole, immediately below the opening. Caving of the pit's walls often constitutes a serious disadvantage. It is cheap and easy to construct when the necessary tools are available. It is widely used in many parts of the world, especially in the Middle East and in South-East Asia.

The bucket latrine, or box-and-can privy, has been extensively used in the past in Europe, the Americas, and Australia; it is still used in many countries of Africa, South-East Asia, and the Western Pacific. Its use is decreasing, however, even in these areas. Although, theoretically and under unusually efficient control, it should be possible to devise and operate a bucket-latrine system in a hygienic manner, experience everywhere shows that, in actual practice, this is not the case. As usually operated the bucket-latrine system attracts flies in enormous numbers, not just at the latrine site but all along the conveyance route to the disposal ground itself. There is considerable handling of the excreta. Regarding this system it may now be safely stated that insanitary handling of the buckets and night-soil is the rule, although exceptions may be found in a few properly operated and supervised systems. The hazards of soil pollution and of surface- and ground-water pollution are ever present. There are usually considerable odour and unsightly conditions. Although the initial cost of a bucket latrine is not high, the cost of operation makes it, within a few years, the most expensive type of installation. Its use is justified only in areas, the Western Pacific, for example, where excreta are needed as soil fertilizer. Even here it is believed that the conventional bucket-latrine system should be considerably improved or replaced by a latrine such as the compost privy mentioned below.

*Feuillées* and *trench latrines* are commonly used in some territories in Africa, in camps, and at times of emergency. As stated by Médecin-Général Sanner,<sup>81</sup> the *feuillées* are installations which may be relatively satisfactory or grossly insanitary, depending upon whether certain precautions are observed or neglected. These precautions (which will be described later) depend for their application upon the user and, in most cases, are not followed in actual practice. The system thus frequently results in violations of the most fundamental standards of sanitation, the most important of which are, in this particular instance, soil pollution and accessibility to flies and animals. Its use is not recommended.

The "overhung privy" is often used in limited areas that are frequently or periodically covered with water, especially the sea. This applies to coastal fishing villages in some countries of South-East Asia and the Western Pacific and in a few other places. The criteria listed above do not apply exactly. New criteria were considered at the WHO Seminar on Sewage Disposal held in Ceylon in August 1955. The most important factors in this case are the degree of salinity of the receiving water, its depth, and the degree of possible dilution. This type of installation should be considered only as a last resort under unusual circumstances.

### **Installations for Special Situations**

The compost privy has been used in areas where it is desirable to compost safely in the privy itself a mixture of faeces and other organic wastes (straw, kitchen wastes, grass clippings, etc.). To serve this purpose, two or more pits are required, and consequently the cost is greater than for ordinary pit latrines. If poorly constructed and operated, this privy may attract flies, which may breed in the material. Also, odours may be a problem. The compost privy is simple to build but requires some operation and maintenance. Since the pits are used alternately, handling of their contents is kept to a minimum and is done after their decomposition and reduction by anaerobic bacteria. The humus-like product is stable and safe and is a good soil fertilizer.

The chemical toilet is an efficient installation which fulfils all the above-mentioned criteria except the one which pertains to cost. It is, relatively speaking, very expensive both in initial cost and in operation. Its chief advantage is that it may be placed inside the dwelling. It is frequently used in rural houses and schools of the economically more favoured areas of the world.

## **THE PIT PRIVY**

### **Description**

The pit privy (as shown in Fig. 10 and 11) consists of a hand-dug hole in the ground covered with either a squatting plate or a slab provided with riser and seat. A superstructure or house is then built around it.

### **Design and Function of Its Parts**

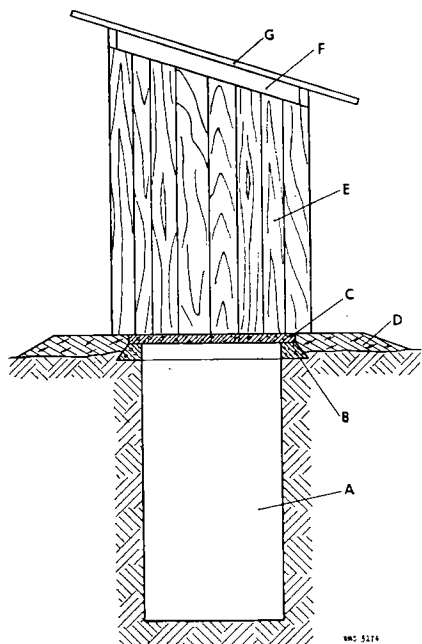
#### **The pit**

The function of the pit is to isolate and store human excreta in such a way that no harmful bacteria can be carried therefrom to a new host. The pit is usually round or square for the individual family installation

and rectangular for the public latrine. Its dimensions vary from 90 cm to 120 cm (36 in. to 48 in.) in diameter or square. Common figures for family latrines are 90 cm (36 in.) diameter or 1.06 m (42 in.) square. For public installations, the pit will be 90 cm to 100 cm (36 in. to 40 in.) wide ;

its length will depend upon the number of holes provided. The depth is usually about 2.50 m (8 ft), but may vary from 1.80 m to 5 m (6 ft to 16 ft). In Iran, and elsewhere, some pits have been dug to a depth of 7-8 m (23-26 ft) in soils which are very stable (see Fig. 12-15).

FIG. 10. VARIOUS PARTS OF A SANITARY PRIVY



- |           |                           |
|-----------|---------------------------|
| A = Pit   | E = House, including door |
| B = Base  | F = Ventilation           |
| C = Floor | G = Roof                  |
| D = Mound |                           |

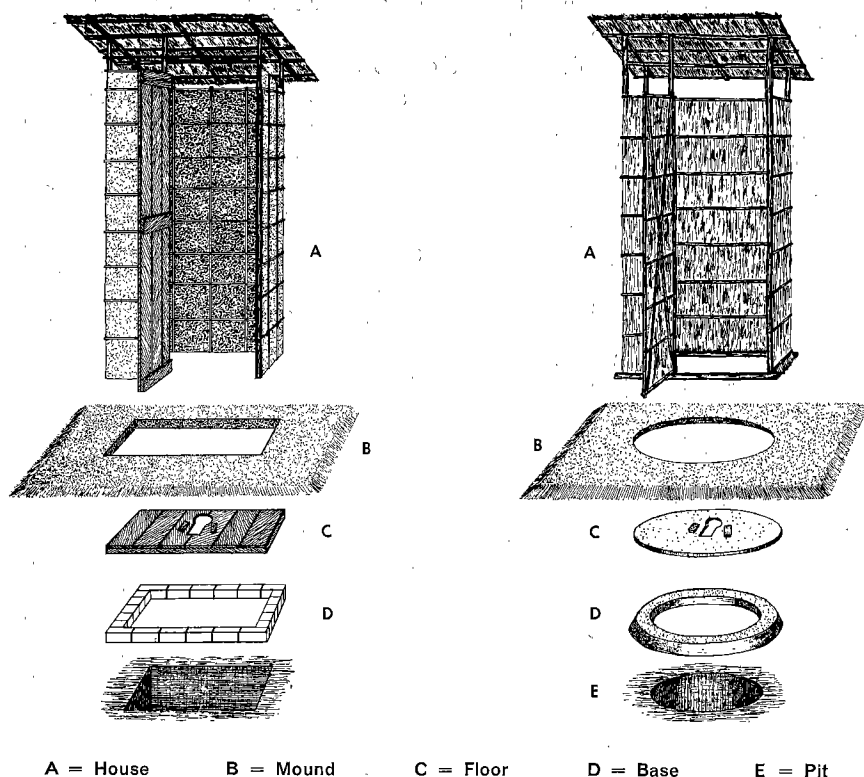
### *Life of a pit*

One of the very important aspects of the pit is its useful life. The longer a pit privy will serve a family without being moved or rebuilt, the more certain is the health protection which it can give and, therefore, the more value it has to the family and community. It is important, by increasing the capacity and efficiency of privy pits, to extend their useful life and thereby to reduce the annual cost per person of the installation. The life of a privy depends on the care with which it is built, the materials used in its construction, and the time required for the pit to fill.

The critical factor, usually, is the time required for the pit to fill ; this, in turn, depends on the method of anal cleansing and on the volume of the pit and the conditions within it. By the word "conditions" are meant the efficiency of bacterial decomposition and the degree of abuse to which the pit is subjected (i.e., the stones, sticks, mud balls, garbage, coconut husks, etc. thrown into it).

In deciding on the volume of a pit, it is necessary to consider whether the pit will be wet or dry, i.e., whether it will penetrate the ground-water table or not. In either case, however, it is essential to remember that the decomposition process starts as soon as the excreta are deposited in the pit and that, through decomposition and compaction, the volume of the slowly accumulating sludge is smaller than the total amount of excreta

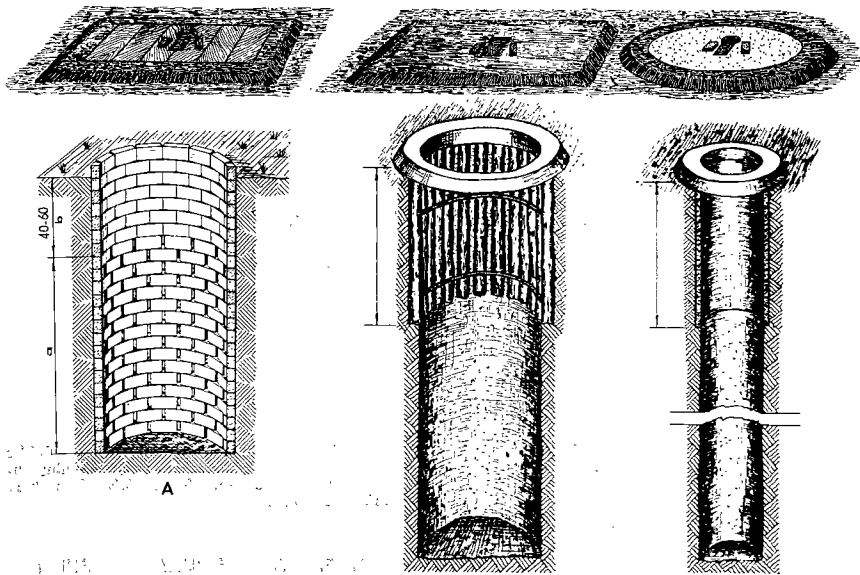
FIG. 11. THE PRINCIPAL PARTS OF TWO TYPES OF SANITARY PRIVY



deposited. Strictly speaking, the rate of accumulation of digested sludge and of partially digested excreta is not directly proportional to the amount of excreta added each year. This phenomenon is illustrated graphically in Fig. 16. From this graph, which is based on approximate data only, it will be noted that, after the digestion process has been well established, the actual volume of material in a wet pit might be reduced in time to approximately 10 % of the total waste (faeces and urine) deposited. This graph is very approximate, however, and may need to be substantially modified in the light of experience in different areas. These data should be developed in each country by controlled field observations carried out over a number of years. Only in this way can reliable figures be obtained as a basis for future design of latrine capacity. The following considerations are based on data contained in the report on the aforementioned WHO-sponsored seminar on sewage disposal.<sup>a</sup>

<sup>a</sup> *Report on Seminar on Sewage Disposal (Rural and Urban)*, Kandy, Ceylon, 1955 (Report issued by the WHO Regional Office for South-East Asia, New Delhi)

FIG. 12. VARIOUS COMBINATIONS OF DIFFERENT TYPES OF PIT, PIT LINING, BASE, AND FLOOR



a = Open joints

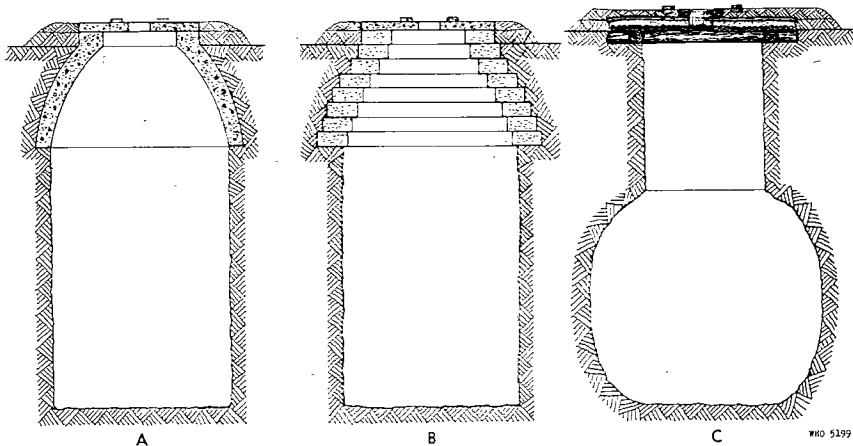
b = Joints laid with mortar

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

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

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

FIG. 13. LARGE-VOLUME PITS WITH SMALL FLOORS AND SUPERSTRUCTURES

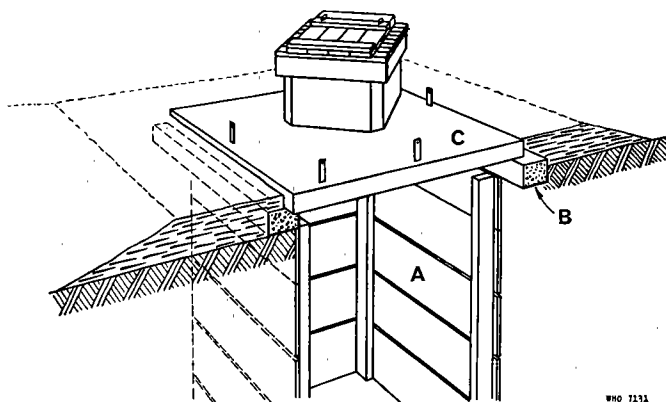


A = Large diameter or square pit with soil-cement cone at top to reduce size of opening and accommodate small floor (Cone may be of any material which will provide the strength to support the weight on top.)

B = Similar to A, but with brick

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

FIG. 14. TYPE OF PIT, PIT LINING, BASE, AND FLOOR RECOMMENDED BY THE US PUBLIC HEALTH SERVICE



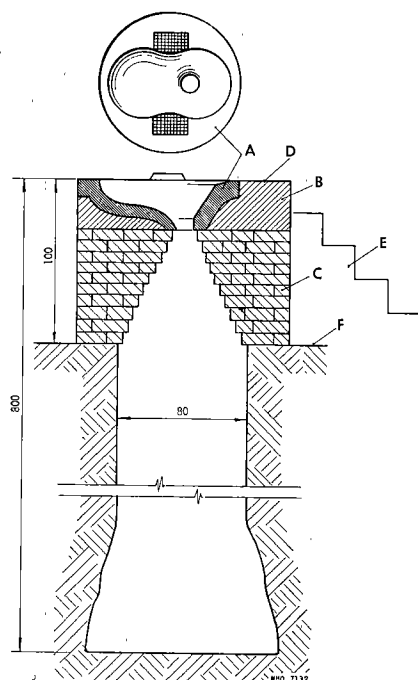
WHO 7131

- A = Wooden pit lining, 2.5 × 15 cm (1 × 6 in.) boards. About 1.2 cm (0.5 in.) space left between boards below top two  
 B = Concrete sill  
 C = Concrete floor and riser

Adapted, by permission, from United States Public Health Service (1933) *The sanitary privy*, Washington, D.C. (Revised type No. IV of *Publ. Hlth Rep. (Wash.)*, Suppl. 108).

FIG. 15. TYPE OF RURAL PIT PRIVY DEVELOPED BY TCA\* IN IRAN

In wet pits, assuming that the daily production of one litre (approximately one quart) of excrement contains 100 g (3.5 oz.) of dry solids and that digestion for one year under wet-pit conditions will reduce this mass by 80%, a total of 20 g (0.7 oz.) of dry solids will remain. Further assuming an 80% moisture content in the digested sludge, one arrives at the figure of 100 g (3.5 oz.) of wet sludge after a one-year digestion period.

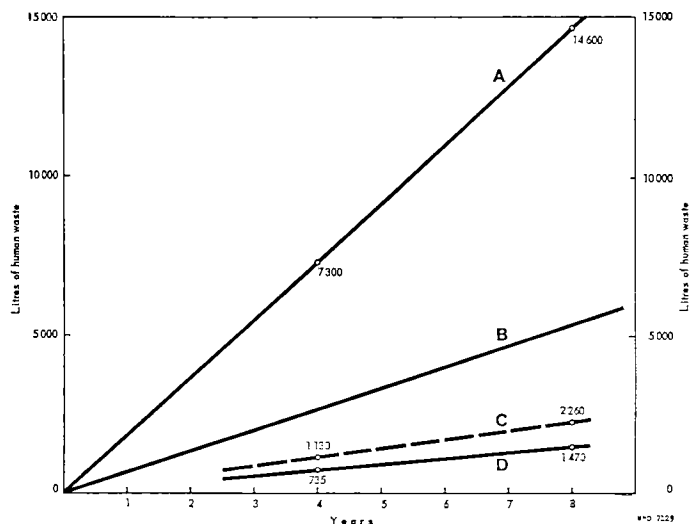


WHO 7132

- A = Round, reinforced concrete slab. Can be easily rolled to privy site without breakage. Water is used for anal cleansing  
 B = Lime-mud mixture  
 C = Brick or stone masonry  
 D = Floor of privy  
 E = Steps leading to entrance door  
 F = Original ground-level

\* Technical Co-operation Administration of the USA

FIG. 16. SLUDGE ACCUMULATION IN PIT LATRINES



- A = Human waste (liquid and solid) deposited in pit by a family of five (at the rate of one litre, or quart, per person per day)  
 B = Corresponding amounts of solid wastes alone (approximately)  
 C = Rate of accumulation of sludge, by volume, in dry pit  
 D = Rate of accumulation of sludge, by volume, in wet pit

This amounts to 36.5 l (1.3 cu. ft) per person per year. Thus, a family of five would require sludge-storage space of 184 l (6.5 cu. ft) per year.

