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SMALL CITIES WATER SUPPLY

TDY REPORT

(Nov. 15 to Dec. 7, 1979)

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GENERAL INFORMATION

A. Background for the Study

During Robert Huesmann's visit to AID/W in July 1979, he met with Joseph Haratani, NE/TECH/HPN, to discuss the need to review the status of water supplies in the secondary cities in Yemen and to explore possibilities for the introduction of alternative and appropriate lower cost systems. Huesmann felt that sufficient attention was being provided by the YARG and donors to the five large cities (Sana, Hodeidah, Taiz, Ibb and Dhamar) and to the small villages, leaving the secondary cities essentially untouched. Based on this discussion, USAID/Sana agreed to a visit by Haratani, accompanied by an alternative technology consultant, to carry out the following scope of work.

B. SCOPE OF WORK

1. Review available information and studies on the water supply and sanitation sector.

2. Review water supply and sanitation sector projects of YARG, USAID and other donors.

3. Identify possible small city water supply and sanitation projects.

C. STUDY TEAM VISIT

The study team was composed of two members, Joseph Haratani, NE/TECH/HPN, team leader, and Michael W. Skenfield, alternative technology consultant. The team arrived in Yemen on Thursday, November 15, 1979 and departed on Friday, December 7, 1979.

During its study in Yemen, the team traveled throughout most of the country except the extreme north and eastern Yemen, both regions being relatively sparsely populated. (See Map I, Population Distribution). The team traveled north to Khamer in the central highlands, to Mahweit in the midlands, west to Hodeidah on the Red Sea coast, south through the Tehama lowlands, and finally back to Sana through Taiz and the Southern Highlands. Its itinerary took the team through six of the ten provinces (Sana, Mahweit, Hodeidad, Taiz, Ibb and Dhamar). (See Map II, Administrative Division). This coverage of the most populated regions of the country provided a fairly representative cross-section of Yemeni

topography, demography and culture upon which this study is based.

II. ASSUMPTIONS

It is generally accepted that safe water, good personal hygiene and household sanitation, and safe excreta disposal are key prerequisites to good health. USAID/Sana has given high priority to the water supply and sanitation sector as evidenced by its program and its request for this study.

Based on discussions with USAID/Sana the study team assumed that inadequate sector attention was being given to the secondary cities in Yemen. The team also assumed that the YARG is strongly committed to improving the health of the Yemeni people and gives high priority to water supply and sanitation sector programs. The team further assumed that the target population gives equally high priority to this sector and that they will support and contribute to appropriate and practical water supply and sanitation projects.

III. METHODS

A. Document Review: The team reviewed available reports and information about Yemen water and sanitation sector while in Washington, D.C. and in Yemen at the following locations:

1. USAID Office
2. YOMINCO Library
3. UNDP
4. Swiss Technical Cooperation, Ministry of Public Works
5. Save the Children Federation/Mahweit

B. Official interviews: The team arranged appointments with various government organizations dealing with water systems and sanitation. Brief descriptions of the governmental agencies are given in Section IV of this report. The following organizations were interviewed:

1. Confederation of Yemeni Development Associations (CYDA)
2. National Water and Sewerage Authority (NASA)
3. Yemen Oil and Mineral Corporation (YOMINCO)
4. Ministry of Public Works, Rural Water Division (RWD)
5. Ministry of Health (MOH)

6. Ministry of Municipalities (MOM), Dept. of Environmental Health (DEH)

C. Discussions with AID, Peace Corps and other expatriates: The team met with Robert Huesmann USAID/Director; USAID/staff; Jack Henry, AID Contractor. Meetings were held with Byron Aldridge and Al Armstrong of the USGS working with YOMINCO. The team was also given invaluable guidance by Paul Dresch of German Agency for Technical Cooperation, Ltd., by Melinda Babcock, YOMINCO Librarian, and Mohamed Abu Bakr, USAID staff.

Those expatriates who had lived in the villages were particularly helpful in describing the socio-cultural characteristics of the Yemeni people. Those who were more familiar with the government structure were instrumental in arranging interviews and were essential for the team's understanding of the bureaucracy in Yemen.

D. Visits to Yemeni homes: The team made arrangements to visit homes in Sana'a and in villages they visited. During off-hours not committed to interviews, travel or writing, the team walked the back streets of several towns to observe and experience the daily life patterns of the Yemeni people.

E. Personal observation and use of water and sewage disposal systems: The team inspected and used toilets in hotels, office buildings and individual homes. The team also visited plumbing stores and observed plumbing construction on buildings in Sana'a and other towns.

IV. FINDINGS

A. GENERAL

The centuries old Yemeni civilization has survived only because it developed life support systems which were in balance with its arid environment. Cisterns were built to provide water during the extended dry seasons. The limited rainfall run-off was chanelled to irrigate farm terraces. Dry farming was practiced extensively. In villages where household water was obtained daily by women carrying jugs on their heads, the value of water was appreciated and water usage was kept low.

Today the Yemeni people suddenly have money to spend. They can afford to drill wells and to use

diesel engine-driven pumps to extract water from sub-surface aquifers. They can now irrigate lands that have been traditionally dry-farmed. They can now pipe water instead of transporting it in buckets. With the help of machines, water is becoming more accessible and convenient.

Plumbing stores now display modern squat-plate toilets (requiring more water), lavatories and faucets, tubs and kitchen sinks. Appliance stores display large quantities of tiny automatic washing machines.

With their new-found wealth, the Yemeni people will soon incorporate these water-using fixtures and appliances into their homes. The end result will be a two-fold strain on water resources:

a. Greater accessibility and convenience will encourage greater water use.
b. The installation of piped kitchen sinks and washing machines in the home will create a greater volume of waste-water requiring proper disposal.

The combination of ever-increasing demands on water and decreasing supplies of water indicate that Yemen has a serious resources problem with which it must deal.

With water mining already occurring in parts of the Sana basin, it is likely that water demand will overtake available water supply in Sana before the turn of the century.

Since water is an overriding constraint to the development of Yemen, USAID/Sana should focus its efforts to assist the YARG in addressing this critical issue in its development plans.

B. SECTOR ORGANIZATION

The water supply and sanitation sector in Yemen is managed by the following YARG agencies:

1. Central Planning Office (CPO), Ministry of Development (MOD).

Contact: No contract was made at the request of our USAID coordinator for protocol reasons.

Comment: In our meeting with NWASA officials, Ali Zein, Sudanese Advisor, had suggested that CPO officials would be the most helpful in contacting key officials in the towns we visited. Since this contact was discouraged, we relied on the many persons we contacted informally during our visit to gain the information needed.

2. Rural Water Division (RWD), Ministry of Public Works (MPW).

Contact: Ibrahim Ashami, Deputy Director General.

Comment: When I introduced myself as a representative of A.I.D. investigating the status of water supplies for secondary cities, Mr. Ashami told me that RWD had specifically requested USAID/Sana for assistance in this sector five years ago but never received a response. He was surprised and pleased that A.I.D. was belatedly showing interest in the secondary cities. In the meanwhile RWD has agreed with the Japanese government to implement water supply projects through a Japanese firm, Pacific Consultants International, for the towns of Yurim, Bayt al Faqih, Sadah and Al Bayda.

UNDP/WHO is providing technical assistance to RWD through two WHO sanitary engineers, ten United Nations Volunteers (engineers and diesel mechanics) and one Netherlands Volunteer.

In addition to USAID assistance, RWD is receiving assistance from Peace Corps, UNICEF, WHO, UNDP, Japan, Iraq, Saudi Arabia, Abu Dhabi, the Federal Republic of Germany and the Netherlands.