Actual observations on wet-pit latrines in West Bengal, India, where ablution water is used, gave a figure of 25 l (0.88 cu. ft) of sludge per person per year. In the Philippines, where solid cleansing materials are used, a wet-pit figure of 40 l (1.4 cu. ft) was obtained.

It is recommended that for the design of the effective capacity of wet-pit latrines a provision of 37 l (1.3 cu. ft) per person per year should be allowed. If cleansing materials such as grass, stones, mud balls, coconut husks, or similar solids are used, it is recommended that this figure be increased by 50% to a total of 57 l (2.0 cu. ft) per person per year.

It is recognized that digestion of solids is less rapid and less complete in dry-pit latrines than in wet-pit latrines. Actual observations in the Philippines indicate a reduction by dry-pit digestion of about 50% in volume per year. In the absence of more accurate data, this rate is tentatively accepted. In Brazil, a privy of one cubic metre (35 cu. ft) of effective capacity will serve an average family of five for four years; this represents a capacity of 0.05 m<sup>3</sup> (1.75 cu. ft) per person per year. Somewhat lower figures have been found in the USA, but higher figures are reported from areas where different types of anal cleansing materials are employed. For

design purposes, a provision of 0.06 m<sup>3</sup> (2 cu. ft) per person per year is recommended, to be increased by 50% in cases where the types of personal cleansing materials normally employed might indicate that such an allowance is necessary.

It is further recommended that, where practicable, wet pits should have a minimum depth of 3 m (10 ft). With regard to pit storage capacity, it is desirable to design for as long a period as possible, i.e., for 10-15 years. However, it is recognized that, from the standpoint of cost, or because of difficulties in supporting pit walls in unstable soil formations, it might sometimes be impossible to attain this objective. Nevertheless, it is strongly recommended that pits should be designed for a life of at least four years.

**TABLE IV. WET-PIT VOLUME AND DEPTH\* FOR RURAL LATRINE WITH AN ASSUMED CROSS-SECTIONAL AREA OF 9 SQUARE FEET AND INTENDED FOR A FAMILY OF FIVE**

Service life	Personal cleansing material			
	water		solid	
	volume (cu. ft)	depth (ft)	volume (cu. ft)	depth (ft)
4 years (minimum)	26	3	40	4.6
8 years	52	5.8	80	9
15 years (maximum)	97	11.8	150	16.6

\* Depth given is effective pit depth, and 1-2 ft (30-60 cm) are usually added to obtain overall depth of pit.

Table IV shows the pit volume and dimensions for household latrines for families and gives varying periods of service life based on wet-pit conditions. Table V presents similar data for dry-pit conditions.

These tables show that, where there is little possibility of maintaining water in pits or holes, a pit privy with the largest possible volume is best. From the economic standpoint, the deep pit, although higher in initial cost, will prove to be a profitable investment.

Finally, one factor that also influences the cross-sectional area of the pit, although to a lesser extent, is the size of the floor that covers it. The size of the floor slab depends much on the type of material from which it is built. This matter is discussed in a later section (p. 52).

When the level of excreta comes to within 50 cm (20 in.) of the ground surface, the pit should be closed and filled with earth. A new pit should be dug, preferably near the old one, and the superstructure moved over it (or rebuilt, as the case may be). The faeces in the old pit should be left

**TABLE V. DRY-PIT VOLUME AND DEPTH\* FOR RURAL LATRINE WITH AN ASSUMED CROSS-SECTIONAL AREA OF 9 SQUARE FEET AND INTENDED FOR A FAMILY OF FIVE**

Service life	Personal cleansing material			
	water		solid	
	volume (cu. ft)	depth (ft)	volume (cu. ft)	depth (ft)
4 years (minimum)	40	4.5	60	6.7
8 years	80	9	120	13.3
15 years (maximum)	150	16.6	—	—

\* Depth given is effective pit depth, and 1-2 ft (30-60 cm) are usually added to obtain overall depth of pit.

to decompose anaerobically for 9 to 12 months, after which the digested material may be easily removed and utilized as soil fertilizer. The cleaned pit may then be re-used.

To prevent mosquito breeding in wet pits, it may be desirable to add a cupful of kerosene each week to the pit, or to spray it with Malariol<sup>a</sup> or a 5% solution, emulsion, or suspension of BHC (benzene hexachloride) or dieldrin. No disinfectants should be added to the pit.

### *Lining of pit*

It is often necessary to provide a pit lining to prevent the sides from caving in. This is true especially in rainy seasons where privies are dug in fine-grained alluvial soils, sandy soils, and similar formations, or when they penetrate deeply into ground water. Even in stable soil formations, it is desirable to line the top 40-60 cm (16-24 in.) of the pit in order to consolidate it and to prevent it from caving in under the weight of the floor and the superstructure.

Materials commonly used for this purpose include bricks, stones, concrete blocks, laterite blocks, adobe materials, lumber, rough-hewn logs, split cane, and bamboo. When the first five materials mentioned above are used, they are laid with open joints over most of the walls' height and with mortar near the top of the walls, the reason being that with these materials the lining also serves usefully as a base for the floor. Brick linings (see Fig. 13) should preferably be round, not square, as they then develop arch action and are much stronger for the same wall thickness. Wooden logs and bamboo should be used exclusively to support the walls

<sup>a</sup> Malariol is the proprietary name for a blend of oil (70% diesel oil and 30% gas oil), often referred to as "anti-malarial mixture"; it is made by Shell Chemicals Ltd, London.

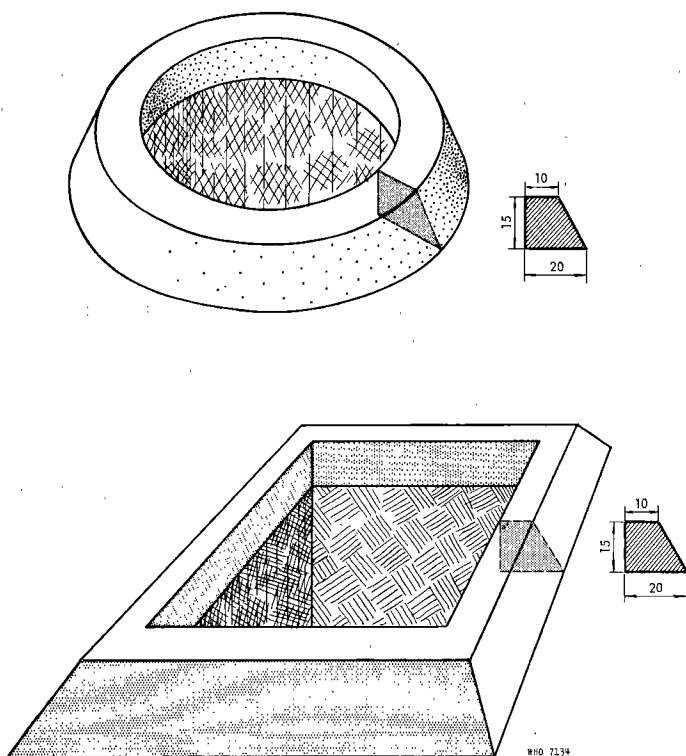
of the pit, not as a foundation for the floor. Rough-hewn logs will, of course, last longer than bamboo linings; both, however, may be tarred in order to increase their useful life. The use of rot- and termite-resistant woods is recommended wherever possible.

Where a lining is necessary, it is often given to the family by the health department, along with the floor or slab.

### The base (Fig. 17-19)

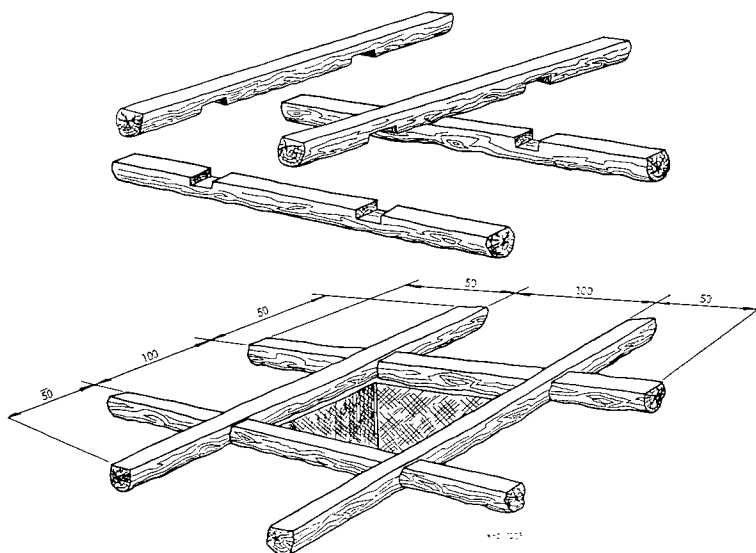
The base serves as a solid, impervious foundation upon which the floor can rest. It also helps to prevent the egress of hookworm larvae. Properly made of a hard, durable material, it helps to prevent the entrance of burrowing rodents and of surface water into the pit. Pit lining in most cases will serve as a base although it may need to be strengthened at the ground surface.

FIG. 17. TYPICAL ROUND AND SQUARE BASES.  
(BUILT WITH SOIL-CEMENT OR CLAY)



Measurements shown are in centimetres.

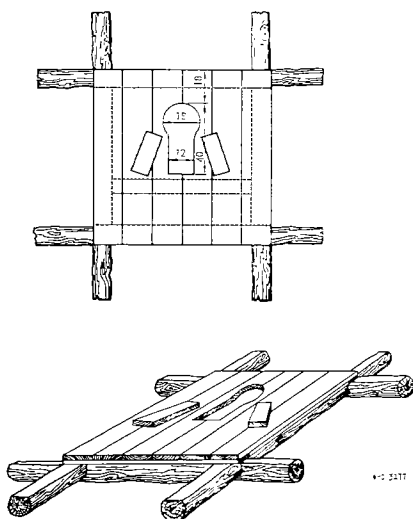
FIG. 18. A HEWN-LOG PRIVY BASE



Measurements shown are in centimetres.

The foundation should be at least 10 cm (4 in.) wide on top in order to provide a good surface for the floor to rest upon, and 15 cm (6 in.) or more at the bottom in order to give a stable contact with the ground. Its shape will be that which will fit the pit (see Fig. 17 and 18). The base should be high enough to raise the floor 15 cm (6 in.) above the level of the surrounding ground, thus, with the mound, protecting the pit from flooding.

FIG. 19. HEWN-LOG BASE WITH WOODEN FLOOR



Measurements shown are in centimetres.

The following materials may be used in the construction of the base :

(a) plain or reinforced pre-cast concrete—same mix as floors ;

(b) soil cement—5%-6% cement mixed with sandy clay soil and tamped at optimum moisture content ;

(c) clay—tight clay, well tamped at optimum moisture content ;

- (d) brick—mud-dried, burned, adobe, etc.
- (e) stone masonry ;
- (f) rough-cut logs—hardwood, termite-resistant.

### The floor (Fig. 20-32)

The floor supports the user and covers the pit. It should be constructed so as to fit tightly on the base, with a minimum of small cracks and openings between the surfaces. The squat-type plate or slab for pit privies has been found to be the most suitable for rural conditions in most parts of the world. However, in many countries a slab provided with a riser and seat may be found to be more acceptable. This aspect of slab design requires careful consideration. An eminent health educator and social anthropologist has stated that customary posture in defaecating is perhaps the single most important fact bearing on the acceptance or rejection of privies.

The floor or slab should normally extend to the superstructure walls, as a peripheral earth strip might be soiled and become a medium for hookworm infestation. It should be made of a durable, impervious material with a hard surface which will facilitate cleaning. Materials commonly employed include :

- (a) reinforced concrete ;
- (b) reinforced concrete with brick filler ;
- (c) wood ;

FIG. 20. HEWN LOGS TO FORM HOLE AND FOOT-RESTS

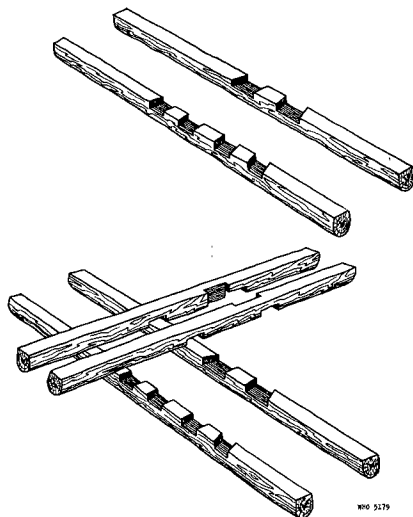
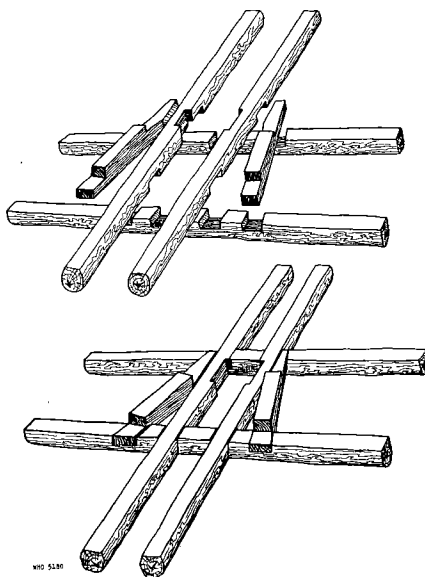


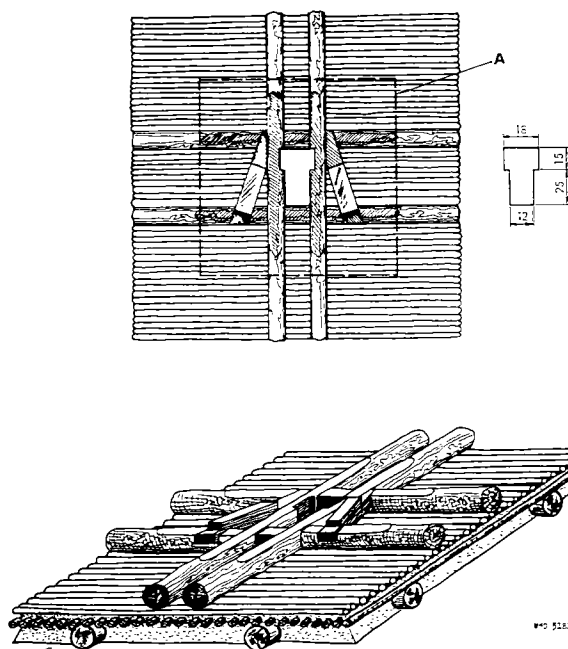
FIG. 21. HEWN LOGS FORMING HOLE AND FOOT-RESTS, ASSEMBLED AND UNASSEMBLED



(d) built-up floor of small-diameter wooden poles with chinks filled by mud or soil-cement mixture.

The consensus of opinion is that concrete is, in the long run, the most practicable, most acceptable, and cheapest material for the privy floor. Wooden floors come next in the line of preference. "Built-up" floors, as shown in Fig. 22-24, are less desirable because they are difficult to keep clean and, as they get soiled (especially by children), are likely to spread hookworm.

FIG. 22. HEWN LOG FORMING HOLE AND FOOT-RESTS SHOWN IN PLACE UPON SECOND LAYER OF TREE LIMBS IN BUILT-UP FLOOR

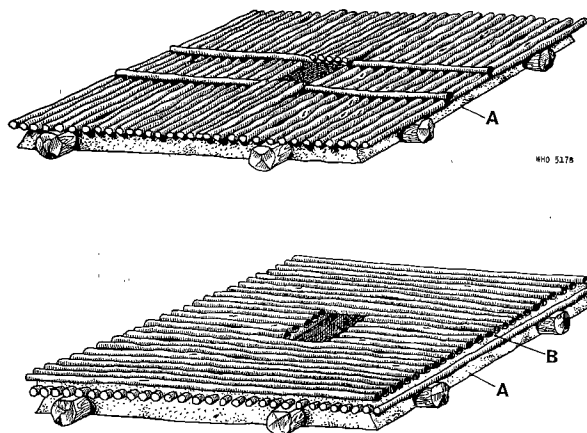


Measurements shown are in centimetres.