3. National Water and Sewerage Authority (NWASA).

Contact: Mohamed Abu Talib, Deputy Director

General

Comments: NWASA was originally created to manage the water supply and sewerage systems in Sana and Hodeidah. It is now also responsible for Taiz, Ibb and Dhamar. It is very likely that as some of the secondary cities grow, NWASA will be asked to take over their water supply and sewerage management.

4. Yemen Oil and Mineral Corporation (YOMINCO)

Contacts: Mahmoud Al-Odeni, Chief, Surface Water; Abdallah Al-Thari, Chief, Ground Water; Jamal Ahmed Zaifallah, Geophysical Technician.

Comments: YOMINCO with the assistance of USGS is collecting basic water resource data. It is collecting stream flow data from 12 stream gaging stations and rainfall data from 60 rain gauges located throughout the country. It is also establishing probably the best library on water resources of Yemen.

5. Ministry of Health (MOH)

Contact: Dr. Hamadnalla Elamin, Deputy Director General of Preventive Medicine.

Comment: The MOH is not involved with the provision of domestic water supplies. It only monitors water quality by conducting chemical and bacteriological analyses.

6. Department of Environmental Health (DEH), Ministry (MOM)

Contact: Ismail El-Thawr, Director General

Comment: This Ministry was recently split off from the Ministry of Public Works and is just now in the process of becoming operational. It presently has no water supply projects although it has overall responsibility for municipal water supplies and sewerage.

7. Confederation of Yemeni Development Associations (CYDA)

Contact: Hamoud Al-Salahih

Comment: All village water supply project requests from LDAs are channelled through CYDA. CYDA provides technical and financial assistance (often from external donor sources) to the LDAs.

C. DONORS

The team found a large number of foreign organizations and governments involved to some degree in community water systems. None, however, were found to be directly involved in sanitation and sewage disposal. The organizations found to be working with water systems are as follows:

1. USAID: Through various YARG agencies and projects.
2. Peace Corps: Volunteers assigned to RWD project.
3. USGS: Technical assistance to YOMINCO.
4. UNICEF: Providing pipe for rural water projects.
5. UNDP: Providing technical assistance to RWD.
6. IBRD: Water supply/sewerage loans to big cities.
7. WHO: Technical assistance to RWD.
8. UN Volunteers: Assigned to RWD.
9. Netherland: Technical assistance & equipment to RWD.
10. SCF: Mahweit Province Village Water Supplies.
11. CRS: Initiating joint project with German Agency for Technical Cooperation, Ltd.
12. Fed. Rep. Of Germany: Water supply for Al Mahabisha.
13. Saudi Arabia: Financed 28 wells drilled by Japanese.
14. Japan: Rural Water Phase I - 50 wells (loan), Phase II-24 wells (grant).
15. EEC: Well improvement in Al Kabbaita villages.
16. Abu Dhabi: Sana water supply grant.
17. Iraq: Grant funds to RWD.

TECHNICAL

1. Geography (See Map III, Physical Geographic Division). Scattered bits of information and evidence indicate that the Western Highlands and perhaps the Western midlands were once forested. Deforestation over the centuries has been accompanied by a reduction in rainfall and in spring flows (according to reports from older Yemeni people). Today the Highlands throughout Yemen are experiencing low precipitation rates and gradually diminishing spring flows. Furthermore, water levels measured in wells in the Central Highlands are dropping at a rapid rate (presumably because of increased pumping and declining precipitation levels), according to a UNDP official.

The Western Midlands appear to be an area of high precipitation rates and of greatest surfacewater availability. Much of the precipitation falling on the slopes of the Western Highlands makes its way into aquifers and wadi alluvium and which reappears along midland slopes as springs and in wadi channels as perrenial streams. Moisture-laden air coming from the Red Sea and picking up warmth and more moisture over the Western Lowlands, cools as it rises and precipitates the bulk of its moisture in the Midlands and Western Highlands.

The Western Lowlands are a "coastal desert." Precipitation levels are low and natural vegetative cover is sparse. Wadis that run freely in the Midlands disappear into the dry sands of the Lowlands. Water that appears on the surface drop out of sight and well below the surface of the deep lowland alluvial plain. Only during heavy rainfall and rapid run-off periods do the lowland wadis flow.

Soils of the Highlands and Midlands exist only in wadi basins and on terraced slopes. Ridge tops and mountain slopes are mainly exposed bedrock. It is in the ridges and slopes where most of the villages are situated. Yemeni homes appear to "sprout" of the rocks.

On the lower Midlands and out on the Western Lowlands the topography flattens and soil depths increase. The thatched Tehama homes

of this region sit on deep and highly permeable silty and sandy soils of an ancient seashore.

2. Water Supply

A. General

Yemen is a water-short country. Although parts of the country (Ibb region) receive as much as 1000 mm. (40 inches) of rainfall per year, three controlling factors produce a semi-arid regime. First, rainfall only occurs during two short periods of the year, from the beginning of April to the end of May and from the end of July to the end of September. Second, the regions of highest rainfall are characterized by steep, rocky slopes which contribute to the rapid run-off of rainfall not collected on farm terraces. Third, the country lies between 13 degrees and 18 degrees north latitude and experiences warm to hot climates the year around. Some information sources suggest that denuding of the land for the collection of firewood has contributed to the problem of aridity. However, there are no long-term rainfall data for Yemen to either prove or disprove this thesis.

Although there are many small perennial spring-fed streams (most of which flow west from the highlands), there are no major rivers in the country. (See Map IV, Physical Setting). The main sources of water for irrigation, industrial and domestic use are from wells, springs and cisterns. Natural surface waters are a very minor resource. Their use is generally restricted to the narrow flood plains adjacent to perennial streams.

B. Springs

Of the secondary cities visited, the only one that depends on springs for its major water supply was Mahweit. Al Masiyah spring which flows out of the center of the town is the main source. There are also several cisterns which collect surface runoff, the largest having a capacity of 2400 cubic meters. This cistern was less than a third full at the time of our visit. Cistern water is not used for drinking in Mahweit, only for washing

clothes and for watering livestock. However in some of the neighboring villages where there are no nearby springs, the people drink cistern water.

There are several springs around and below Mahweit that are used mainly for irrigation. Although the Koran states that water belongs to everyone, traditional usage patterns, especially for irrigation, make it politically unfeasible to divert the total flow of springs for domestic water supplies.

The general pattern in and around Mahweit finds the villages perched on the peaks of mountains and ridges and the springs appearing hundreds of meters below them. Under these contrary conditions, the limited water that can be diverted for town supplies becomes an expensive commodity because of piping and pumping costs.

C. Wells

All of the towns we visited in the highlands (Amran, Raydah, Khamer and Mabar) and in the Tehama (Mansuriyah, Bayt al Faqih and Zabid) depended on wells for their domestic water supply. Although there are significant differences in water resources between the highlands and the Tehama, the existing water supply systems fit into a general pattern. Water is pumped from a dug or drilled well using a one-cylinder diesel engine (usually a Japanese built Yanmar) coupled by belt-drive or drive-shaft with a right-angle gear head to a multi-stage turbine pump. The water is pumped to an elevated tank or a ground level tank above the town and distributed to public spigots and to individual households. Households that receive piped water are usually served by a single tap. Usually the kitchen does not have piped water. Where water is hand-carried, a water canister with a spigot is filled by bucket and used as the only source of water in the kitchen. In none of the towns visited were all of the households connected with piped water. The townspeople interviewed expressed the need for improvement and expansion of their water supply system.

D. Cisterns

The common occurence of exposed bedrock throughout the highlands presents an ideal watershed condition for the collection of rainfall runoff into cisterns. It is an excellent example of appropriate technology and its continued use should be encouraged.

As the rainfall data collection coverage of the country is expanded, changes in rainfall patterns might reveal new areas where additional cisterns should be built to collect runoff.