A = Limits of pit

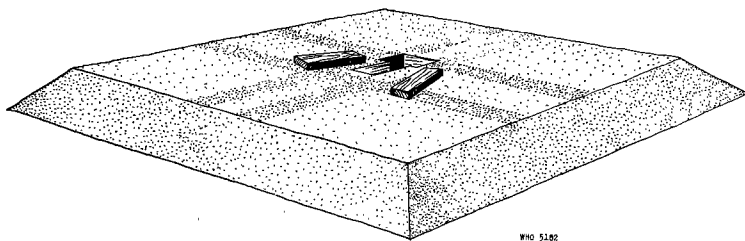
Latrine slabs or floors may be round, square, or rectangular. When slabs are to be made or cast at a central shop, it is advantageous to adopt a standard shape and size in order to facilitate production. The size of concrete slabs, which influences to a certain degree the cross-sectional area of the pit and the size of the superstructure, is governed by their weight and by the difficulty of transportation (where this applies).

FIG. 23. BUILT-UP FLOOR OF SMALL-DIAMETER TREE LIMBS  
PLACED OVER HEWN-LOG BASE



- A = Fill in with compact earth all around after the base is placed and before covering with tree limbs  
 B = First layer of limbs is covered with 5 cm (2 in.) of dense earth, followed by another layer of tree limbs

FIG. 24. COMPACT EARTH FINISHING THE BUILT-UP FLOOR

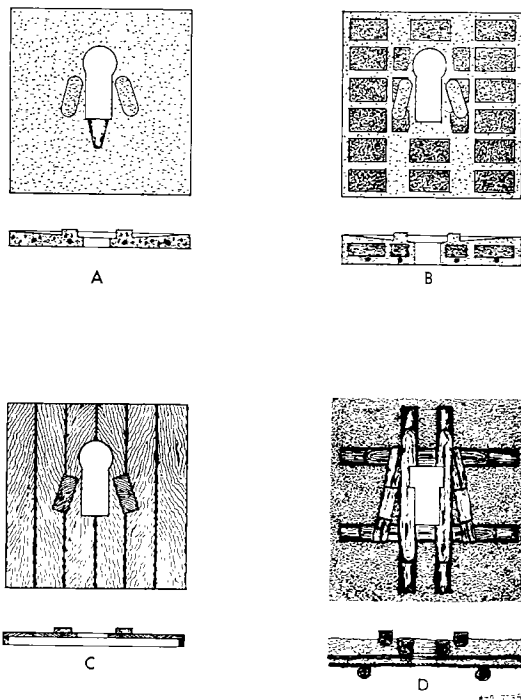


All factors considered, appropriate dimensions for concrete slabs may be  $100 \times 100$  cm ( $39 \times 39$  in.) in over-all size. Such a slab will weigh approximately 136 kg (300 lb.) if the average thickness is 6.35 cm (2.5 in.). Smaller slabs,  $91 \times 91$  cm ( $3 \times 3$  ft), have been built where it is easy to complete the floor at the site with a cement surface. Round slabs, 91 cm (3 ft) in diameter, have also been used. Their advantage is that they may be rolled to the latrine site instead of being transported. Fig. 25 and 26 show various types of floor made of lumber, wooden poles and reinforced concrete. Fig. 27 shows a round concrete slab 91 cm (3 ft) in diameter.

The thickness of slabs also varies a great deal in practice. In order to reduce weight, the tendency, of course, has been to reduce the thickness

to a minimum consistent with safety. In this respect, however, much depends on the quality of the concrete and the reinforcement available (see p. 73). When these factors are satisfactory, the slab may be 6-7 cm (2.3-2.7 in.) thick on its edges and 5 cm (2 in.) thick at its centre. A slab 1 m square will then weigh approximately 130 kg (286 lb.). The surface

FIG. 25. VARIOUS TYPES OF FLOOR



- A = Reinforced concrete
- B = Reinforced brick-mortar
- C = Wood
- D = Floor built up with tree limbs and earth

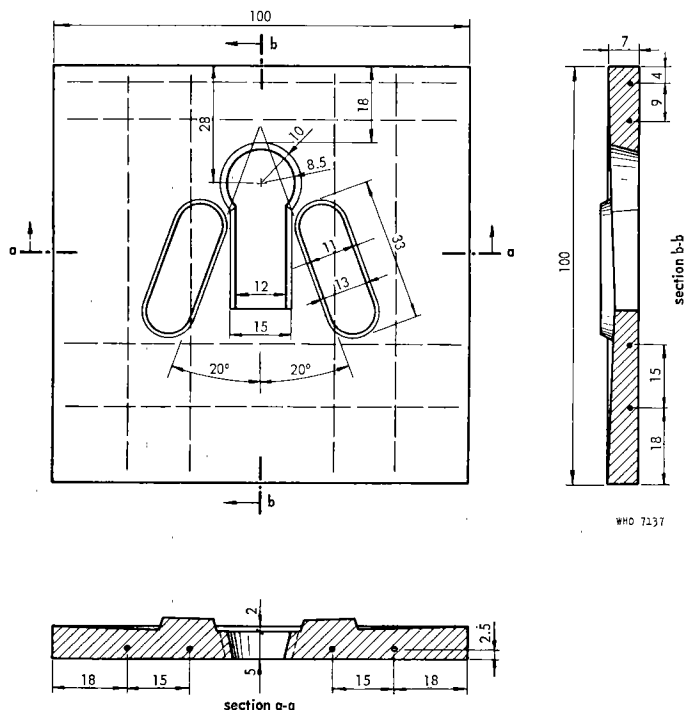
of the slab will slope towards the hole, which is an advantage in Asian countries where water is used for anal cleansing. Where solid cleansing materials are used, the slab may be of uniform thickness throughout, but not less than 6 cm (2.3 in.) thick.

Where it is not possible to cast concrete slabs in place and where the problem of transportation is serious, the possibility of casting the slab in four parts may be considered. Fig. 28-32 show how such a slab may

be built and installed. This procedure is particularly useful for large concrete slabs.

The shape and size of holes for floors with seats are fairly standard in European and American countries. With respect to squatting plates,

FIG. 26. SQUARE CONCRETE SLAB FOR PIT AND BORED-HOLE LATRINE

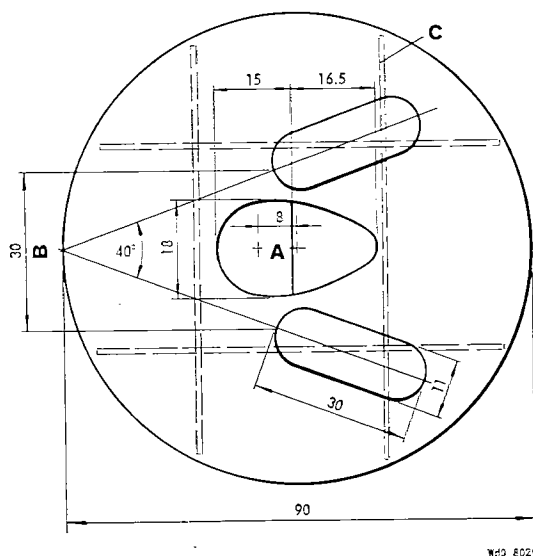


Measurements shown are in centimetres.

however, the literature shows a wide variety of hole dimensions, often with conflicting claims regarding their particular merits. The important considerations are :

1. The opening should be large enough and shaped so as to minimize—or better, prevent—soiling of the floor. An opening having an effective length of about 38 cm (15 in.), preferably more, will satisfy this requirement.
2. It should not be so large that small children may fall into the pit. An opening having an effective width or diameter of 18 cm (7 in.) or less will satisfy this requirement.

FIG. 27. CIRCULAR SLAB FOR BORED-HOLE LATRINE \*



Measurements shown are in centimetres.

\* Built in East Pakistan. See also Fig. 52.

A = Centre open hole 2.5 cm (1 in.) back of centre if slab is 80 cm (31 in.) in diameter ; centre open hole 8.0 cm (3 in.) back of centre if slab is 90 cm (35 in.) in diameter

B = Between back centre foot-rests

C = Reinforcement

#### *Notes on construction of slab*

Concrete for slabs should be not weaker than 1 part cement to 6 parts aggregate, with a minimum of water.

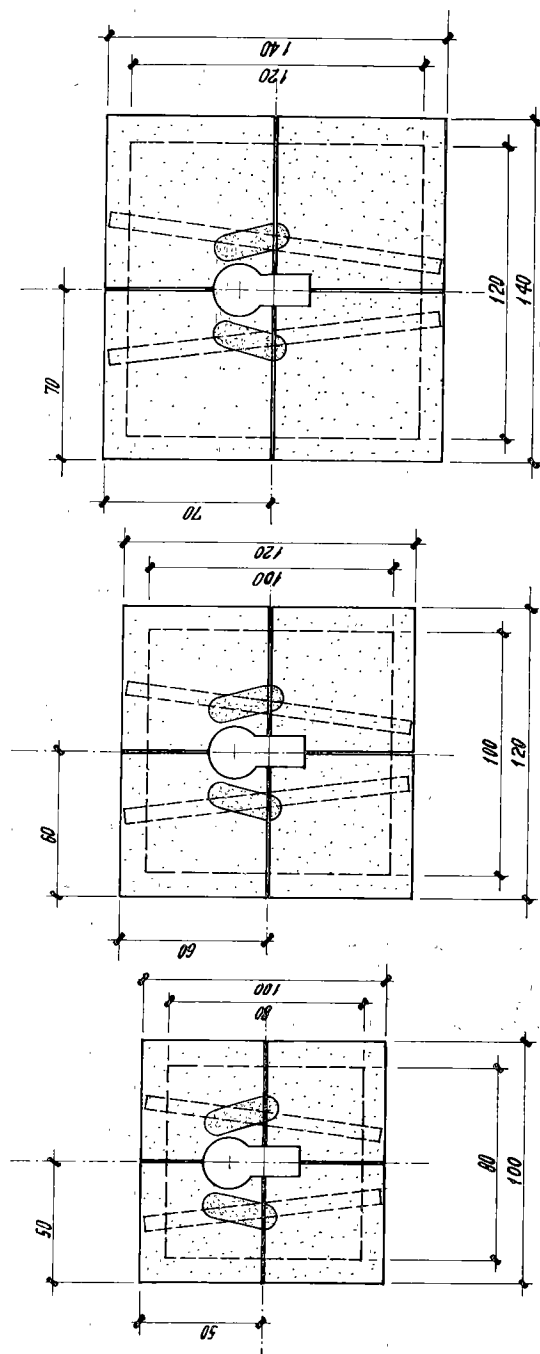
Slab is reinforced with strips of bamboo of timber quality. Reinforcing strips are about 2.5 cm (1 in.) wide, have had inner, weaker fibres stripped away, and have been soaked in water overnight before use.

Slabs are cast upside down in one operation. Base of form is of wood with indentations for foot-rests. Base of form is encircled by sheet metal strip which makes outer wall of form. Side walls of hole form and foot-rests are made with slight slope so as to come out easily. Form for open hole is removed when concrete has taken initial set. Slabs are removed from form in about 40 hours and stored under water, preferably for 10 days or more. Since these slabs are round, they may be rolled some distance when conveyance is difficult.

In communal installations, the number of openings will depend on the number of people to be served. It is good practice to provide one hole for not more than 15 users, preferably one for each 10-12 persons.

It is often recommended that squatting plates should be provided with slanting foot-rests to minimize the possibility of soiling the floor. Foot-rests usually form an integral part of the squatting plate and should be designed to be used by both adults and children. When foot-rests are not properly built—for instance, when they join the floor at a sharp angle or are excessively long, etc.—they make it difficult to clean and scrub the floor.

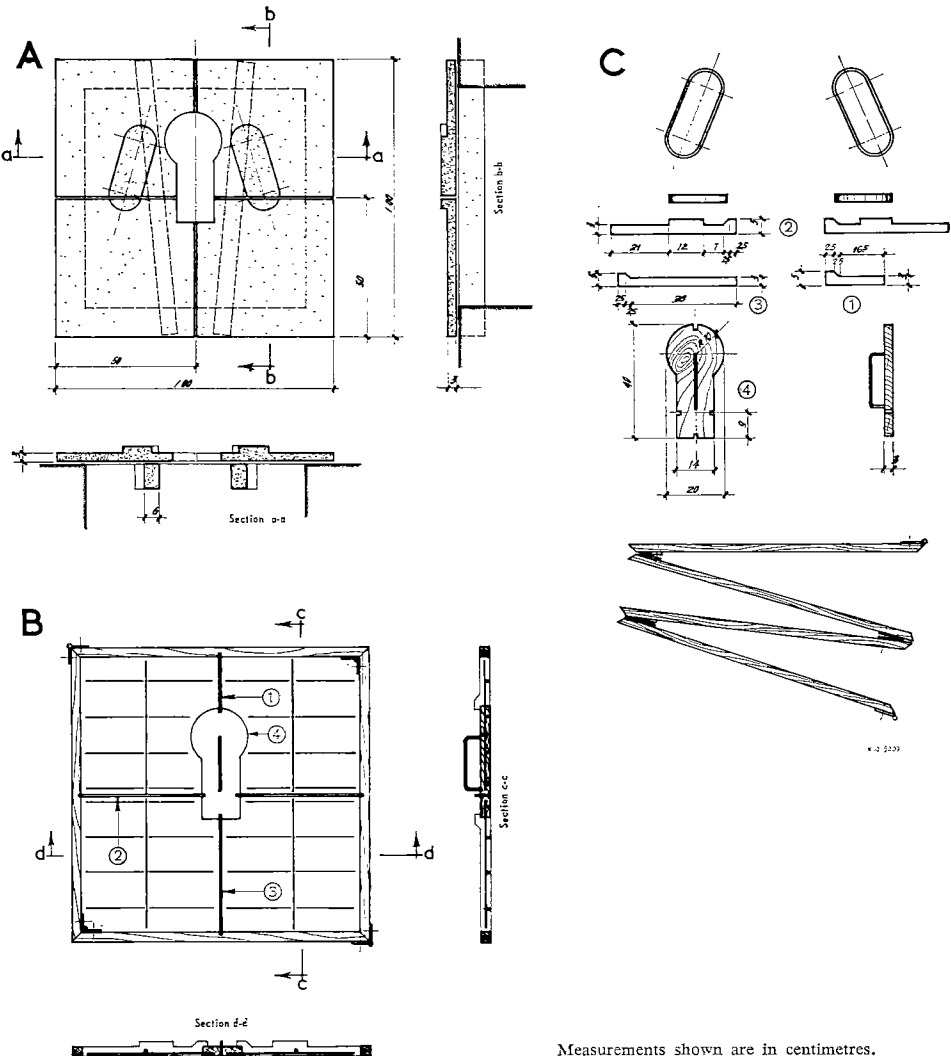
FIG. 28. FOUR-PART PRIVY FLOORS



Measurements shown are in centimetres.

The four-part privy floor can be made in various sizes. The larger the floor, the larger the pit, so the longer it will last, either with or without composting. All details are the same as those shown in Fig. 29, with altered dimensions. Reinforcement should be adapted to slab size. Joints are sealed with cement mortar.

FIG. 29: DETAILS OF FOUR-PART PRIVY SLAB 100 CM (39 IN.) SQUARE



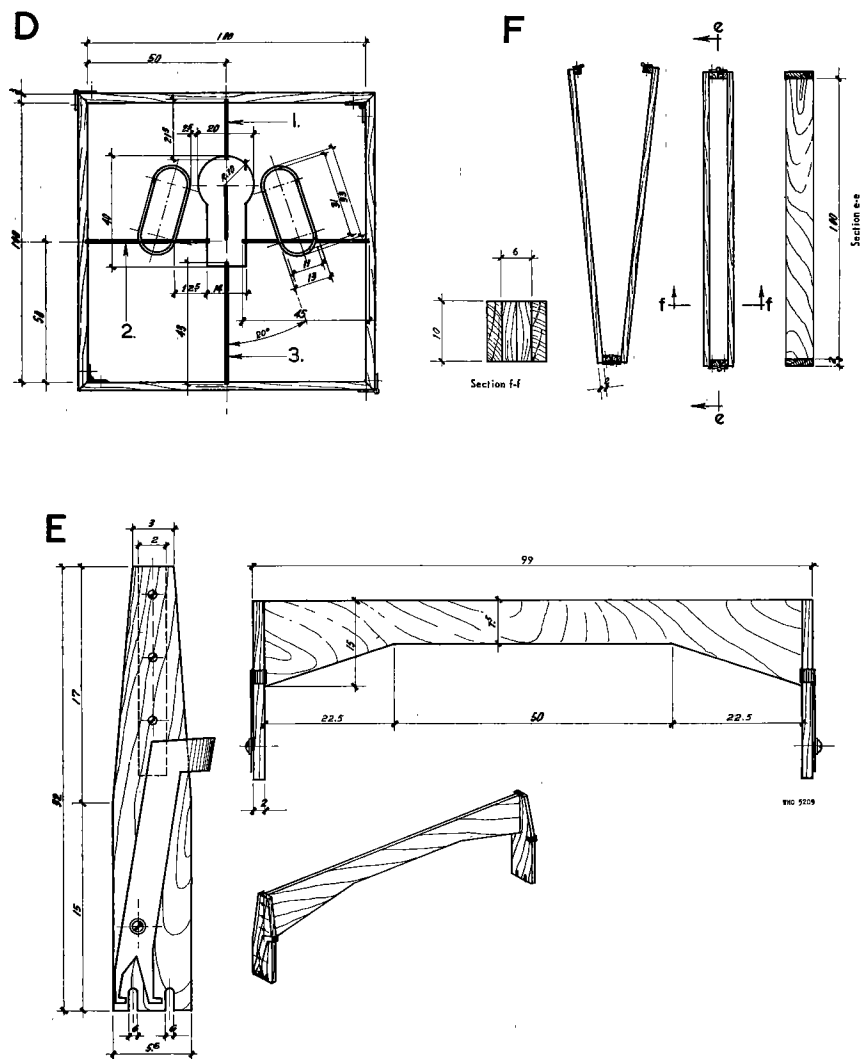
Measurements shown are in centimetres.