3. Excreta Disposal

The traditional Yemeni method for excreting wastes is from a squatting position. Both men and women squat to urinate and defecate.

After defecating Yemeni people "cleanse themselves" with water. A bucket near a dry toilet or a spigot near a flush toilet provides the water source. If no water is available, as in outdoor dry toilets, a stone is often used.

The followng types of toilets were observed and used by the team:

Traditional dry pit-toilet. (Figure 1) This is the toilet most commonly found in the stone or adobe homes of Yemen. There are a number of variations of the structure, but the end result is the same. Urine is separated from fecal matter, falls on the floor in front of the raised feces hole and flows along a channel and through a hole in the wall to the outside. This urine flow is usually aided by water splashed along the floor.

Feces are excreted into a hole and drop to a pit in the ground floor below or, in the case of single story homes, into a pit beneath or alongside the house. The pit either has a small opening to the outside at ground level or a sealed-up partition wall that can be broken into for cleaning.

In the cities these pits are occasionally cleaned out and the material hauled away to

an undetermined location. In the village the practice is to utilize dried feces from the pit for fertilizer.

Modified flush/pit toilet. (figure 2) In the Tehama where many of the stone/adobe homes have living quarters on the ground floor, a modified toilet is used. This looks like the pit toilet from above, but instead of feces dropping straight down, they fall into a sewer pipe which slants off to the side and into a underground leaching pit adjacent to the outside wall. The solids are moved through the sewer pipe with water splashed down the hole from a bucket or hose.

Toilet plumbed to sewer lines. Apparently as multistoried public buildings such as hotels and offices were constructed there was a need for a system other than pit toilets. As a result the flush toilets of both Arab and Western styles came into use.

The porcelain or cement "squat toilet" of Arab design (figure 3) is built into the floor and has a water-seal trap to close off sewer gases.

This toilet is flushed by water in a "high tank" mounted on the wall above. The flush volume is about 4-6 liters. The Team observed that in some cases these toilets did not flush efficiently.

European flush toilets (Figure 4) are commonly found in hotels catering to Westerners. These toilets are designed for a 12-liter flush and appear to be operating from 8-12 liters per flush depending on individual adjustments. They are a "rear-flush" design with the sewer connection in the wall behind the toilet instead of in the floor beneath it. As a result, they flush quite inefficiently, especially when they are adjusted to flush at less than the designed volume. Usually a spigot is mounted nearby for hand wiping and toilet paper is available for Westerners.

A modern hotel such as the Hadda Concorde near Sana'a has installed the American Standard "water saver" toilet which can operate at no less than 13 liters per flush. This could be an indication of what may be considered a modern "improvement" to toilets, but is actually a wasteful use of water. Sewer lines for the above-mentioned toilets usually run into some type of cesspool or leaching pit.

Excreta disposal without toilets appears to be common in small villages. Feces are excreted around the periphera of the villages. Urination and wastewater disposal usually occurs on the ground within the village compound.

Vacant lots adjacent to each Mosque are used for public excreta disposal. In some cases (observed in Khamer and Raydah) a public toilet building has been constructed (Figure 5) and the feces pile up beneath to dry. In other cases (beside several Mosques in Sana'a) the feces and urine are excreted out on the bare ground.

4. Hygiene and Sanitation

Essentially all handwashing is accomplished with cold water. Small tanks with a spigot are located in bathrooms and outside village restaurants. There appears to be a conscious effort on the part of the people to wash their hands after using a toilet and prior to eating. Soap and warm water are not commonly used.

Laundry is usually done in cold water. In the villages it is done around a cistern and the clothes laid out to dry on rocks. Waste water from laundry done inside the home follows the same path for other wastewater.

The common housefly is present in large populations around markets, restaurants and in many households. It is found covering garbage in the streets, exposed sewage, and fruits and other foodstuff in the market.

V. CONCLUSIONS

A. Sector Organization

At present, outside of the five big cities (Sana,

Hodeidah, Taiz, Ibb and Dhamar), all domestic water supply construction is the responsibility of the Rural Water Division (RWD). It appears that the RWD is receiving sufficient technical assistance from the UNDP/WHO institutional support project. RWD is also receiving financial and material support from a multitude of donors to the point that donors are almost competing with each other for a piece of the action.

It seems to the team that RWD is receiving more external funding than it has the capacity to effectively manage. In fact, more than one information source stated that projects already designed, approved and funded, are left in limbo because funds and materials are tied up in the bureaucracy or diverted to other uses.

The Division of Environmental Health (DEH) is at the state of organizational development where external technical assistance could play a significant role in its future operation. In stark contrast to the RWD, the DEH is receiving little assistance from major donors. The team suggests that DEH should be the obvious focus for USAID/Sana's initiatives in the excreta disposal and sanitation sub-sector. None of the other YARG agencies (i.e., CPO, NWASA, YOMINCO, MOH) have major interests in village and town water supply and sanitation; however, each has resources which should be utilized in the planning and implementation of projects.

B. Donors

Based on the large number of donors now involved in this sector, the team does not see the need for USAID/Sana to expand its village and town water supply activities beyond project 044. The major problem is not the need for additional sources of funds but the need for YARG to systematically organize and coordinate the many donor inputs.

C. Technical

1. Water Supply

The team concludes there is no program gap regarding secondary cities water supplies. Any further USAID/Sana involvement with RWD will only tend to increase the project logjam that now exists. The only logical manner for USAID/Sana to become involved in secondary

cities water supply projects is through third party agencies (e.g., SCF, RS, Peace Corps).

2. Excreta Disposal

On the whole, the traditional excreta disposal system used in each area is the best and most appropriate method. Ample sunlight for sterilization and drying is present throughout the country. Exposing excrement to sunlight is the most effective means for purifying that waste material. Sanitation problems arise when excrement is exposed to vectors of disease (flies, cats, dogs) or direct human contact (bare feet). Minor modifications can be made to each system to make it sanitary.

Dry pit-toilet. A seal on the toilet hole and on the access hole to the pit can prevent vectors of disease from contacting fecal material. Better control and ultimate disposal of urine is important for improving this system. Other modifications can modernize the method and make it work more effectively and be more aesthetically acceptable (modifications are shown on figures 6 and 7).

Modified flush/pit toilet. The pit in this toilet system is already sealed-off. However the other modifications described above for the dry pit-toilet would make this a more effective system.

Squat toilet and flush tank. This is merely a modernization of the modified pit toilet described above. Its characteristics are as follows:

(1) Provides a water seal instead of a hole cover.
(2) Combines urine with fecal matter (generally considered a disadvantage since urine tends to counteract the natural decomposing organisms in the feces).
(3) Utilizes 2-4 times as much water as the

modified flush/pit toilet.
(4) Places a definite control on urine movement.

The team considers this fixture inappropriate because of increased water use and because it combines urine and feces. A more appropriate fixture would be one that separates urine.

Western flush toilets. The use of a Western-style toilet that flushes at greater than 3 liters is an irresponsible and unnecessary use of precious water supplies in Yemen. The use of any western toilet is inappropriate and should be prohibited except perhaps in dwellings catering to western quests where a low volume (3 liter) design could be used.

3. Personal Hygiene and Sanitation

There appears to be a popular misconception among the Yemeni people that cleansing with cold water is sufficient. The team noticed that at number of streetside restaurants in villages there were small tanks of water, a dirty towel and a sign depicting hands being washed under a spigot. An awareness of the need to cleanse hands is present in this society. The next step is to effectively introduce warm water and soap into that cleansing process.

Sunlight is an ever-present source of energy in Yemen. It can be utilized for the production of needed hot water by a relatively simple installation on each roof top (Figure 8). In the Highlands a freeze-protection provision should be designed in the system. In the Lowlands and Midlands where freezing does not occur, the design can be quite simple.

The team visited with members of health clinics in Amran, Mahweit and Hodeidah. Work in these clinics deals with teaching mothers how to cleanse themselves and their children. Warm water is not available to the clinics or to the Yemeni villager unless they heat it on a stove. Providing solar heated water to clinics as an example would provide a direct avenue for education and demonstration.

VI. RECOMMENDATIONS

A. Sector Organization

The team recommends that USAID/Sana limits its future water supply projects through RWD to Project 044 until at least the present project logjam is cleared and RWD is capable of effectively managing and implementing its project portfolio.

The team further recommends that USAID/Sana explore the possibility of providing technical assistance to the DEH/MOM in the areas of excreta disposal and sanitation.

B. Donors

Because of the large number of donors participating in water supply projects through the RWD, the team recommends that any future USAID/Sana water supply projects be implemented by third parties (e.g., SCF, CRS, Peace Corps) or other donors (e.g., Federal Republic of Germany, Japan) rather than through RWD.

C. Technical

1. Water Supply

The team recommends that USAID/Sana identify, plan and implement appropriate low-volume, low-pressure water supply demonstration projects through third party agencies. These projects should include the use of solar energy to heat water in homes, clinics and other institutions.

2. Excreta Disposal

The team recommends that USAID/Sana plan and implement projects to demonstrate dry and composting excreta disposal systems based on traditional home construction methods and designs.

3. Personal Hygiene and Sanitation

The team recommends that USAID/Sana plan and implement projects to demonstrate the use of solar energy to heat water and to demonstrate and encourage the use of warm water and soap for hand and utensil washing through existing projects (e.g. SCF nutrition center in Mahweit)

or through new projects.

4. Project Design

All of the above technical recommendations are closely interrelated and the team recommends integrating these components within a single project package whereever feasible.

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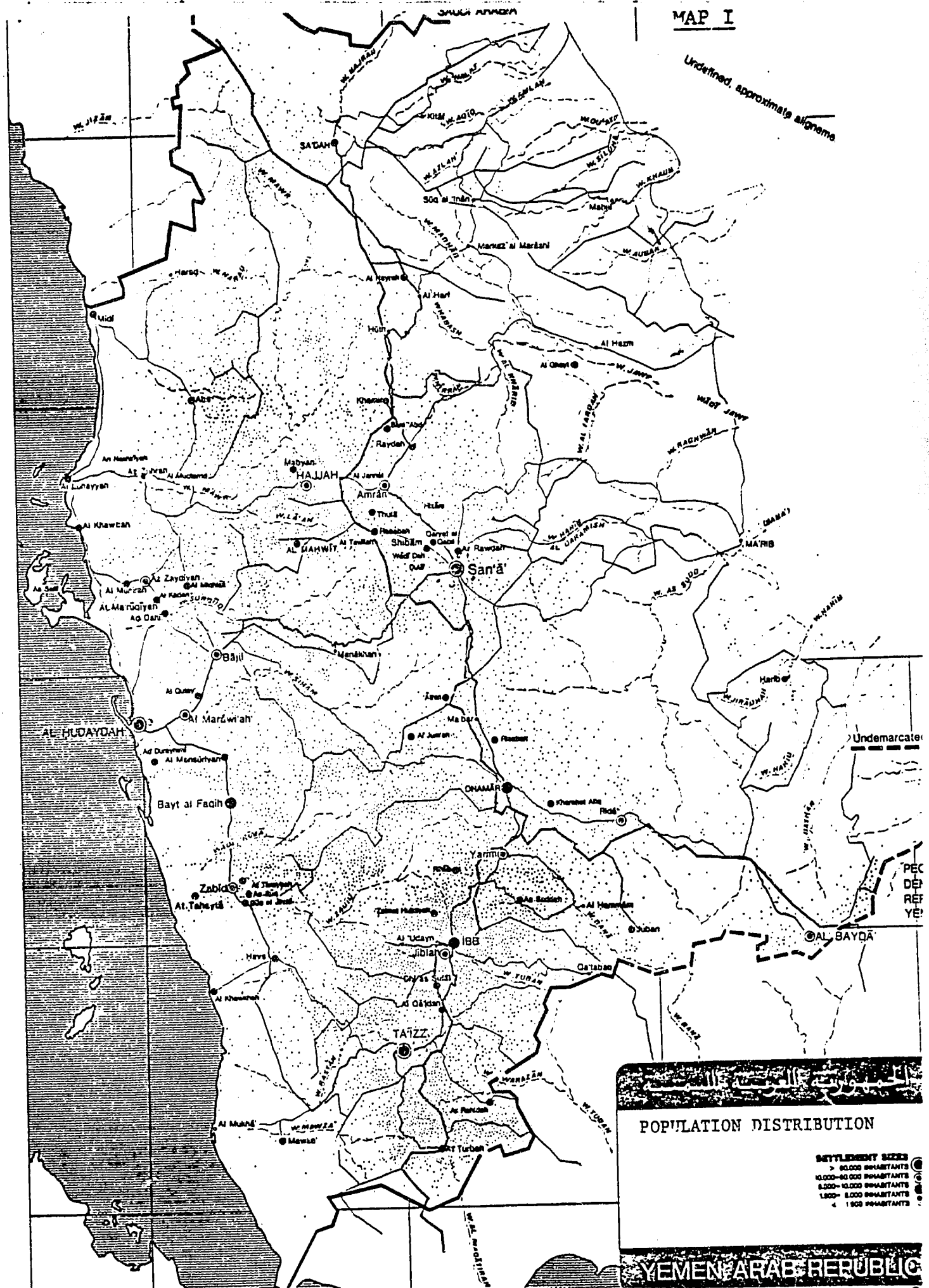
MAP I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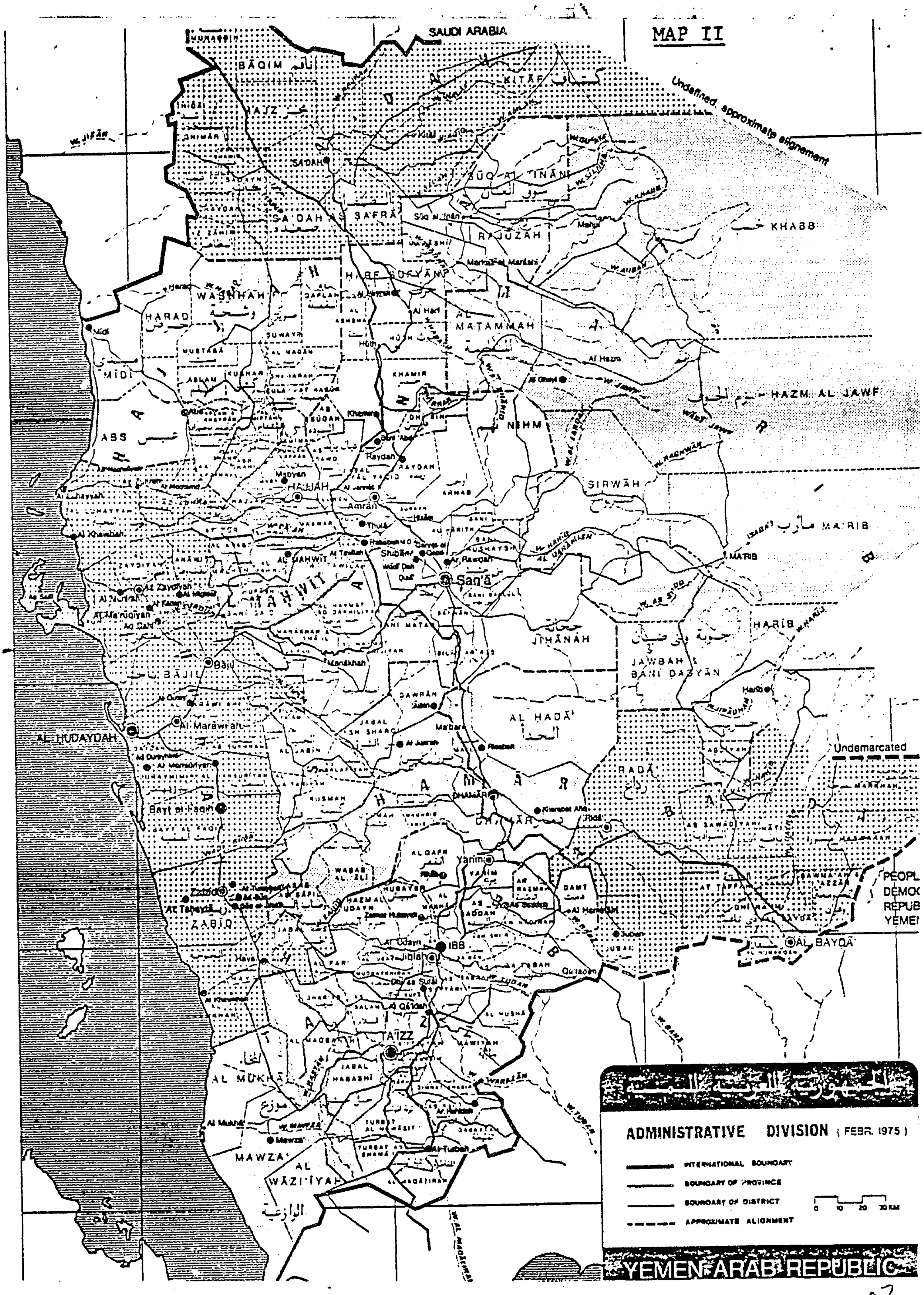
YEMEN ARAB REPUBLIC