A = Finished floor

B = Floor form without foot-rests ready for pouring but with reinforcement shown in place

C = Complete set of forms

FIG. 30. DETAILS OF FOUR-PART PRIVY SLAB 100 CM (39 IN.) SQUARE  
(CONTINUED)

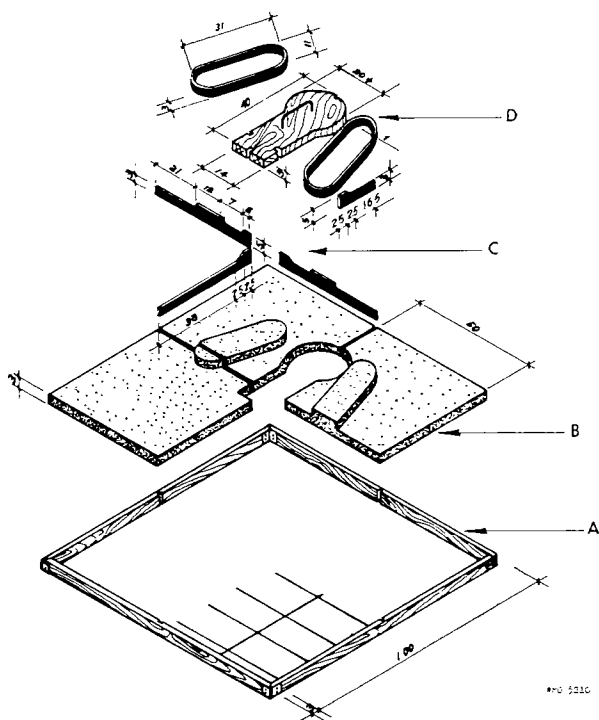


Measurements shown are in centimetres.

- D = Floor form ready for pouring, with foot-rests included  
 E = Form for holding steel in place while pouring beams  
 F = Beam forms

Another factor which bears upon the acceptance or rejection of a privy by the users is the free distance from the opening to the back wall of the latrine. When this distance is too small, the back of the user will rest against the wall, which may not at all times be very clean and free

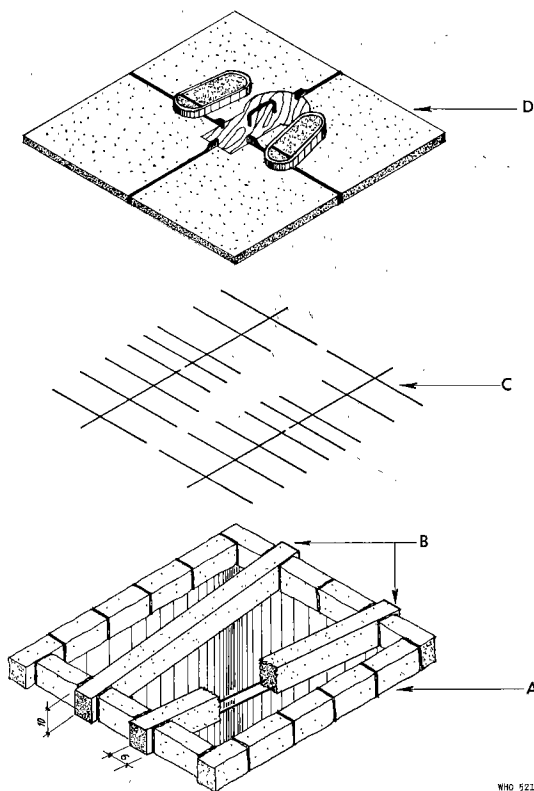
FIG. 31. FOUR-PART PRIVY SLAB, SHOWING FORMS



- A = Wooden outside form, showing reinforcing steel for one part ready for pouring  
 B = Three parts of floor ready for installation  
 C = Metal dividers separating floor for pouring  
 D = Foot-rest and hole forms

from ants or other insects. Also, there is a chance that excreta may soil the upper portion of the pit wall. Yet this distance should not be too large; otherwise there is a likelihood that the back part of the floor will be soiled. The minimum distance between the rear edge of the opening and the superstructure wall should be 10 cm (4 in.)—preferably 15 cm (6 in.)—and the maximum, 18 cm (7 in.).

FIG. 32. FOUR-PART PRIVY SLAB WITH BASE AND REINFORCEMENT



WHO 5211

Measurements shown are in centimetres.

- A = Brick base
- B = Reinforced concrete beams to support four-part floor
- C = Plan of floor reinforcing
- D = Floor showing forms for foot-rests and hole as well as metal dividers separating floor into its four parts

This floor can be easily carried to the point of installation since it is divided into four parts and the slab is very thin. More labour is required for construction and installation, but materials are fewer.

### The mound

The function of the mound is to protect the pit and base from surface run-off which otherwise might enter and destroy the pit. It should be built up to the level of the floor and be very well tamped. It should extend 50 cm (20 in.) beyond the base on all sides. In exceptional cases in flood plains and tidal areas, the mound may be built up considerably above the ground for protection against tides and flood waters. It will normally be built with the earth excavated from the pit or surrounding area, and

FIG. 34. COMPLETED PRIVY, SHOWING PALM THATCH WALL AND ROOF COVERING

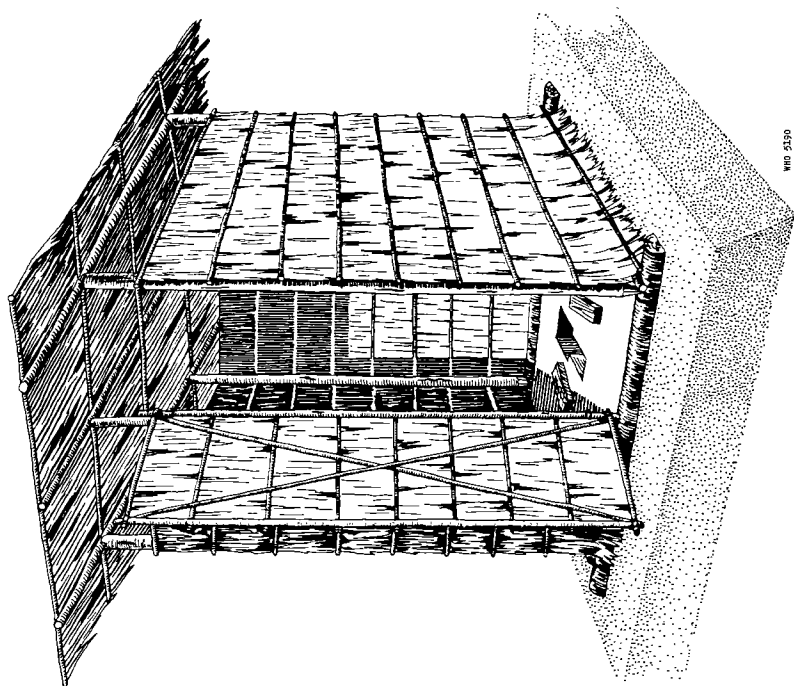


FIG 33. SKELETON FOR PORTABLE SUPERSTRUCTURE FROM ROUGH-CUT TREE LIMBS AND LOGS

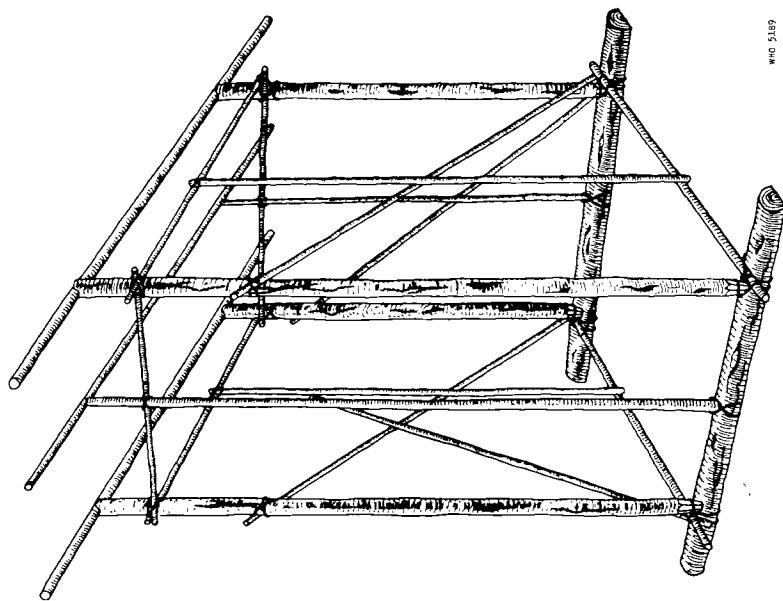


FIG. 35. WATTLE HOUSE WITH PALM THATCH ROOF

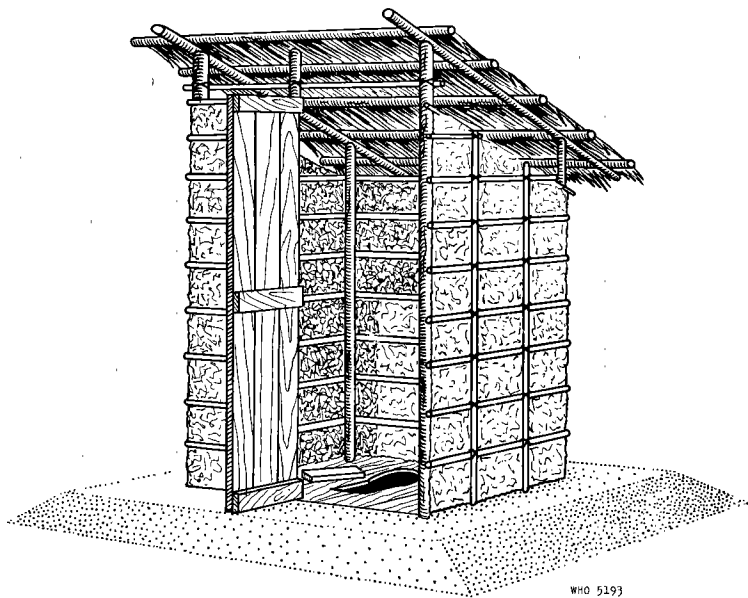
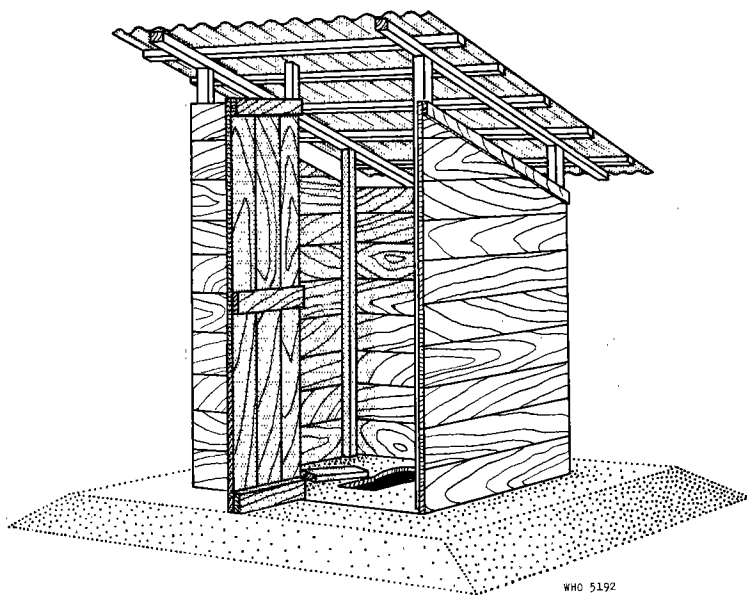


FIG. 36. HOUSE OF CUT LUMBER WITH CORRUGATED METAL OR ASBESTOS CEMENT ROOF



may be consolidated with a stone facing to prevent it from being washed away by heavy rains. In front of the entrance door, it may be preferable to supplement the mound with a masonry or brick-built step. This helps to keep the latrine floor clean.

In the Philippines, where the dwelling is often built above the ground on piles, the latrine floor is also elevated ; and a drop-pipe leads the excreta downward to the covered pit below. This is called the " antipole " system.

### **The house or superstructure**

The house affords privacy and protects the user and the installation from the weather. Fig. 33-38 show various types of house and a typical wooden house frame for use in rural areas. From the sanitary viewpoint, the house is less important than the pit or the floor. For this reason, when latrine programmes are undertaken on a campaign basis, the house is often left for the people to erect in the manner which is most satisfactory to them, only general advice being offered by the health inspector. Standardized superstructures are desirable, however, from many standpoints, among which economy of construction and durability are most important.

A properly built superstructure should conform to certain rules, the most significant of which are :

1. **Size.** It should preferably fit the dimensions of the floor or slab and should never be too large, lest people be tempted to defaecate on any part of the floor at times when the area around the opening has been soiled by previous users. The height of the roof over the slab near the entrance door should be 2 m (6.5 ft) or more.

2. **Ventilation of superstructure.** It is desirable to provide openings 10-15 cm (4-6 in.) wide at the top of the house's walls to facilitate constant ventilation.

3. **Lighting.** Natural light should be available wherever possible. However, the superstructure should provide sufficient shade over an uncovered seat or hole in order not to attract flies.

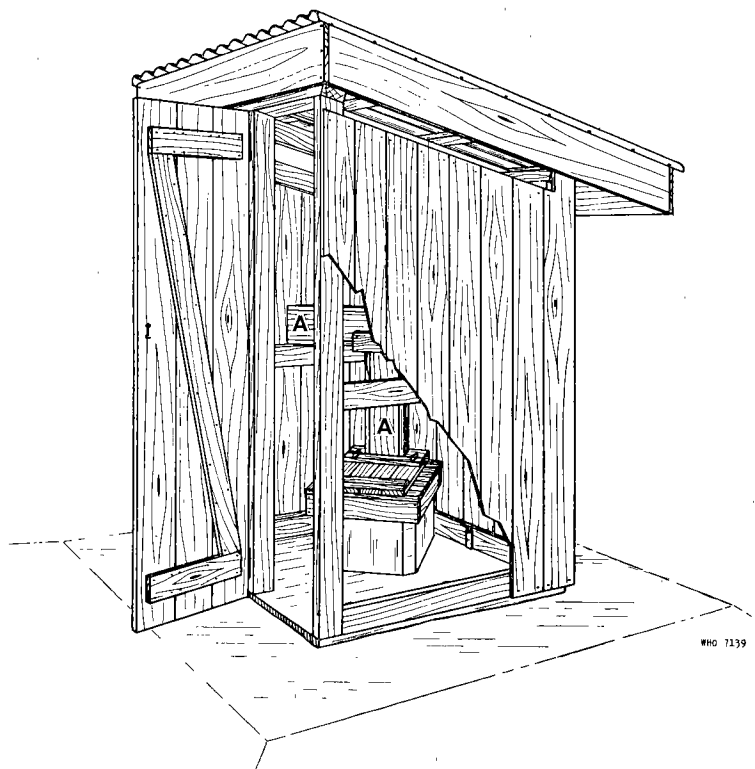
4. **Cleanliness.** A superstructure which is left dirty and in a constant state of disrepair will soon be abandoned and unused as a latrine. It is therefore extremely important that the house be kept clean at all times, both inside and outside, and that no poultry or animals be housed in it. White or coloured washings of the superstructure should be encouraged, and the vegetation immediately surrounding it should be trimmed. The roof should cover the house completely and have a large overhang to protect the mound and the walls from rain and roof drainage. One of the duties of the health department staff, especially the sanitarians and health educators, is to provide constant advice to the family regarding the cleanliness and the proper use of the latrine.

When it is expected that a latrine will not last long because of small pit capacity, the slab and superstructure should be so designed as to facilitate their removal to a new pit when the existing pit is filled.

Materials used in the construction of the superstructure include, among others, the following :

- (a) wood—cut lumber, may be expensive in some areas ;
- (b) asbestos cement sheets—expensive in most places but durable and portable ;
- (c) metal—expensive but serves for long period ;
- (d) palm or grass thatch—easily available in many places, cheap, and quite durable. (When it is placed on a properly constructed frame, this house can be moved.) ;

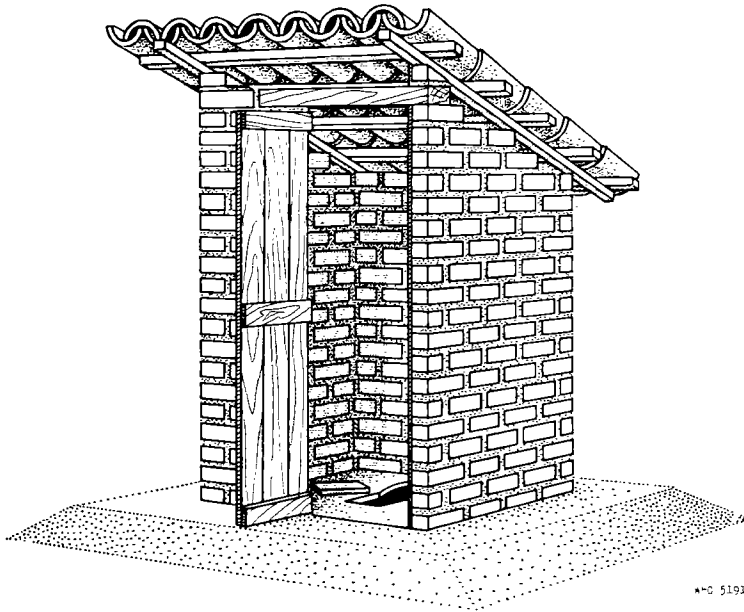
FIG. 37. TYPE OF SUPERSTRUCTURE RECOMMENDED BY US PUBLIC HEALTH SERVICE



Adapted, by permission, from United States Public Health Service (1933) *The sanitary privy*, Washington, D.C. (Revised type No. IV of *Publ. Hlth Rep. (Wash.)*, Suppl. 108).