MAP II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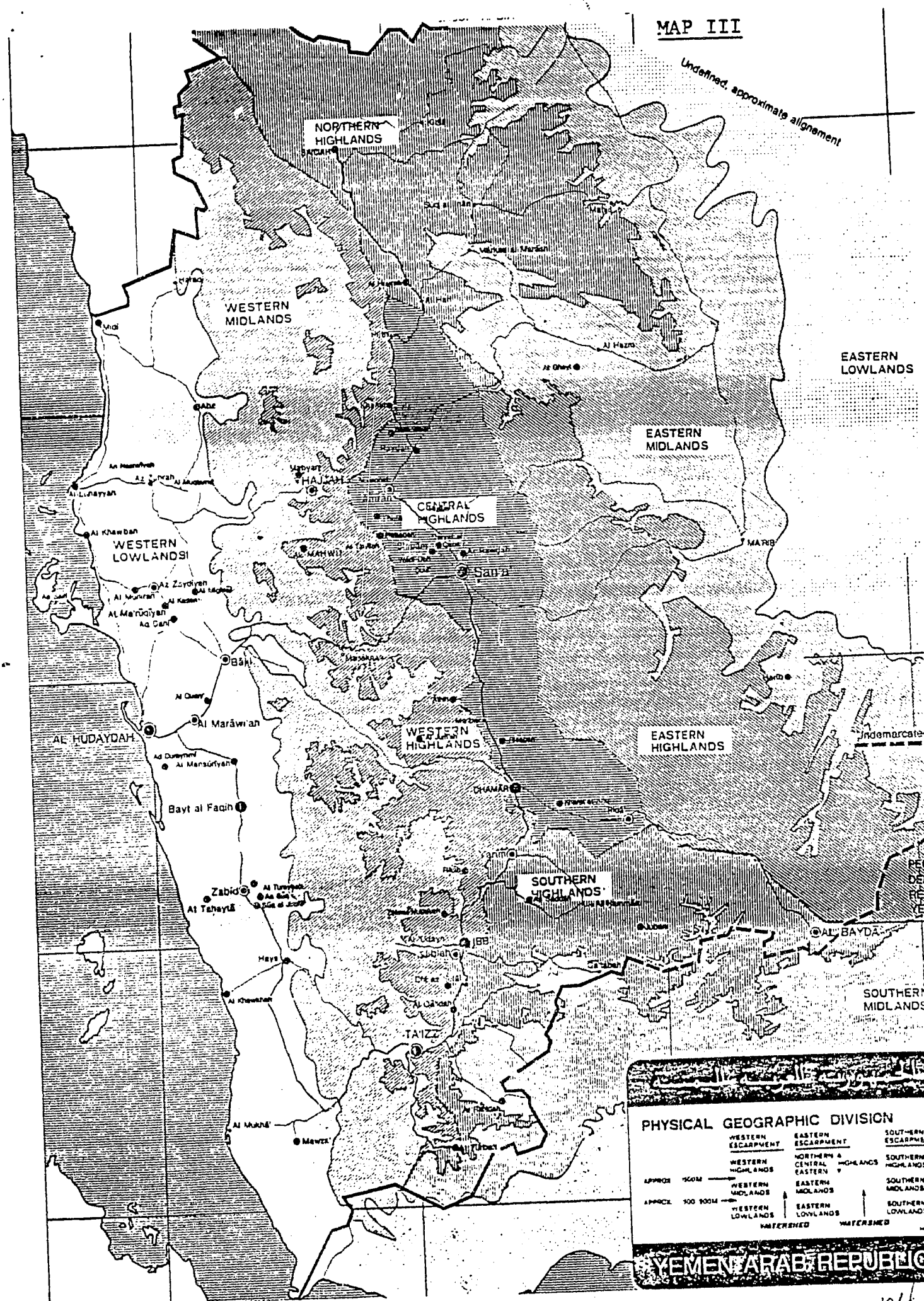
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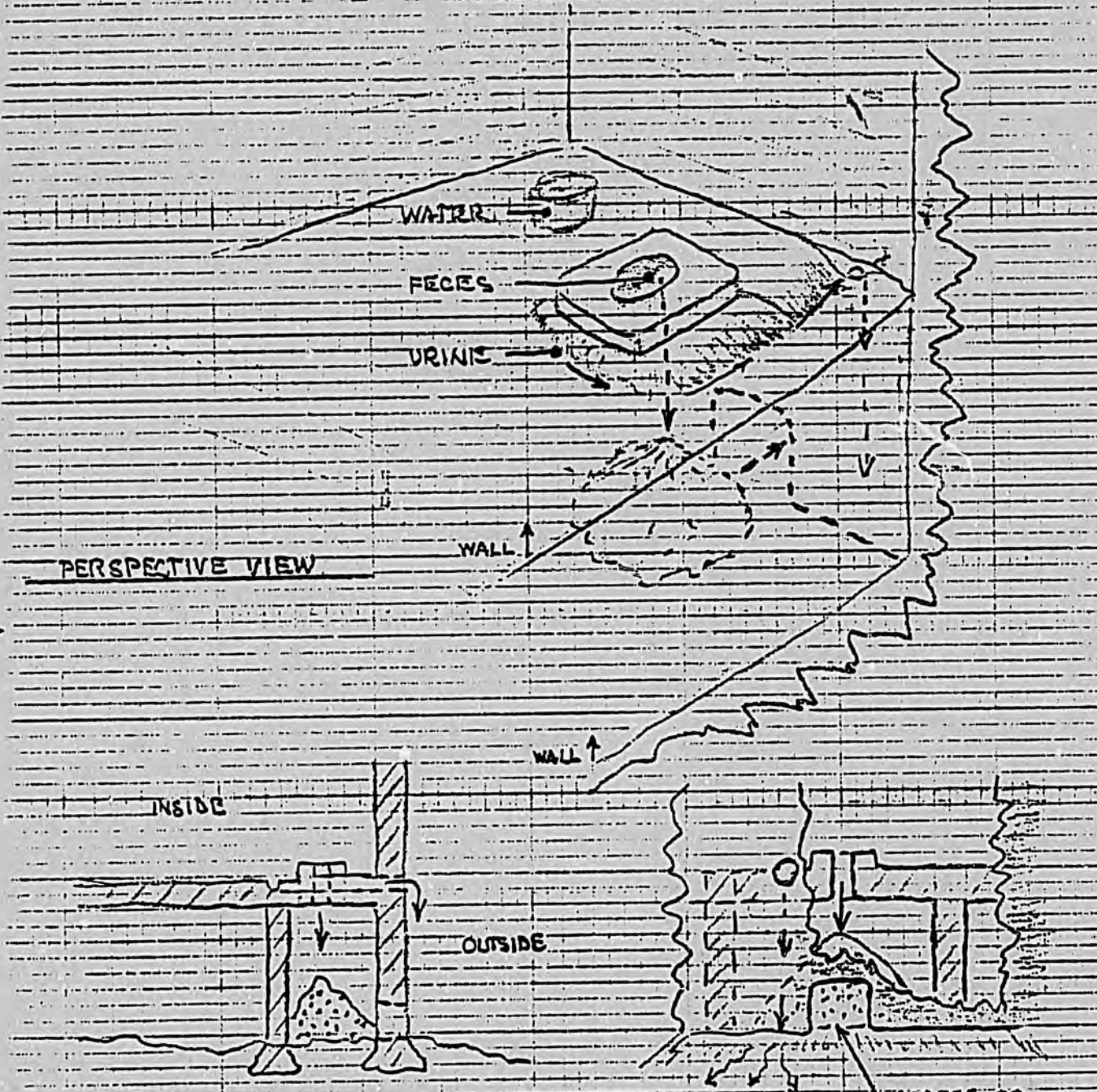
Sana'
MARIB
AL HUDAYDAH
Al Marâwi'ah
Bayt al Faqih
Zabid
At Tahaytâ
Hays
TA'IZZ
Mawza'
AL BAYDA
CHAMAR
Undemarcated
PHYSICAL GEOGRAPHIC DIVISION
WESTERN ESCARPMENT
EASTERN ESCARPMENT
SOUTHERN ESCARPMENT
WESTERN HIGHLANDS
NORTHERN & CENTRAL EASTERN HIGHLANDS
SOUTHERN HIGHLANDS
APPROX 1500M
WESTERN MIDLANDS
EASTERN MIDLANDS
SOUTHERN MIDLANDS
APPROX 100-900M
WESTERN LOWLANDS
EASTERN LOWLANDS
SOUTHERN LOWLANDS
WATERSHED
WATERSHED
YEMEN ARAB REPUBLIC

MAP IV
SAUDI ARABIA
Undefined, approximate alignement
Undemarcat
PHYSICAL SETTING
YEMEN ARAB REPUBLIC
SA'DAH
Sūq al 'Inān
Harad
Midi
Al Hazm
Al Ghayl
WĀDĪ JAWF
W. RAGHWĀN
Abs
Khamira
Bani 'Abd
Raydah
Mabyan
HAJJAH
Amrān
Az Zuhrah
Al Luhayyah
Al Khawbah
Thulā
Shibām
AL MAHWĪT
Ar Rawdah
MA'RIB
San'ā'
Az Zaydiyah
Al Munirah
Al Marāwi'ah
Ad Dahi
Bājil
Manākhah
Harib
W. AS SUDD
AL HUDAYDAH
Al Marāwi'ah
Al Mansūriyah
Ma'bar
DHAMĀR
Ridā'
Bayt al Faqih
WĀDĪ RIMA'
Yarim
Zabid
At Tuhaytā
Al Hammām
Juban
AL BAYDĀ'
Al 'Udayn
IBB
Jiblah
Qa'tabah
Hays
Al Khawkhah
TA'IZZ
Ar Rahidah
Al Mukhā
Mawza'
At Turbah
W. MAWZA'
W. ZABID
W. TUBAN