A = Vent pipe with lateral outlet

FIG. 38. HOUSE OF BRICK WITH TILE ROOF



(e) brick—mud dried, adobe, burned—permanent but not easily portable ;

(f) mud—if placed on proper form and protected from rains, makes a durable house ; not easily moved ;

(g) protective fence—in some areas where there is little rainfall a fence or screen is built around the privy for privacy in place of a house.

### Pit ventilation

The provision of a pit or seat vent may be considered under certain circumstances. In temperate climates or during cool seasons, there is often an appreciable difference in temperature between the air in the pit and the outside air. This temperature difference provokes condensation on the under side of the seat (or hole) cover. It is also believed that a vent induces a draught of air which helps to keep the pit materials dry and small in bulk (completion of aerobic stage of decomposition).

In tropical areas, however, evidence seems to indicate that venting serves no useful purposes. The temperature difference mentioned above is negligible, and the openings are uncovered in most cases. (See Fig. 37 for a typical vent installation.)

### Location of Pit Privy

The general rules given on page 32 apply to the pit privy. It may be added here, however, that pit privies should preferably be built at some distance, about 6 m (20 ft) or more, away from a dwelling.

### Cost

The cost of pit latrines varies considerably from country to country, depending on the design and local costs of labour and materials. Several figures have been quoted in the existing literature on sanitation, but only a few representative examples are given below since absolute cost figures do not mean much. In order to appreciate their real meaning and value, it is necessary to have information on the local *per caput* income. For countries of South-East Asia and the Western Pacific, it has been recommended that the maximum cost of an earth-pit latrine, including all labour and materials, should not be more than the average monthly income of a manual labourer. This rule might well apply to rural areas everywhere. It is extremely desirable that the cost be reduced to the lowest possible amount consistent with the criteria of health protection, structural safety, and acceptability.

In countries of South-East Asia, the earth-pit privy cost, in 1955, between 30 and 125 Indian rupees (US \$6.30 to \$26.25), including labour and material for the pit, squatting plate, and superstructure. A lower cost of US \$2.30 has been obtained on a WHO-assisted project in Thailand for a latrine with water-seal slab (see p. 87). This cost, however, does not include labour for the pit and superstructure. In Nigeria in 1940, a pit latrine was developed with a pit 91 cm (36 in.) in diameter and 1.83 m

**TABLE VI. AVERAGE LABOUR COSTS PER UNIT IN TIME AND CRUZEIROS FOR 1600 PRIVIES BUILT IN THE AMAZON VALLEY, BRAZIL**

	Man-days	% of total labour	Cost in cruzeiros *	% of total cost
Slab	0.42	5.9	8.68	8.0
Pit	1.60	22.5	21.04	19.2
Base	1.10	15.5	21.57	19.7
Mound	0.78	11.0	11.52	10.5
House	3.21	45.1	46.61	42.6
	7.11	100.0	109.42	100.0

\* US \$1.00 = 20 cruzeiros at the time of this construction.

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**TABLE VII. ANALYSIS OF ALL COSTS FOR 1600 PRIVIES  
IN AMAZON VALLEY, BRAZIL: AVERAGE COST PER UNIT IN CRUZEIROS\***

	Material	Labour	Super- vision	Local transport	Misc. undis- tributed	Totals	% of total cost
Slab	21.31	8.68	6.07	2.41		29.47	12.1
Pit	2.94	21.04	4.64	0.07		28.69	11.7
Base	5.94	21.57	8.63	2.82		38.96	15.9
Mound	1.58	11.52	3.64	0.07		16.81	6.9
House	44.04	46.61	10.63	2.77		104.05	42.5
Miscellaneous					26.61	26.61	10.9
<b>Totals</b>	<b>66.81</b>	<b>109.42</b>	<b>33.61</b>	<b>8.14</b>	<b>26.61</b>	<b>244.59</b>	
<b>% of total cost</b>	<b>27.3</b>	<b>44.7</b>	<b>13.8</b>	<b>3.3</b>	<b>10.9</b>		<b>100.0</b>

\* \$1.00 = 20 cruzeiros at the time of this construction.

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(6 ft) deep and with a dried mud cover supported on sticks. The contract price for such a latrine was 1/- (US \$0.25). In Brazil between 1945 and 1952, the average cost of pit and bored-hole privies was found to be 244.59 cruzeiros (US \$12.23) per unit. These latrines (two-thirds of which were pit privies) had reinforced concrete, squat-type floors, soil-cement bases, tamped earth mounds, and either wooden or palm-thatch houses. The analysis of labour costs and of total costs is shown in Tables VI and VII.

### Advantages and Disadvantages

These have been discussed on page 40. Suffice it to say here that, out of the heterogeneous mass of latrine designs produced over the world, the sanitary pit privy emerges as the most practical and universally applicable type.

### Construction

#### Materials

The types of material which may be used to construct various parts of the pit privy have been mentioned above. It is extremely important, in designing privies for rural areas, to plan for the maximum use of local materials. It has been stated earlier that the ultimate objective in any privy project is to get the people of the community to solve their own excreta disposal problem in a sanitary way. The people should therefore be shown a method and means that they can adopt. If the privy units

are difficult to build and full of expensive, imported material, the people cannot be expected to take over by themselves in the future. It should be recommended also, of course, that only good materials be employed. In some cases this may be almost paradoxical, but it is obvious that an installation which begins to fall apart soon after it is constructed is useless. Good materials mean those which will build a sound unit.

In selecting the materials some consideration should be given to the importance of the various parts of the privy ; and, if there is a possibility of employing materials brought in from the outside, such materials should be used on the most important parts. The floor is probably the most vital single part of the unit ; if it can be constructed of reinforced concrete, many subsequent problems are thereby solved. In the first place, concrete makes an impermeable surface that facilitates cleaning ; secondly, if well constructed it will last indefinitely, which is extremely useful for the future when the privy must be moved over a new pit. A good floor is perhaps the biggest stumbling block in getting families to build sound units by themselves. In many countries, especially in Central and South America, there is no further need for intensive privy promotion and construction work in rural areas ; yet health departments continue to fabricate concrete floor slabs, and either to sell them at reduced prices or to give them to the families, who build their own units under the supervision and guidance of the sanitarian. It should therefore be noted that materials can play a valuable role in the rural sanitation programme, and that they should be chosen with care, due consideration being given not only to the initial, but also to the future cost and use.

### **Mass production**

Mass production methods are extremely useful in the construction of sanitary privies whether these are built a few at a time or in great numbers. It is well for the health department to decide on a limited number of types and then to prepare standard plans not only for the unit, but also for its various parts. This procedure has the advantages of :

- (a) economy of construction in time and materials ;
- (b) setting the design, i.e., limiting to a considerable extent the variations which inexperienced staff are apt to introduce into the construction if plans are not made in detail ;
- (c) facilitating procurement of materials ;
- (d) facilitating tremendously the training of workmen to construct the units.

It follows, of course, that where a better selection of materials is possible more use can be made of production in series. In areas where each unit must be constructed of native materials collected locally, there is less

opportunity to apply mass production methods ; but even here some standardization is possible.

The most common and easily mass-produced part of the unit is the concrete floor slab. Forms can be constructed at a central point according to detailed plans to assure uniformity and then be sent to the point of manufacture of the slabs. Here, with a crew of four or five men and ten forms, floors for several hundred privies can be produced in a short time. With proper care, each form can be used hundreds of times. The secret of long form-life lies in careful packing for shipment, keeping them well soaked with oil at all times, and careful handling when in use. A metal form has a fairly high initial cost, but it will last almost indefinitely if properly cared for. In places where transportation facilities permit, floors have been manufactured at a central point and distributed over long distances. This is rather uncommon, and breakage has been found to be high.

After most of the floors have been constructed, one form can be kept at each health centre or wherever an inspector has his headquarters. With the necessary materials, he can usually keep up with the demand for slabs without any special help from his supervisor or any formally organized construction project.

Cribbing of various materials for pits and bored holes has been pre-fabricated in the same way as floors. Houses or parts of houses also lend themselves to production in series.

In many areas, concrete slabs are cast on the spot. This method also has its advantages, which are as follows :

1. There is an opportunity to educate villagers by demonstration.
2. Local voluntary labour and aggregates may be used to reduce unit cost.
3. There are savings in the transportation cost of heavy slabs (about 300 lb. each).
4. There are fewer breakages due to transport.
5. Little technical knowledge is required.

The choice between the two methods must be made by those in the field, and will depend on the type of project, the family's contribution in terms of materials and labour, and other factors.

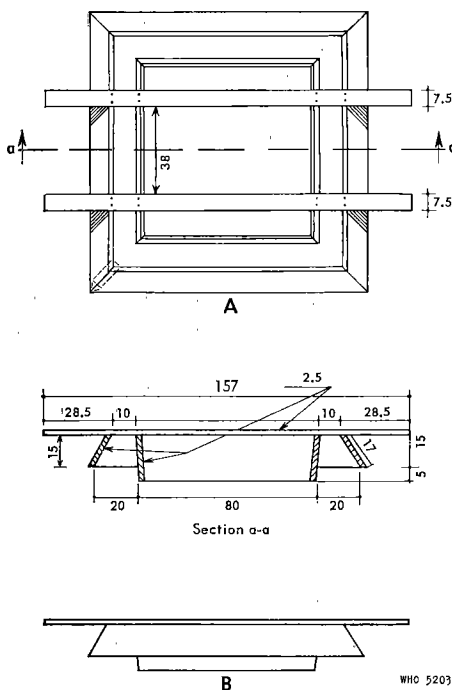
### **Use of jigs and forms**

In any fabrication process, whether simple or complicated, standardization is always desirable to make each part of each unit exactly the same. Building privies is no exception ; and, in order to ensure reasonable similarity, jigs and forms are employed. In digging pits, for example,

it is well to make a simple form marking the limits of the pit where excavation should start. Then, to guide the digger, another form can be made to fit exactly inside the pit, thus assuring that the latter is reasonably close to the size intended.

After the pit is completed, a form can be used to make the base (see Fig. 39). It fits the pit exactly (and facilitates the construction of the base) because the size has been defined by the previous form.

FIG. 39. WOODEN FORM FOR CONCRETE OR SOIL-CEMENT BASE TO USE ON 80-CM-(31-IN.-) SQUARE PIT



Measurements shown are in centimetres.

A = Plan      B = Front view, placed on pit

The engineer will find it well worth his time to study carefully the design of the unit to be built and to break it down into its components, using forms and jigs wherever possible to control the work in the field. If, for example, the pits are not started with guides, they will vary from 5 cm (2 in.) to 10 cm (4 in.) or more in either direction, in which case the base and floor may not fit.

These devices are useful to the inspector when he is working alone. He can accomplish more in his supervisory work because the forms guide and control the work to a great extent.

### **The labour force**

It will be found advantageous to spend a little time training a labour force when parts or all of the units are to be constructed in any number. In a reasonably short time men can be trained to do good work and to be consistent in their labours. Their success, of course, is directly dependent on the instruction and on the control measures utilized. A small crew for mixing concrete in floor construction, for example, can be made to understand some simple rules for controlling quality. If they have carefully calibrated cans or boxes for measuring the aggregates and are well drilled in concrete mixing and placing methods, they will produce good products with a minimum of supervision.

It is always advisable to appoint one man in a group as its foreman. A little extra pay will usually bring out supervisory ability. This same procedure applies to the fabrication of a part or of the entire unit. Very often it will pay the health department to hire a person who has had some experience as a construction foreman and to train him in privy construction. Working under the technical supervision of a sanitarian, such a man can often do a great deal of work. With this kind of assistance the sanitarian has time for the important job of contacting and winning the support of the families. This type of organization applies to any kind of construction project; it is especially useful in the execution of privy projects when the health department is contributing money and material.

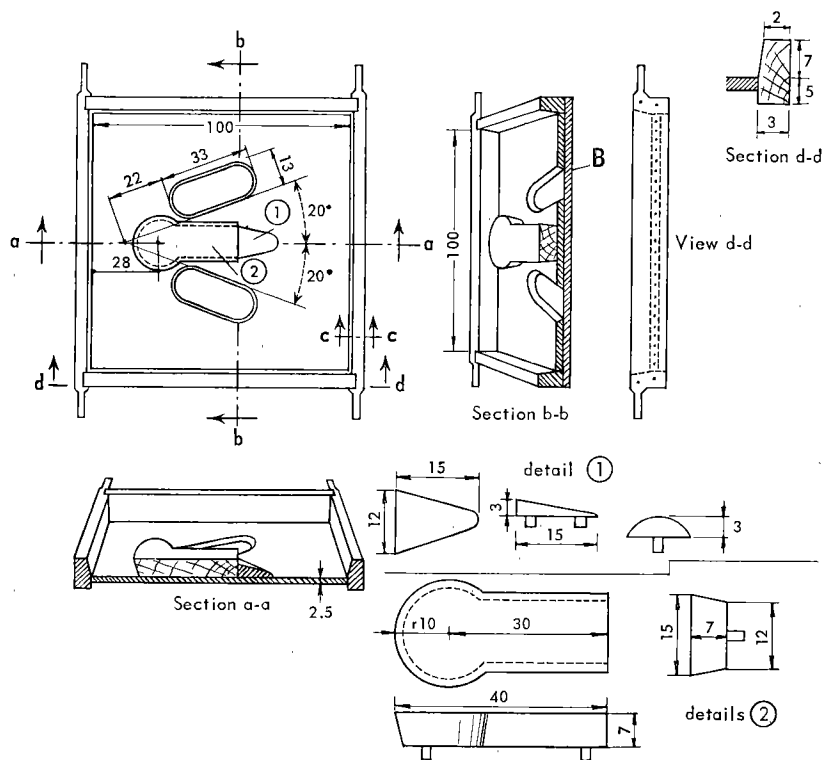
### **Construction procedures**

Procedures used for the digging of pits and the construction of latrine floors and superstructure vary a great deal from one country to another. No attempt will be made to describe them all or to indicate which method is considered best. As pointed out before, the design of latrine features must take into consideration local skills. The following technical information, however, may prove useful in most instances.

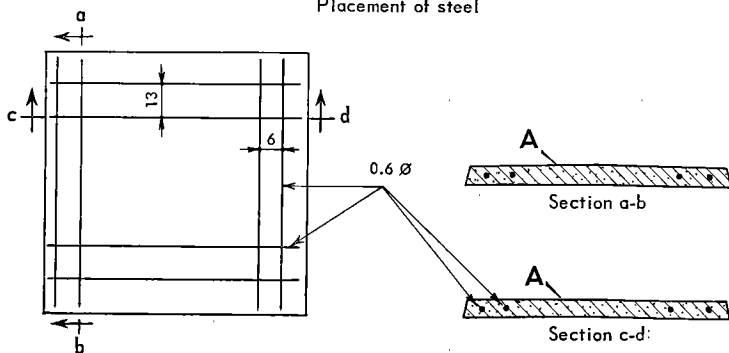
Fig. 19 shows a method of constructing wood in floors out of green logs and wooden planks or wooden poles. Fig. 39 illustrates a simple wooden form for building a concrete or soil-cement base. Typical wooden and steel forms for concrete slabs are shown in Fig. 40 and 41. Wooden forms can be built anywhere to suit the particular slab design and dimensions desired.