The Yemeni Toilet



M.W.S. 11/79

FIGURE 1

MODIFIED FLUSH / PIT TOILET

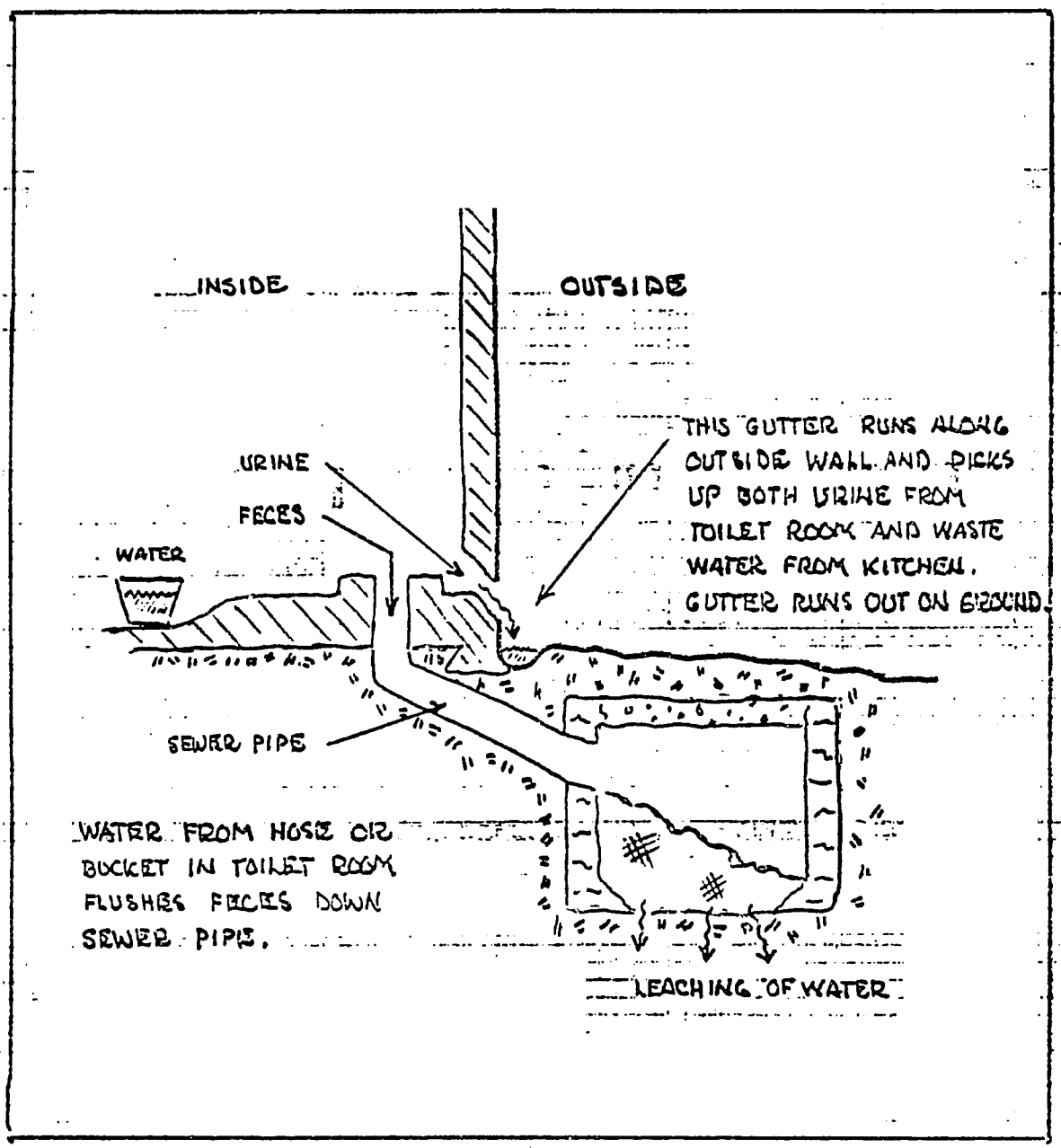


FIGURE 2

SQUAT-PLATE

WATER SEAL

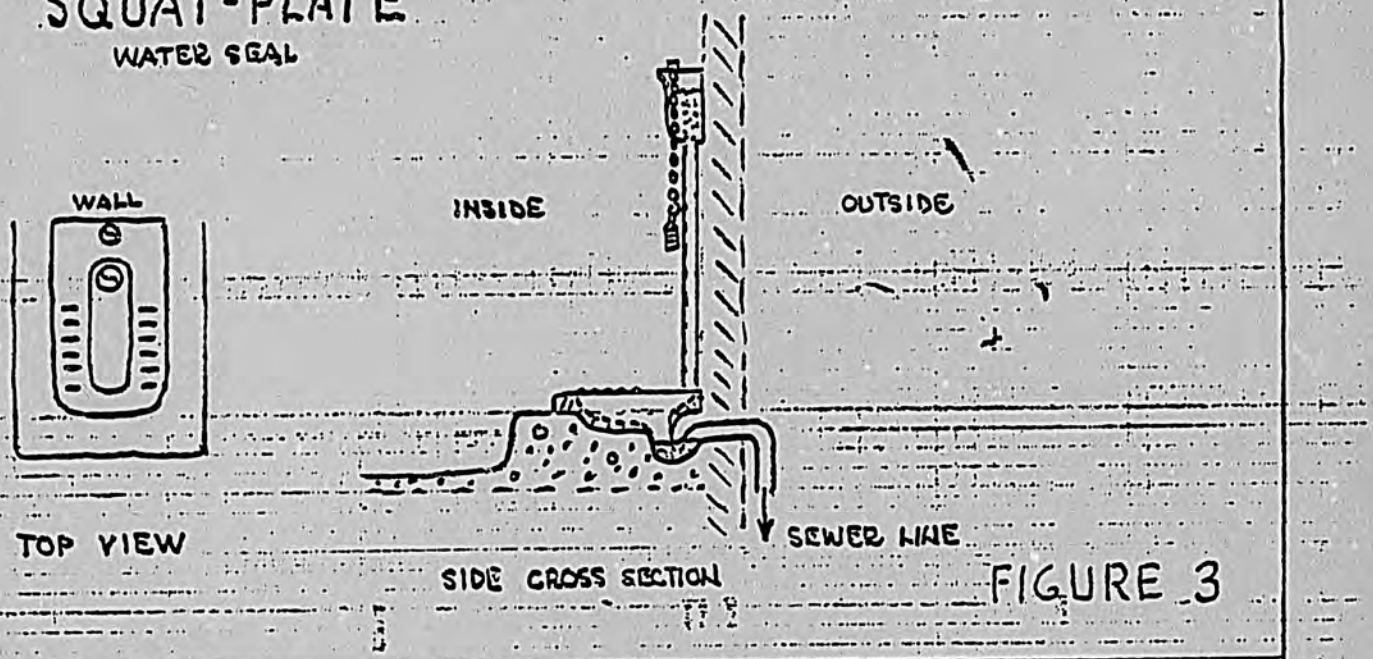


FIGURE 3

EUROPEAN

WATER SEAL

FIGURE 4

M.W.S. 11/79

OUTDOOR PUBLIC "H'MOM"

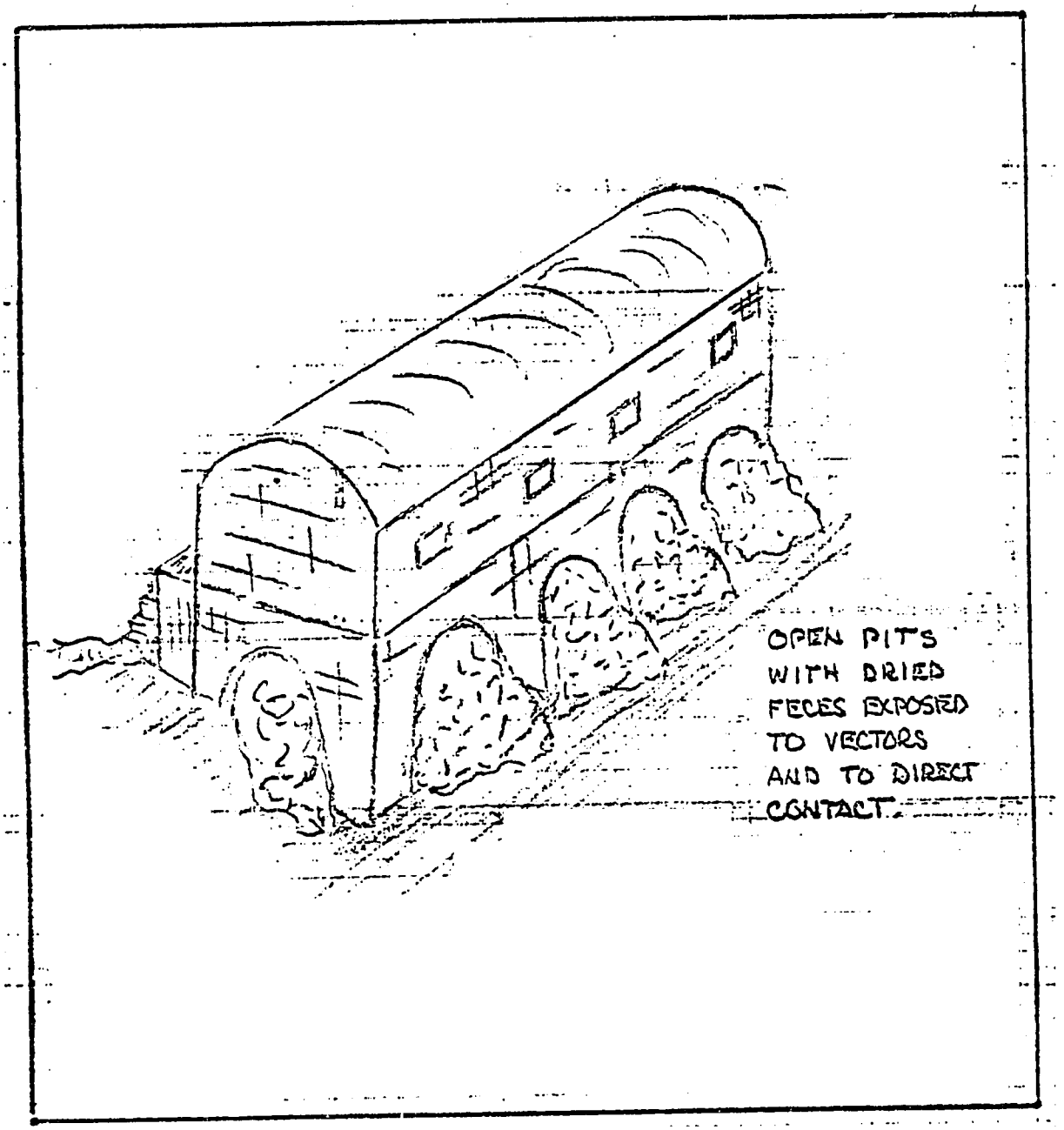
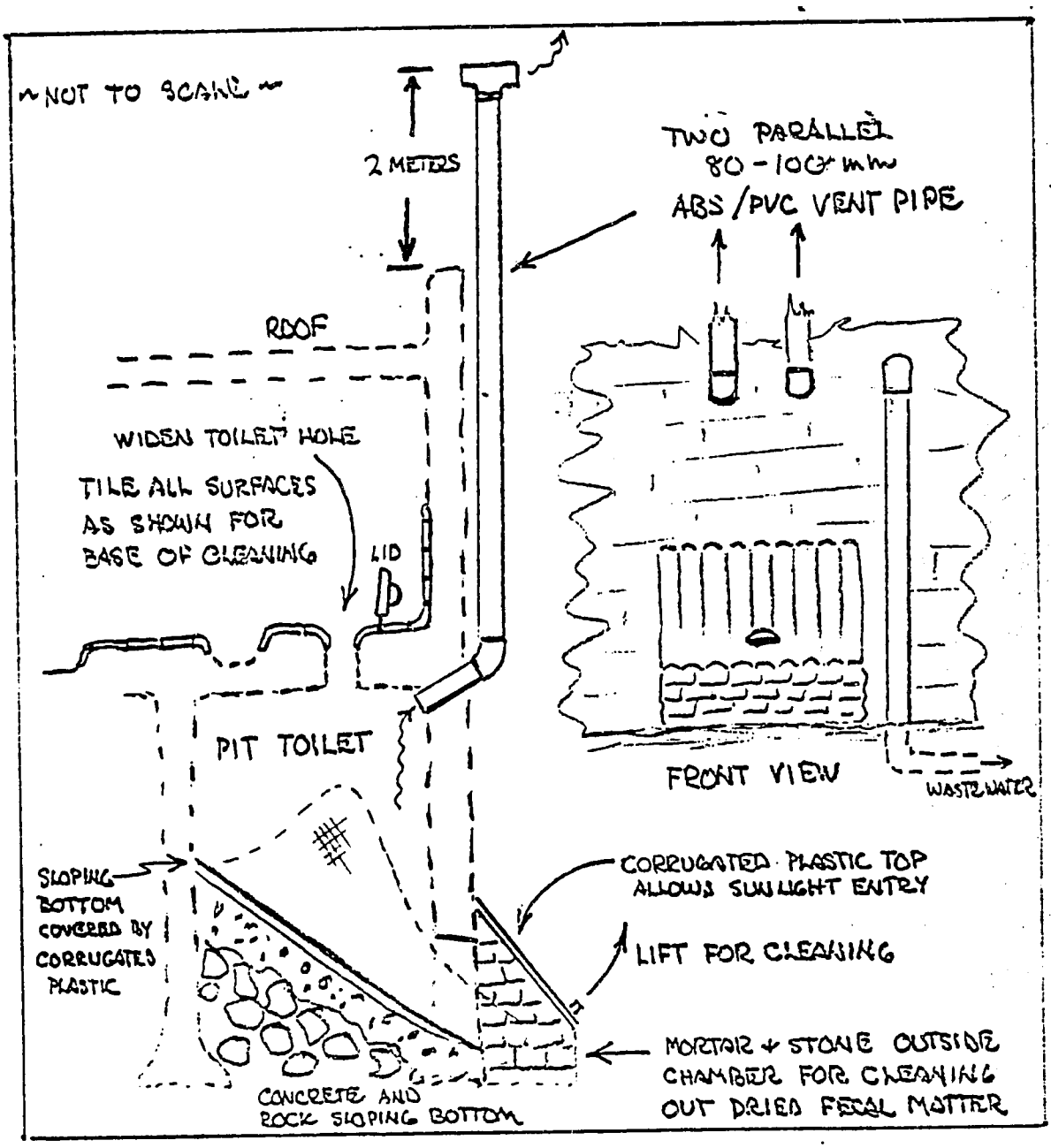