Concrete made of one part cement, two parts sand, four parts broken stone (not over 2 cm (0.75 in.) in diameter), and just enough water to

FIG. 40. WOOD FORM FOR PRIVY SLABS 100 CM (39 IN.) SQUARE



## Placement of steel



WHO 5205

Measurements shown are in centimetres

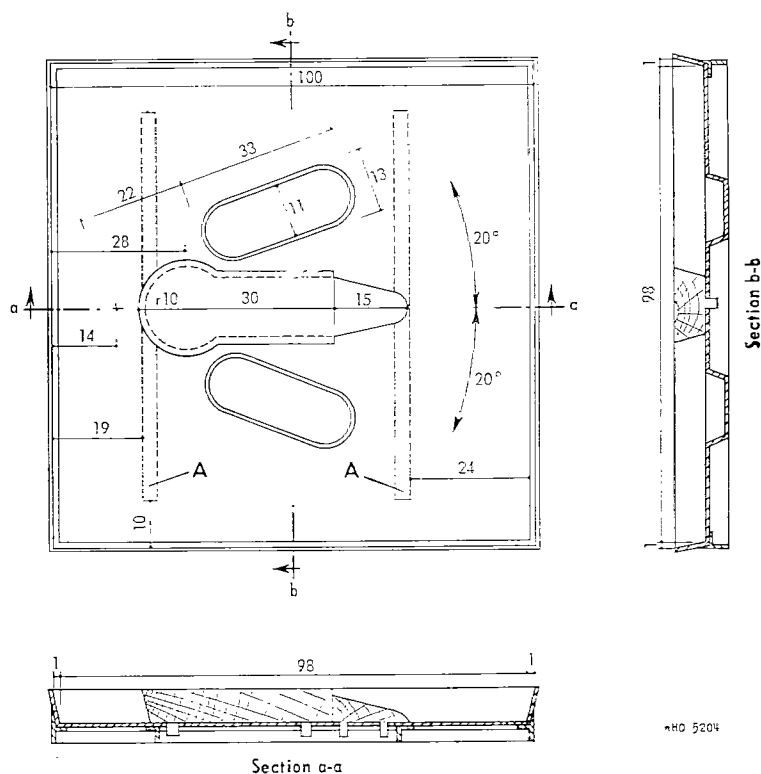
A = Slightly concave slab upside down

B = Board to support form for foot-rest only

produce a stiff but workable mixture should be used. The concrete may be mixed by hand or by machine. The sand and gravel used should be clean and free from dirt and other excessively fine matter. Reinforcement may be made of hog-wire, 6.35-mm (1/4-in.) steel, or bamboo<sup>17</sup> (after satisfactory field trials).

Concrete should be carefully poured in the form and should be well tamped or spaded, as this operation will make it flow well around the reinforcing bars. The fresh concrete should be covered with a damp mat or straw, which should be sprinkled with water and kept constantly in a moist condition for seven days. This is very important to prevent the concrete from losing part of its water by evaporation and, hence, its strength. In mass production operations the slab is removed from the form after one or two days and is immediately immersed in water for five to six days. The slab may also be cast on the ground, or rather on a layer of sand

FIG. 41. STEEL FORM FOR CONCRETE PRIVY SLABS 100 CM (39 IN.) SQUARE



Measurements shown are in centimetres.

A = Angles welded to bottom

spread flat over the ground. This eliminates the need for heavy forms. The slab's surface may then be trowelled to a smooth finish from its upper edges towards the hole.

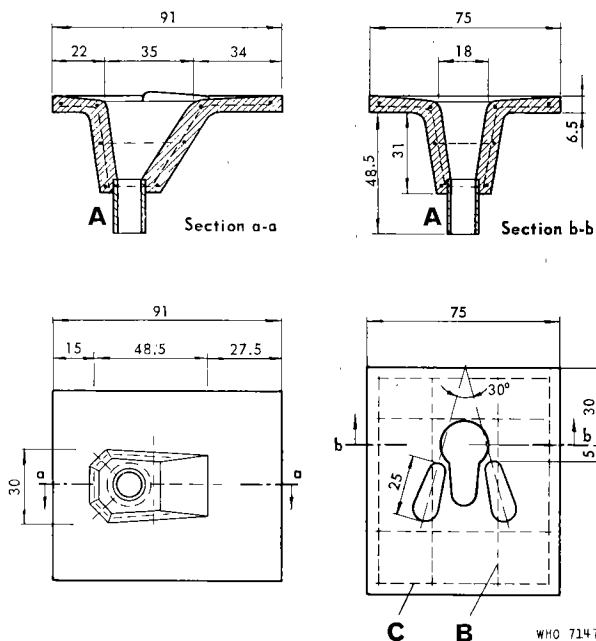
When sand and cement only are available, a mixture of one part cement to three parts sand can be used with brick and reinforcing bars, as shown in Fig. 25 B.

## THE AQUA PRIVY

### Description

The aqua privy consists of a tank filled with water into which plunges a chute or drop-pipe hanging from the latrine floor (see Fig. 42-44). The faeces and urine fall through the drop-pipe into the tank, where they undergo anaerobic decomposition as in a septic tank. The digested sludge, which is reduced to about a quarter of the volume of the excreta deposited, accumulates in the tank and must be removed at intervals.

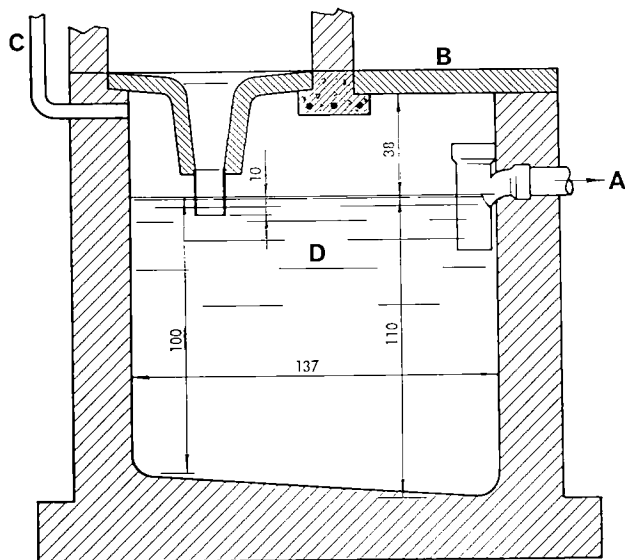
FIG. 42. SQUATTING PLATE FOR AQUA PRIVY



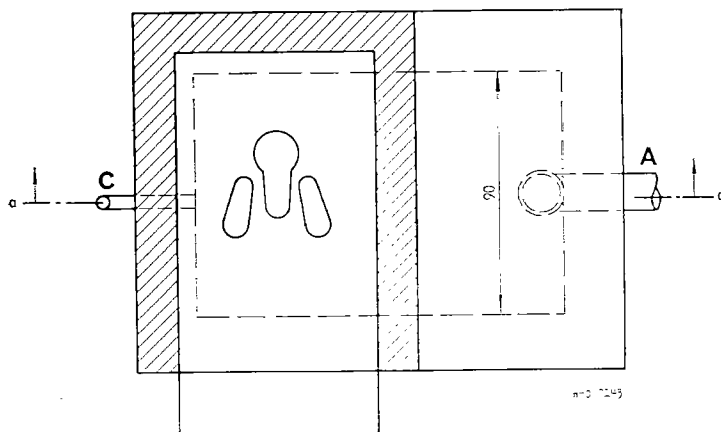
Reproduced from Macdonald, O. J. S. (1952) *Small sewage disposal systems*, p. 138, by kind permission of Messrs. H. K. Lewis, London.

- A = Glazed earthenware pipe cut to 22 cm (9 in.) length
- B = Reinforcement, 0.9 cm (3/8 in.) rod
- C = Reinforcement, 0.6 cm (1/4 in.) rod

FIG. 43. FAMILY-TYPE AQUA PRIVY



Section a-a

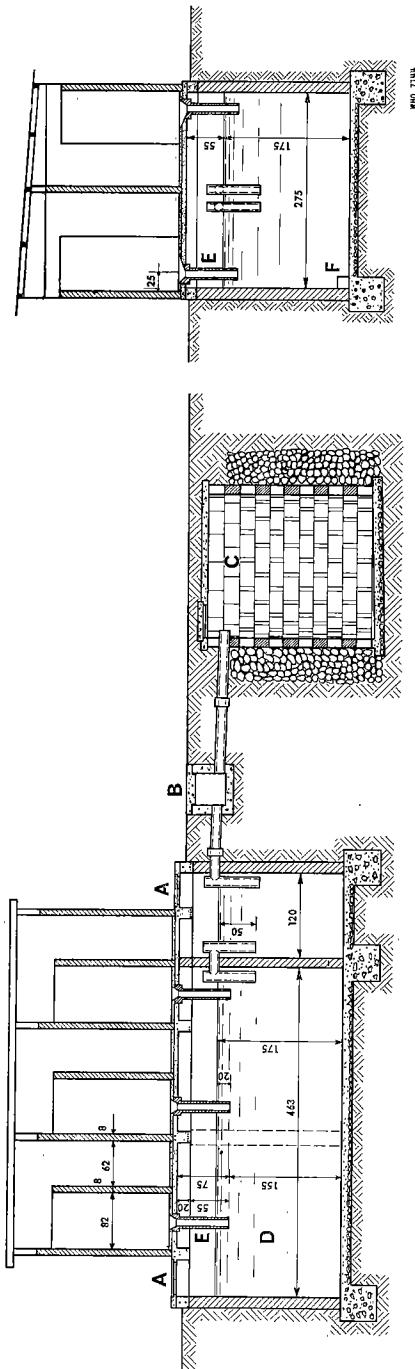


Adapted from Macdonald, O. J. S. (1952) *Small sewage disposal systems*, p. 140, by kind permission of Messrs H. K. Lewis, London.

Measurements shown are in centimetres.

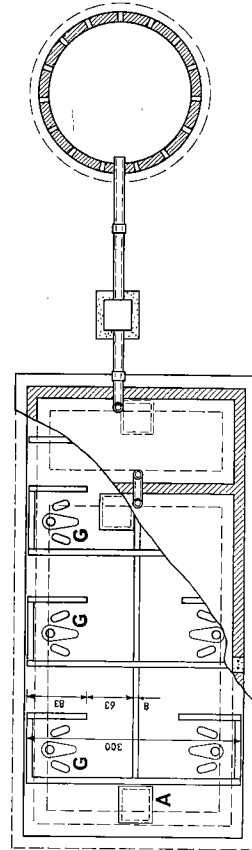
- A = Outlet to soakage trench or soakage pit
- B = Removable, reinforced concrete cover slab
- C = 2.5-cm- (1-in.-) diameter pipe ventilator
- D = Capacity of tank: 1340 litres (295 Imp. gal.)

FIG. 44. PUBLIC AQUA PRIVY BUILT BY UNRWA\* IN REFUGEE CAMPS



Measurements shown are in centimetres.

- A = Inspection manholes,  $40 \times 40$  cm ( $16 \times 16$  in.)
- B = Inspection box,  $40 \times 40$  cm ( $16 \times 16$  in.)
- C = Soakage pit or soakage trench
- D = Capacity of tank:  $22.3 \text{ m}^3$  (4900 Imp. gal.)
- E = Drop pipe 10.5 cm (4 in.) in diameter
- F = Opening  $15 \times 15$  cm ( $6 \times 6$  in.) in partition wall
- G = For shape of hole, see Fig. 45



\* United Nations Relief and Works Agency for Palestine Refugees in the Near East.

## Design and Function of Its Parts

### The tank

The function of the tank is to receive, store, and digest the excreta, to keep them away from flies and other vermin, and to render them innocuous. The shape of the tank depends on local construction facilities and materials; it may be round, square, or rectangular. Concrete tanks built in place are usually square or rectangular since forms for those shapes are easier to construct. Round tanks may be made of plain concrete sewer pipes 90 cm (36 in.) or 120 cm (48 in.) in diameter placed vertically in an earth pit and sealed at the bottom with concrete.

The size of the tank varies with the number of persons for whom it is designed and with the time interval allowed between sludge removal operations. From information gathered and analysed by Macdonald,<sup>29</sup> it appears that the capacity of a family-size aqua privy should preferably be not less than one cubic metre (35 cu. ft), allowing for 6 years or more between cleaning operations. Other data indicate, however, that a smaller tank may also operate efficiently if the precaution is taken to add water to it daily, but that such a tank requires more frequent removal of sludge and undigested debris thrown into the tank. For public latrines of this type, experience dictates a design figure of 115 l (4 cu. ft) per person for the maximum number of persons to be served.

With such sizes, tanks of aqua privies need not be very deep. This is a decided advantage from the viewpoint of construction, especially in areas where ground water or rock level is high. The usual practice is to provide a water depth of 1.0-1.5 m (39-60 in.), 1 m being considered a minimum.

For proper operation of this type of latrine it is important that the tank be water-tight. Should there be any leakage, the water level in the tank will fall below the lower opening of the drop-pipe, and as a result, flies and mosquitos will have access to the tank, odorous gases of decomposition will escape directly into the superstructure, and, finally pollution of the soil and ground water will occur.

Materials commonly used for the construction of the tank include: (a) plain or reinforced concrete, or (b) brick or stone masonry with plaster cover. Concrete is admittedly the best material to ensure water-tightness; in addition, it is permanent and relatively easy to work with. In areas where bricks and stones are abundant, they may be cheaper to use; but they require a coat of rich cement plaster to make them water-tight.

### The floor or slab

The floor or slab of aqua privies is usually of the squat type and is provided with a short length of pipe as shown in Fig. 42 and 43. Depending upon its design, it may or may not include a bowl. The earlier type of

septic privy was provided with a riser and seat but had no chute. As a result, the water and scum in the tank were accessible to flies and mosquitos, which bred in it; septic odours were also noticeable. The use of this type of privy is being progressively abandoned in certain better developed countries in favour of better, water-carried, sewage disposal systems.

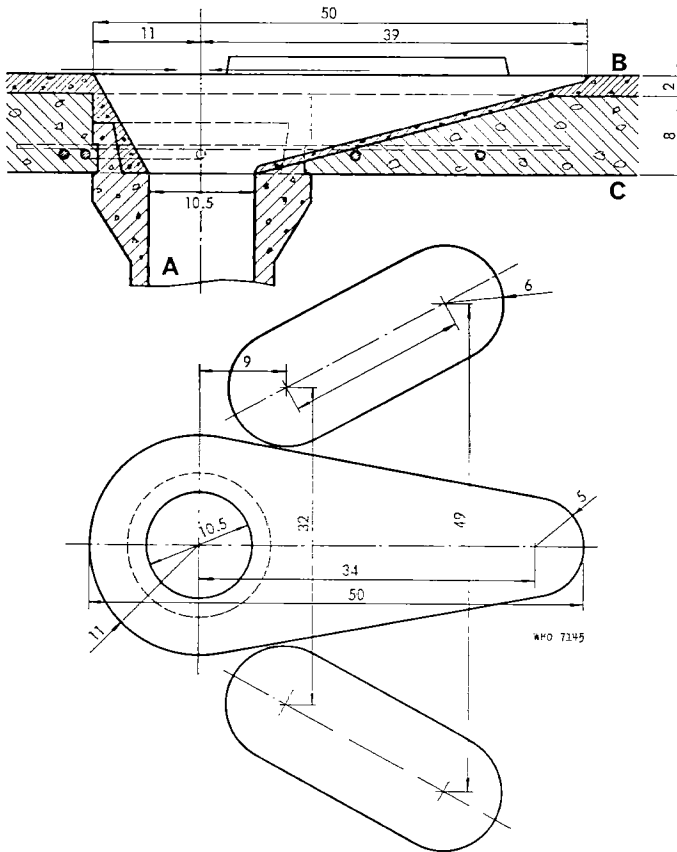
The floor or slab may be made of concrete, wood, or other material. Since the aqua privy is permanent in nature, the floor is usually made of a durable material such as concrete. This material lends itself well to mass production methods, as previously noted in connexion with the construction of pit-privy floors and slabs (pp. 52 and 71). Typical slab designs for aqua privies are shown in Fig. 42 and 45. The size and thickness of the concrete slabs are governed by the same considerations as those already mentioned for pit-privy slabs. The slab surface is provided with a small slope from the edges towards the hole or bowl to ensure drainage into the tank of the water used for cleaning and flushing the slabs, in addition to the water normally used in certain parts of the world for ablution or cleansing purposes.

The bowl is usually made of cement and is pre-cast with the slab, while the chute or drop-pipe is made of earthenware or vitrified clay pipe. Cement pipes may also be used, but will not last as long as the other types mentioned since the lower extremity will tend to disintegrate along the line of contact with the liquid in the tank. The size of the pipe varies from 10 cm (4 in.) to 20 cm (8 in.) in diameter, depending on the anticipated use and maintenance of the privy. If the privy is properly used, the smaller size will be satisfactory; but, in places where stones, mud balls, or sticks are likely to be used for personal cleansing, the larger size will tend to reduce blockage of the pipe. The smaller pipe size will prevent the water from splashing and will normally be free of crust-forming scum when the latrine is in constant use. Pipes larger than 20 cm (8 in.) expose too much of the water surface, over which mosquitos may lay their eggs; in addition, there is an increased nuisance of splashing water.

As to the depth of submergence of the drop-pipe, practice varies a great deal. On this point also Macdonald<sup>29</sup> has made a study of the practice followed in many countries and has experimented with 15-cm (6-in.) and 10-cm (4-in.) diameter pipes set with a 15-cm (6-in.) and 10-cm (4-in.) submergence or water seal. He concluded that "the best results were obtained with a 4-inch pipe having a seal of 4 inches, as a narrow pipe and a short seal increases the effectiveness of flushing". A 10-15-cm (4-6-in.) submergence should be sufficient in most cases provided there is reasonable assurance that the tank is absolutely water-tight and that the liquid level will not drop.

In these latrines, perhaps more than in pit privies, there is a great need for foot-rests, the reason being that the floors of aqua privies are likely to be wet from splashing of cleansing and ablution water. As in

FIG. 45. BOWL FOR PUBLIC AQUA PRIVY \*



\* See also Fig. 44.

Measurements shown are in centimetres.

A = Drop pipe  
B = Rich sand-cement mixture  
C = Reinforced concrete floor

the case of pit privies (p. 57), foot-rests should be properly designed to ensure prompt and easy drainage of such water towards the hole.

### The house or superstructure

The function and design of the house or superstructure for aqua privies are identical to those for pit privies, as discussed above (p. 65).

## Tank ventilation

In aqua privies, where the decomposition of excreta is entirely anaerobic in nature, it is necessary to provide for the escape of the large volume of

gas which is normally produced by fermentation. For this purpose a vent pipe should be installed, as shown in Fig. 43. Its opening in the tank should be just below the slab and away from the scum which might choke it. Its outside opening should be above the roof of the superstructure and away from doors and windows of neighbouring houses, if odours are to be avoided. A 7.5-cm (3-in.) pipe will be satisfactory under most circumstances.

### **The disposal of effluent**

For each litre of water added to the water-tight tank of an aqua privy, a corresponding amount of "sewage" must be evacuated and disposed of as effluent. The latter is septic in character and is loaded with finely divided faecal matter in suspension and in the process of decomposition.

It may also carry harmful bacteria, and the ova of parasitic worms. Furthermore, because of the small size of the tank, the possibility of water's short-circuiting from the chute to the outlet pipe is obvious. For these reasons, the effluent, though small in volume, should never be permitted to run freely over the ground or in open ditches; nor should it be used for irrigation of garden crops eaten raw.

The average amount of water to be evacuated from an aqua privy has been estimated at about 4.5 l (1 Imp. gal.) per person per day.<sup>29</sup> However, a capacity of 9 l (2 Imp. gal.) is recommended for the design of the disposal system. This figure will vary with the degree of availability of water for cleaning purposes and should be corrected by field observations. For example, when an aqua privy is provided with a water tap inside the superstructure, the tank may be expected to receive much more water than is mentioned above and even to be less efficient in its operation. An effluent disposal system designed for a rate of 9 l per person per day will soon be overloaded under such circumstances and will cease to function.

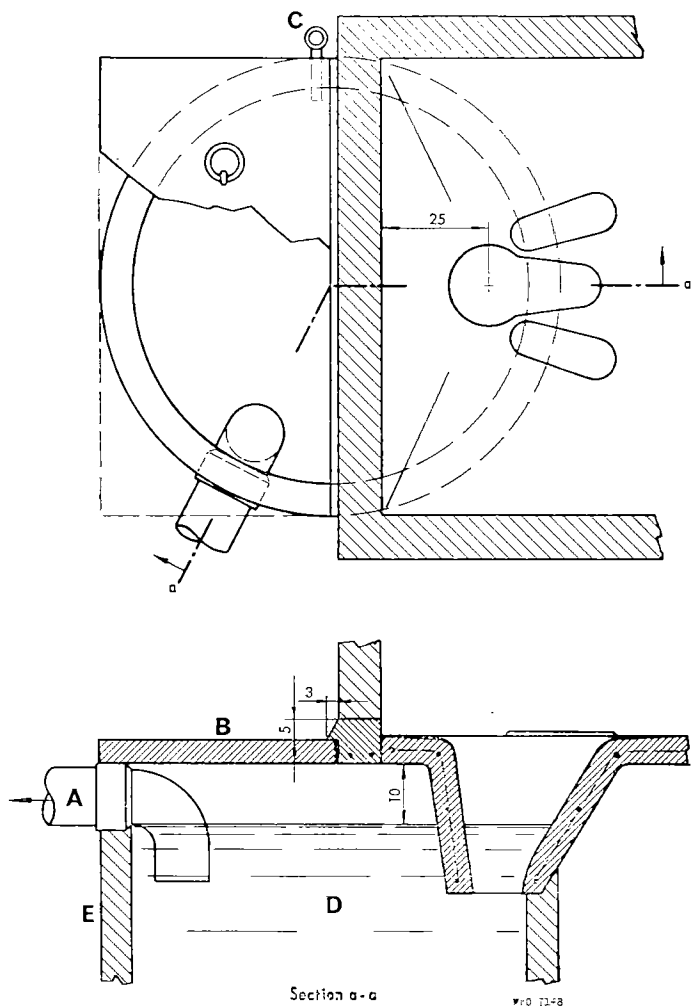
The effluent is carried away through a 10-cm (4-in.) pipe inserted at the proper level into the side of the tank. In order to prevent the scum from entering the disposal pipe, the outlet is fitted with a tee or an elbow, as shown in Fig. 43 and 46. For small installations the disposal of effluent is usually done by seepage pits or subsurface irrigation.

These methods of disposal are discussed later (p. 138 et seq.).

### **Location of Aqua Privy**

A properly operated aqua privy is a clean and odourless installation which may be safely placed close to a dwelling. If proper operation and use cannot be guaranteed, the distance from the dwelling should be increased. Other factors influencing the location of privies in general have been previously discussed (p. 32).

FIG. 46. FAMILY-TYPE AQUA PRIVY USING 90-CM- OR 120-CM- (3-FT- OR 4-FT-) DIAMETER CONCRETE SEWER PIPE FOR THE TANK



Measurements shown are in centimetres.

- A = Outlet to soakage trench or soakage pit
- B = Removable, reinforced concrete cover slab
- C = 2.5-cm- (1-in.-) diameter pipe ventilation
- D = Tank capacity varies with diameter and length of sewer pipe used
- E = 90-cm- or 120-cm- (3-ft- or 4-ft-) diameter concrete sewer pipe, 90 cm (3 ft) long or more, sealed with concrete at lower end

### Operation and Maintenance

The first operation in starting an aqua privy is filling the tank with water up to the invert level of the effluent pipe. Some digested sludge, bailed out from another privy, may be added in order to seed the water with the right types of bacteria and micro-organisms to carry out the decomposition process. This is not absolutely necessary; but, if the tank is not seeded, some time (6-8 weeks) is required to reach an efficient level of operation. Once established, satisfactory action will maintain itself thereafter, provided the privy is in daily use. In areas where anal cleansing with water is not practised, the tank will still receive the small amount of water necessary for its proper functioning through a daily cleaning and flushing of the slab and bowl with two or three buckets of water—i.e., approximately 25-40 l (5-8 Imp. gal.).

As in the case of the wet-pit privy, the human waste deposited in the tank will, when digested, be considerably reduced in volume. After several years' operation (6-8 years, approximately), the digested sludge in a family-size installation will occupy 40%-50% of the tank's water capacity and should then be bailed out. Sticks, stones, mud balls, coconut husks, and similar cleansing agents will not disintegrate and will cause the tank to fill more rapidly, which requires more frequent cleaning. Provision should therefore be made in the design of an aqua privy for periodic sludge removal through a manhole. Such a manhole may be located either inside or outside the superstructure. It should provide for easy access to the sludge and to the outlet tee and the ventilation opening, both of which may need to be cleaned of the scum or other solids accidentally lodged in them. The manhole should be tightly fitted to prevent the ingress of flies and mosquitos. It should also be easily accessible, and not be buried under an earth cover and forgotten.

The sludge bailed out will, of course, contain some undigested matter which is still offensive. This should be buried in shallow trenches 40 cm (16 in.) deep.

One difficulty often experienced with poorly maintained aqua privies is that the drop-pipe gets choked with fresh faeces upon which flies lay their eggs. Maggots then hatch and migrate all over the house's interior walls and ceiling and create a considerable nuisance to the users. An attempt has been made to alleviate this trouble, apparently with success, by providing an arrangement for lifting the chute 20 cm (8 in.) before and during flushing. By this procedure the seal is broken for a short period. Another method is to use a plain stick to push the faeces down the chute.

### Cost

As previously mentioned, the aqua privy is receiving increasing attention in Asian and African countries. If, as recommended, the maximum cost

of a latrine should not be more than the average monthly income of a rural labourer, the aqua privy could not reasonably be considered acceptable or economical in the rural areas of these countries. It is true that this type of latrine has not seen extensive application in the rural villages of South-East Asia and Africa, chiefly because of its high original cost ; it has rather been used in urban or suburban areas, often as a public convenience, and on large plantations and estates.

Few reliable data are available on costs of aqua privies in various countries. In Ceylon, Macdonald<sup>29</sup> found in 1952 that the average costs of aqua privies built with permanent materials and including the super-structure were £22 (US \$61.60) for the single unit shown in Fig. 43, and £39 (US \$109.20) for a double unit. The construction of aqua privy parts by mass production methods would undoubtedly reduce these costs.

### **Advantages and Disadvantages**

From the foregoing considerations, the advantages and disadvantages of the aqua privy can be summarized as follows :

#### *Advantages :*

1. If properly used and maintained, the aqua privy satisfies the seven criteria, set forth on p. 39 relating to health hazards and aesthetic considerations.
2. The aqua privy is a permanent type of installation which is relatively simple and inexpensive.
3. It can be placed near a dwelling.
4. It will withstand abuse.

#### *Disadvantages :*

1. Its rather high initial cost may prevent its extensive use in rural areas in certain parts of the world.
2. It may not be successful in rural areas where there are no organized sanitation and health education services.
3. It requires water (although a small volume only will suffice) for its operation.
4. It requires operation and maintenance on a daily basis.
5. It cannot be used in cold climates.

Among the various types of latrine the aqua privy ranks high, with the pit privy, as a desirable excreta disposal system in areas where the water supply is limited.

## Construction

### Materials

As in the case of the pit privy, locally available materials should be used to the greatest possible extent in the construction of the aqua privy. However, the aqua privy is a permanent installation which should preferably be built of durable materials. Also, the vital part of an aqua privy is its tank, which must be water-tight. This implies that cement must be used for concrete walls, or for joints in stone masonry or brickwork, and for the all-important plaster coat. Cement is not available in every rural area, and often its cost is prohibitive. This consideration alone may preclude the use of the aqua privy in some instances, and the solution of the excreta disposal problem will then be found in the use of the pit privy with a water-seal slab, or another type of installation suitable to local conditions and meeting local acceptance.

Concrete is to be preferred for the construction of the aqua-privy floor, although wood may also be used. For the house, any locally available material may be used, to suit the owner's taste.

### Mass production

The small, family-size, aqua privy lends itself well to construction by mass production methods. The use of large-diameter concrete sewer-pipes, where possible, eliminates the need for forms, which involve lumber and skilled labour, and may result in an appreciable saving of money and construction time (see Fig. 46). The slab, or floor parts, may also be standardized (see p. 71).

### Construction procedures

The training and use of a small crew drawn from local craftsmen for building aqua privy tanks are a decided advantage even in areas where pre-casting of parts is done at a central plant.

The essential steps in the construction of the tank are as follows:

1. Dig a pit to fit the size of the tank and place therein a 10-cm (4-in.) layer of gravel, which should be well tamped to make a firm foundation.
2. Pour at one stretch the bottom concrete, at least 10 cm (4 in.) thick, together with 20 cm (8 in.) of bottom wall, using a 1 : 2 : 4 cement-sand-gravel mix with not more than 23 l (5 Imp. gal.) of water per bag of cement.
3. Continue the wall, inserting the outlet tee and vent pipe connexions at the proper levels. Then plaster the inside surface of the tank with a 1.25-cm (0.5-in.) coat of a rich 1 : 3 cement-sand mixture, paying particular care to the joints in the concrete walls.

4. After the concrete has set, test the tank for water-tightness by filling with water for 24 hours.
5. Lay the floor, and complete the superstructure.
6. Dig the seepage pit or disposal trenches as designed.

The construction of concrete slabs has been described above (p. 73). The only difference to be noted here is that aqua privy slabs are always cast in an inverted position to facilitate the casting of the bowl and the proper placing of the drop-pipe.

## THE WATER-SEAL LATRINE

### Description

The water-seal latrine, also called the pour-flush unit, consists of an ordinary concrete slab into which a specially made bowl is incorporated, as shown in Fig. 47. Usual practices call for a seal 1.25-3.75 cm (0.5-1.5 in.) deep. Such a slab may be installed directly over or at a close distance to, a pit, bore-hole, or septic tank. In the case of the septic tank, the bowl is connected to the tank by a short length of pipe. One to three litres (or quarts) of water are sufficient to flush the contents into the pit. Because of the water seal, flies cannot gain access to the contents of the pit, and odours cannot escape.

### Design and Construction

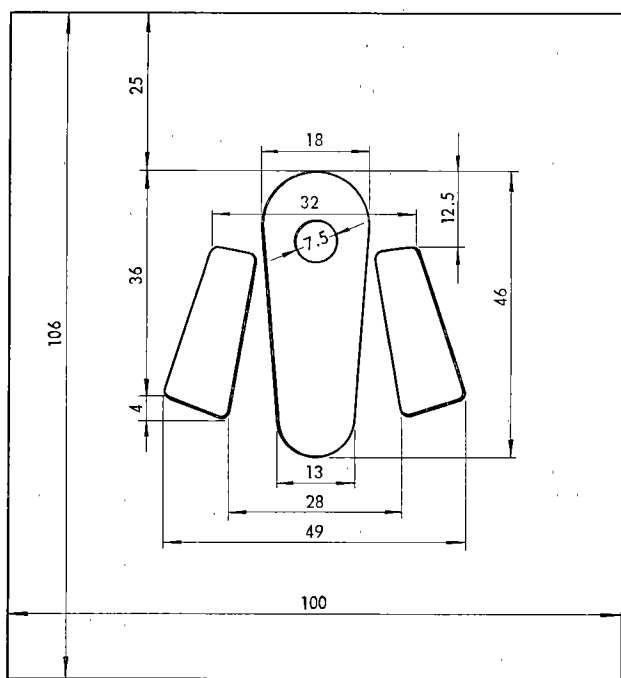
#### The squatting plate

Various methods have been developed to cast the slab and bowl (see Fig. 48 and 49). Sometimes the trap assumes a P-shape or an S-shape, depending upon the location of the slab with respect to the pit.

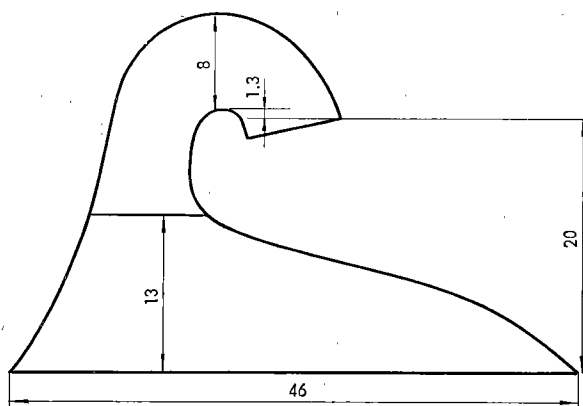
The following description<sup>42</sup> is drawn from experience at Chiangmai, Thailand, where latrine bowls were formed from cement mortar and incorporated in concrete slabs. The Chiangmai technique, which is applicable everywhere, was found to be more practicable and to result in lower costs than most of the previous methods of casting. The dimensions given are intended merely as a guide, since the size and shape of latrine bowls and slabs are subject to local variations. In particular, the inclusion of raised foot-rests is a debatable point (see p. 57).

The general method of manufacture is as follows. A form is prepared in the shape of the interior of the bowl and trap; the form is plastered with a mixture of Portland cement and sand; and the bowl is left to harden and cure at the point of manufacture. The finished bowl is then transported

FIG. 47. WATER-SEAL LATRINE



A



B

WHO 6253

Measurements shown are in centimetres.

A = Plan

B = Form for casting water-seal bowl

to the latrine site ; the latrine slab is cast, with the bowl forming an integral part of it ; and the finished slab, after hardening, is lifted into place over the latrine pit.

A longitudinal profile of the form for the interior of the bowl is shown in Fig. 47 B. Each form consists of two parts, the main portion being made of a rich cement mortar (two parts Portland cement to one part sand), or of solid wood, carefully finished and oiled ; the other part of the form—for the interior of the trap—is made of clay. In Chiengmai, the wooden form costs the equivalent of US \$3.40 and is much preferred to concrete, both because of its superior durability and because of the greater ease with which it allows the bowl to be removed.

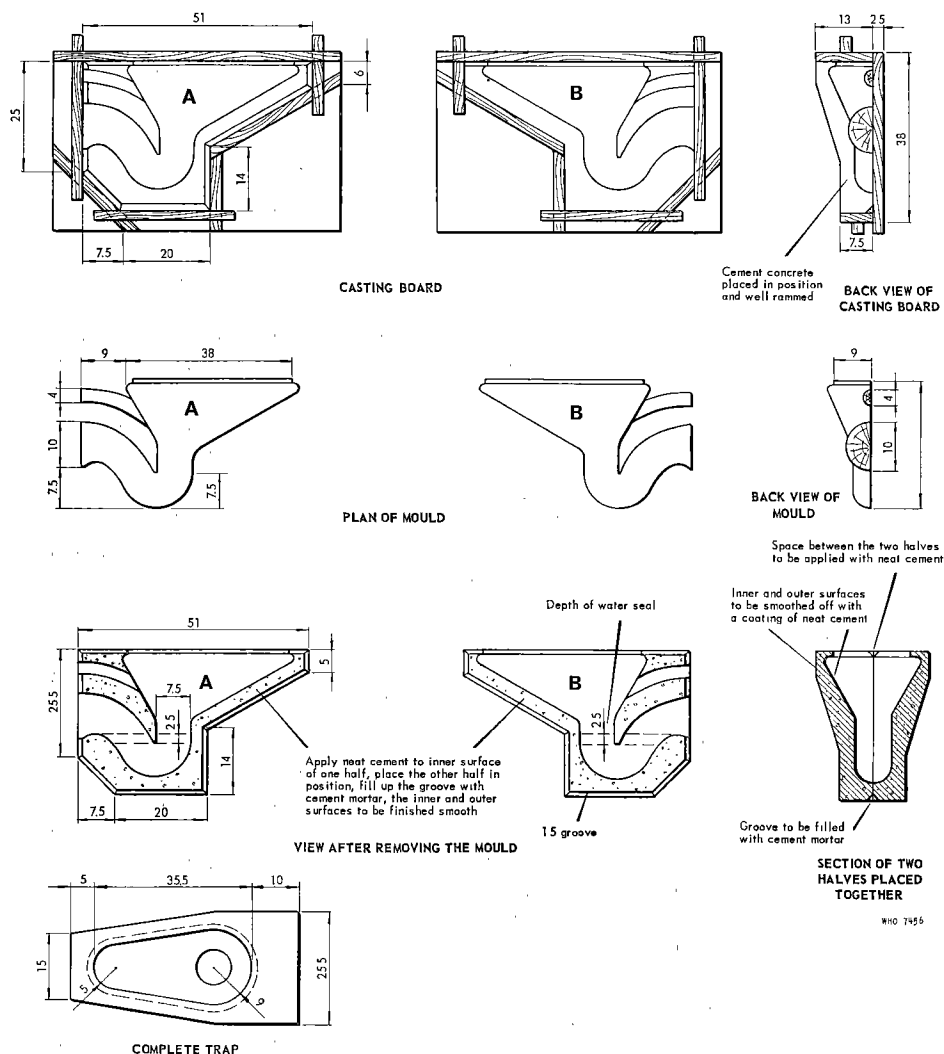
The clay to be used in making the form for the interior of the trap is kept covered with water until needed. When it has been brought to a workable consistency by the addition of ash, it is moulded into a U-shaped roll in a curved pipe-mould. An essential part of the form is a shelf, which is used to support one end of the U-shaped roll of clay ; the other end of the clay roll rests upon the main part of the bowl form. The shelf is located 20 cm (8 in.) above the base of the main form. When the U-shaped roll is set in place, it is carefully smoothed to the main form with a small trowel, so that no irregularity is left on the interior surface of the finished bowl. The whole assembly is then oiled.

A thin cement-sand slurry is pressed over the form by hand, and dry cement is dusted on to provide the bowl with a dense, smooth interior surface. Finally, a stiff mortar, consisting of one part Portland cement to three parts sand, is pressed on by hand and trowelled smooth to a uniform thickness of 1.25 cm (0.5 in.). The bowl is left in place for 24 hours or longer, and is then removed from the form, taking the clay core with it. The operation of preparing the form and making one bowl requires about 25 minutes. After the bowl has hardened, the clay core is dug out of the trap with a small trowel, the entire surface is washed with a cement-water slurry, and the finished bowl is set aside and kept wet for about one week to cure. One 50-kg (110-lb.) bag of Portland cement, costing about US \$1.50, is sufficient for 27 to 30 bowls.

One advantage of the Chiengmai bowl is that the trap discharges forward, beneath the mid-section of the bowl. Experience with traps that discharge towards the rear has shown that the back wall of the pit is liable to be washed away. Such a danger is minimized when the discharge is near the centre of the pit.

The details of the slab used at Chiengmai are shown in Fig. 47 A. The size of the slab must be adapted to the dimensions of the pit. Whether or not a special foundation is needed to support the slab edges depends upon the nature of the soil. The finished bowl is transported to the site of the latrine and is cast into the squatting slab. A hole is dug, and the bowl is inserted so that its rim is level and 5 cm (2 in.) above the surface of the ground.

FIG. 48. METHOD OF CASTING WATER-SEAL SLAB IN CEYLON



Measurements shown are in centimetres.

#### Details of casting

The casting boards A and B with the moulds fixed should be placed in position and cement concrete 1 : 2 : 2 (0.6 cm or 0.25 in. gravel) should be deposited into position and well rammed. Twenty-four hours should be allowed for setting.

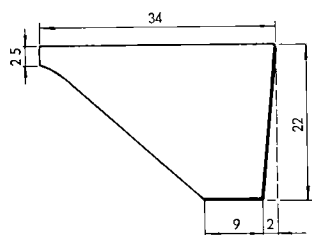
Remove the two halves and apply neat cement to the edge of one half and place the other half in position and fill up the groove with cement mortar.

The inner surface should be smoothed off with a coating of neat cement.

After completion, the trap should be cured in water for a period of at least one week.

FIG. 49. WATER-SEAL TRAP AND SQUATTING PLATE

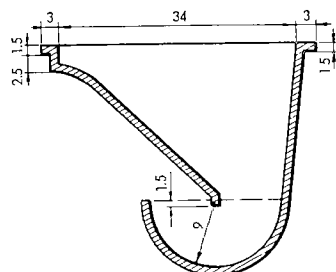
## WATER SEAL TRAP



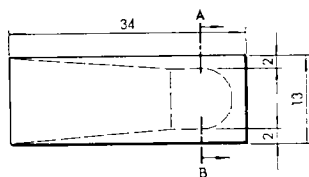
ELEVATION



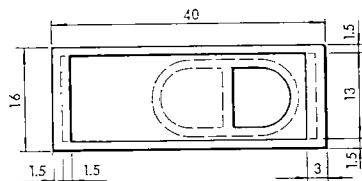
SECTION A-B



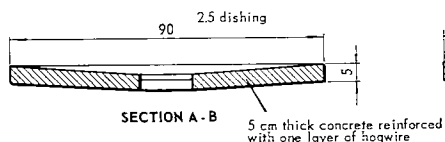
SECTIONAL ELEVATION THROUGH CENTRE



PLAN OF CORE

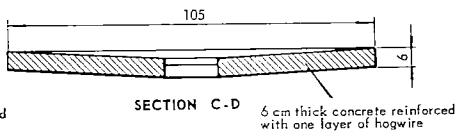


PLAN OF WATER SEAL



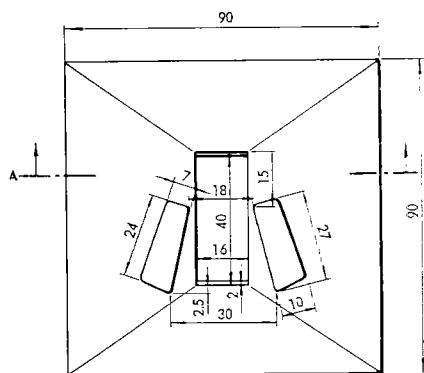
SECTION A-B

5 cm thick concrete reinforced with one layer of hogwire

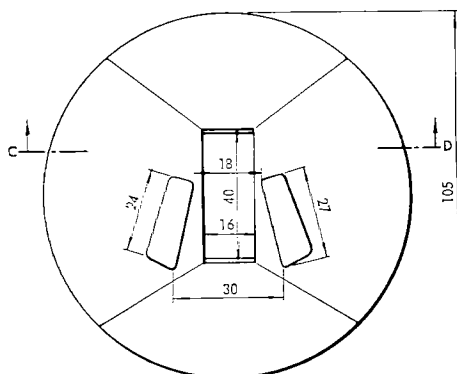


SECTION C-D

6 cm thick concrete reinforced with one layer of hogwire



DETAIL OF SQUATTING PLATE



DETAIL OF SQUATTING PLATE

WHO 7457

Measurements shown are in centimetres.

Siphons made of a cement-sand mixture (1 part cement to 1 part sand). Upper portions and lips 1 cm ( $\frac{1}{2}$  in.) thick; lower portion, 0.9 cm ( $\frac{3}{8}$  in.) thick. Finished weight about 26 kg (12 lb.). Cast inverted in one operation by plastering over core and expendable clay mould (for trap).

Loose soil is packed around the bowl, and a wooden frame, 5 cm (2 in.) high, is set in place, with its upper edge level and 2.5 cm (1 in.) above the rim of the bowl. The ground inside the frame is then smoothed and tamped, so that it slopes downwards from the frame towards the bowl; thus a uniform thickness is preserved in the finished slab. Some kind of reinforcing material—chicken-wire, for example—is then laid, and 5 cm (2 in.) of concrete, made with one part cement, two parts sand, and four parts broken stone (not over 2 cm (0.75 in.) in diameter), is poured on and trowelled to a smooth finish from the upper edge of the form to the edge of the bowl. The slab must have an even finish to ensure easy drainage into the bowl. If foot-rests are required, separate small wooden forms may be used. It should be noted that casting on the bare ground eliminates the need for the heavy and expensive base-boards and ribs which are commonly used. After the slab has hardened, the pit is prepared, and the squatting plate is lifted by hand and set in place over the pit.

The cost of such a slab, based on 1955 prices, has been calculated in Chiangmai as follows:

<i>Item</i>	<i>US \$ *</i>
Bowl. . . . .	0.25
Slab :	
cement (1/3 bag) . . . . .	0.50
labour ** . . . . .	0.23
reinforcement . . . . .	0.23
sand and gravel . . . . .	0.14
Total . . . . .	<u>\$1.35</u>

\* Exchange rate of 22 bahts to the dollar

\*\* Daily wage of US \$0.68

This estimate includes the overhead costs for casting bowls at a central plant, but not, of course, the cost of digging the pit or building the superstructure. According to Chiangmai experience, when a householder supplies the labour for these last two items, his total expenditure on materials for the squatting plate and the superstructure amounts to approximately US \$2.30, that is, about one-sixth of the monthly income of the lowest paid worker.

### **The disposal system**

When the squatting plate is placed over the disposal pit, the latter is designed and built in the same manner as for ordinary pit privies (see p. 42). If the squatting plate is installed inside the dwelling, the pit is dug outside and assumes the shape and design of a leaching cesspool (see p. 123), or of a bore-hole. In this case, the distance between the cesspool or bore-hole and the squatting plate should be as close as the building foundation permits; otherwise, the drainpipe becomes too long and tends

to clog within a short time because of the small volume of water used to flush the faeces from the bowl (see Fig. 50). The drain pipe is usually 10 cm or 15 cm (4 in. or 6 in.) in diameter and made of cast iron or ordinary cement sewer pipe laid with a steep slope (not less than 5%). Because of the added expense and difficulty in laying this pipe, it is often preferable to place the squatting plate directly over the pit or bore-hole.

Another system makes use of a septic tank in lieu of a pit or bore-hole in areas where the ground water is high and interferes with the proper functioning of deep pits. This system is, of course, very expensive for ordinary rural areas and communities. It should be noted that, in addition, a subsoil disposal field is required in such systems for the effluent of the septic tank.

### **Location**

If properly operated, latrines equipped with the water-seal-type slab fulfil all sanitary requirements and may be placed inside the dwelling itself. Some engineering factors governing the location of the disposal system often prevent such an ideal arrangement. However, even then it is possible to locate such latrines very close to the houses which they serve, a condition which ensures its daily use in bad as well as good weather.

### **Advantages and Disadvantages**

These may be summarized as follows :

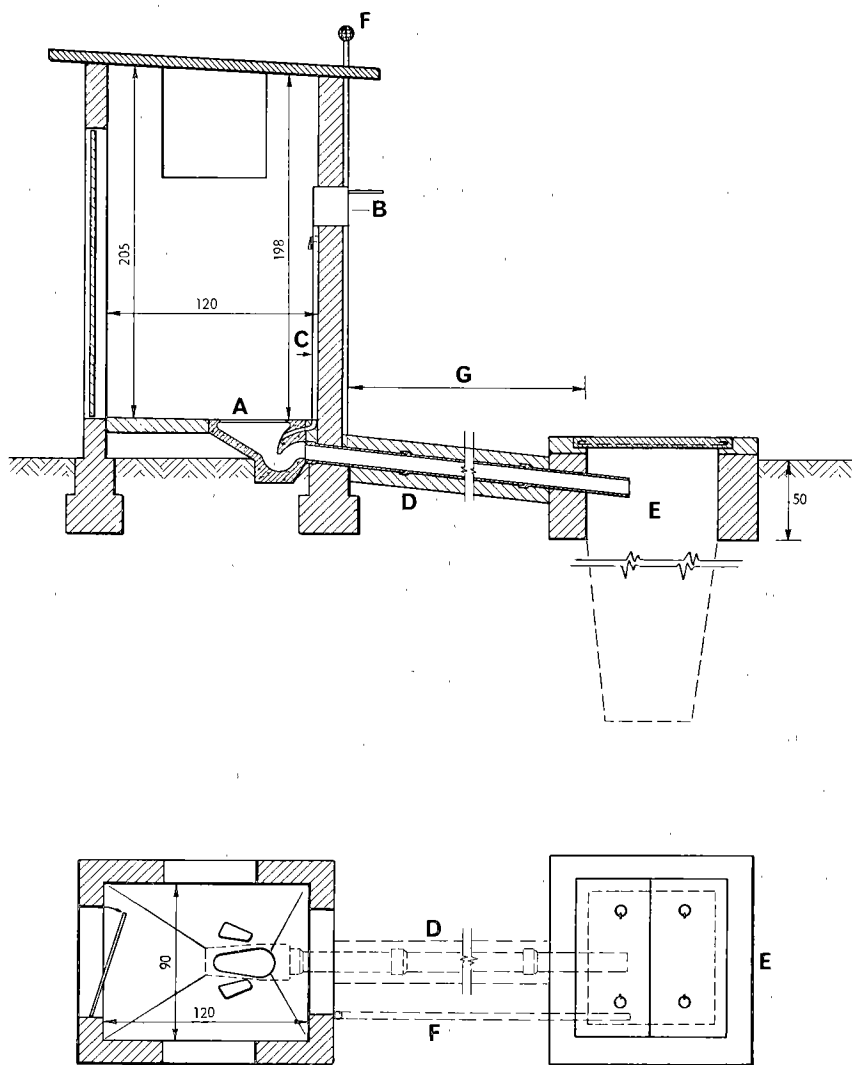
#### *Advantages :*

1. The water-seal (pour-flush) latrine, when properly operated and maintained, satisfies all sanitary and aesthetic criteria (see p. 39).
2. It can be installed near or inside the dwelling.
3. It minimizes contact with flies and vermin.
4. The odour nuisance is kept to a minimum.
5. It is entirely safe for children.
6. With improved construction techniques, it is simple to build and cheap for use in rural areas.

#### *Disadvantages :*

1. It can be used only in areas where water is obtainable (a small volume will suffice) the year round.
2. It requires a period of intensive education in its proper use and cleaning and continued follow-up by sanitation authorities.

FIG. 50. WATER-SEAL LATRINE USED IN CEYLON



WHO 7458

Measurements shown are in centimetres

- A = Water-seal bowl with S trap
- B = Water tank, filled by hand and provided with plug cock and overflow pipe
- C = Water pipe leading from tank to bowl for flushing purposes
- D = Drain pipe embedded in concrete leading to seepage pit
- E = Seepage pit
- F = Ventilation pipe for pit
- G = Distance between bowl and pit should be as short as possible

3. It costs slightly more than ordinary pit privies, but less than aqua privies.

4. In many rural areas of the world, it would require a change in customary use of cleaning materials.

5. It is not readily applicable in areas with impermeable soils.

6. It cannot be used in freezing climates.

In countries of South-East Asia, latrines with water-seal slabs have been used for more than twenty-five years, and appear to have been readily accepted by the rural people of the region, as they fit in well with their customs and religious patterns. Experience shows, however, that the water-seal latrine should be used only in family installations, that it is not suitable for use in public conveniences.<sup>29</sup>

## THE BORED-HOLE LATRINE

### Description

The bored-hole latrine is only a variation of the pit privy, from which it differs by the much smaller cross-sectional area of its pit. The latrine floor, or slab, and the superstructure are the same for both types of installation. The bored-hole latrine, which was developed 30 years ago in the Dutch East Indies,<sup>46</sup> is now extensively used in countries of Africa, the Middle East, South-East Asia, the Western Pacific, and South America.

### Design and Function of Its Parts

#### The bored hole

This consists of a circular hole usually 40 cm (16 in.) in diameter bored vertically into the ground by means of an earth auger, or borer, to a depth of 4-8 m (13-26 ft), most commonly 6 m (20 ft) (see Fig. 51 and 52). Holes of 30 cm (12 in.) and 35 cm (14 in.) have also been used extensively, and are easier to bore than is the larger, 40-cm (16-in.) size; but experience shows that their capacities are much too small. In fact, the volume of the 40-cm- (16-in.-) diameter hole is considerably smaller than that of the pit privy of same depth, the ratio being 1 to 6.5 in favour of a pit 90 cm (3 ft) square. The same pit privy, 90 cm (3 ft) square, is 11.5 times larger than a 30-cm- (12-in.-) diameter bored hole of the same depth.

Because of its small capacity, the bored-hole latrine dug into dry ground and used only by a family of 5 or 6 persons does not last more than 1½-2 years in most instances, and less where bulky cleansing materials