FIGURE 5

IMPROVEMENT OF PIT TOILET



M.W.S. 11/79

FIGURE 6

IMPROVEMENT OF PUBLIC H'MOM

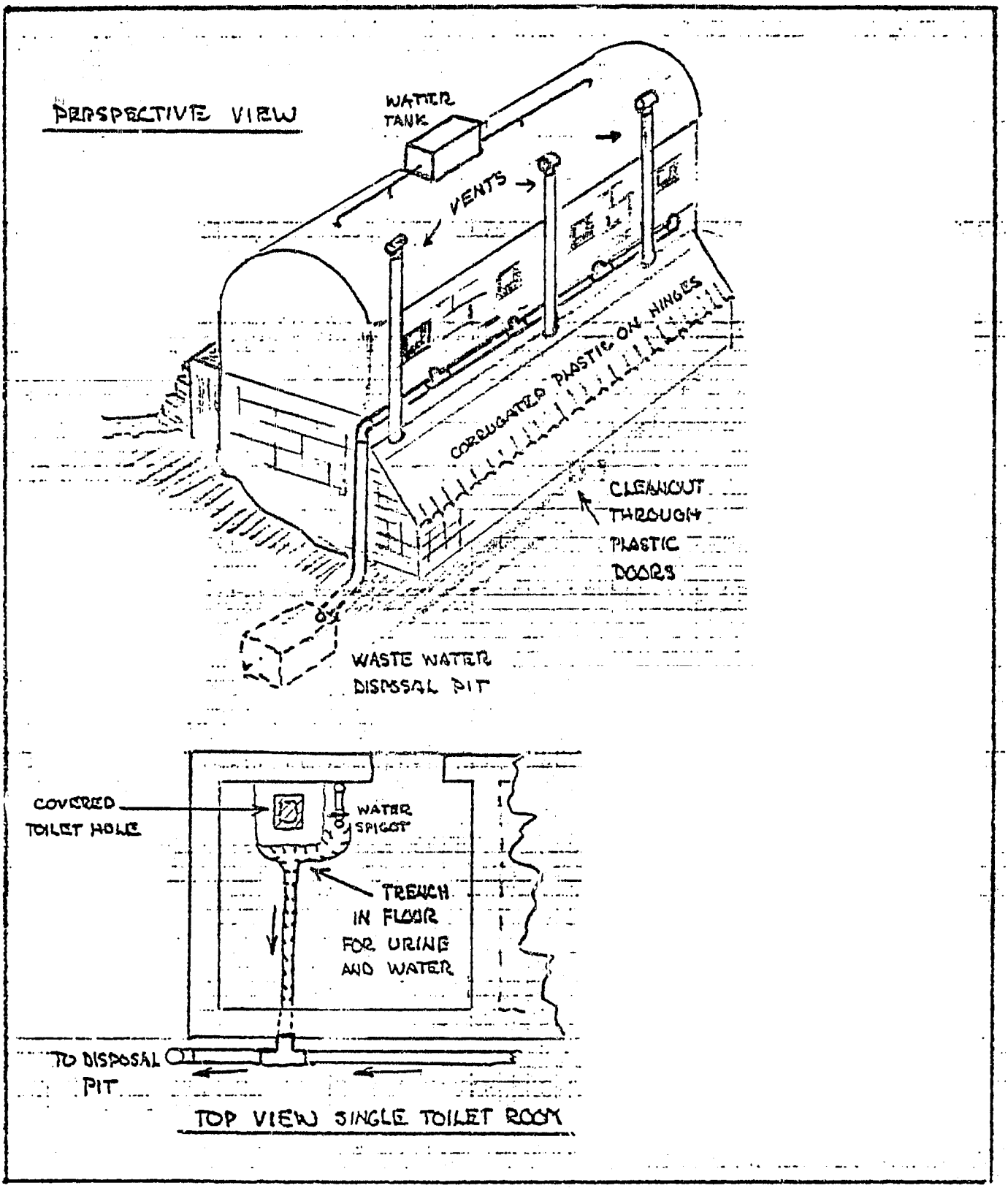


FIGURE 7

SOLAR HOT WATER

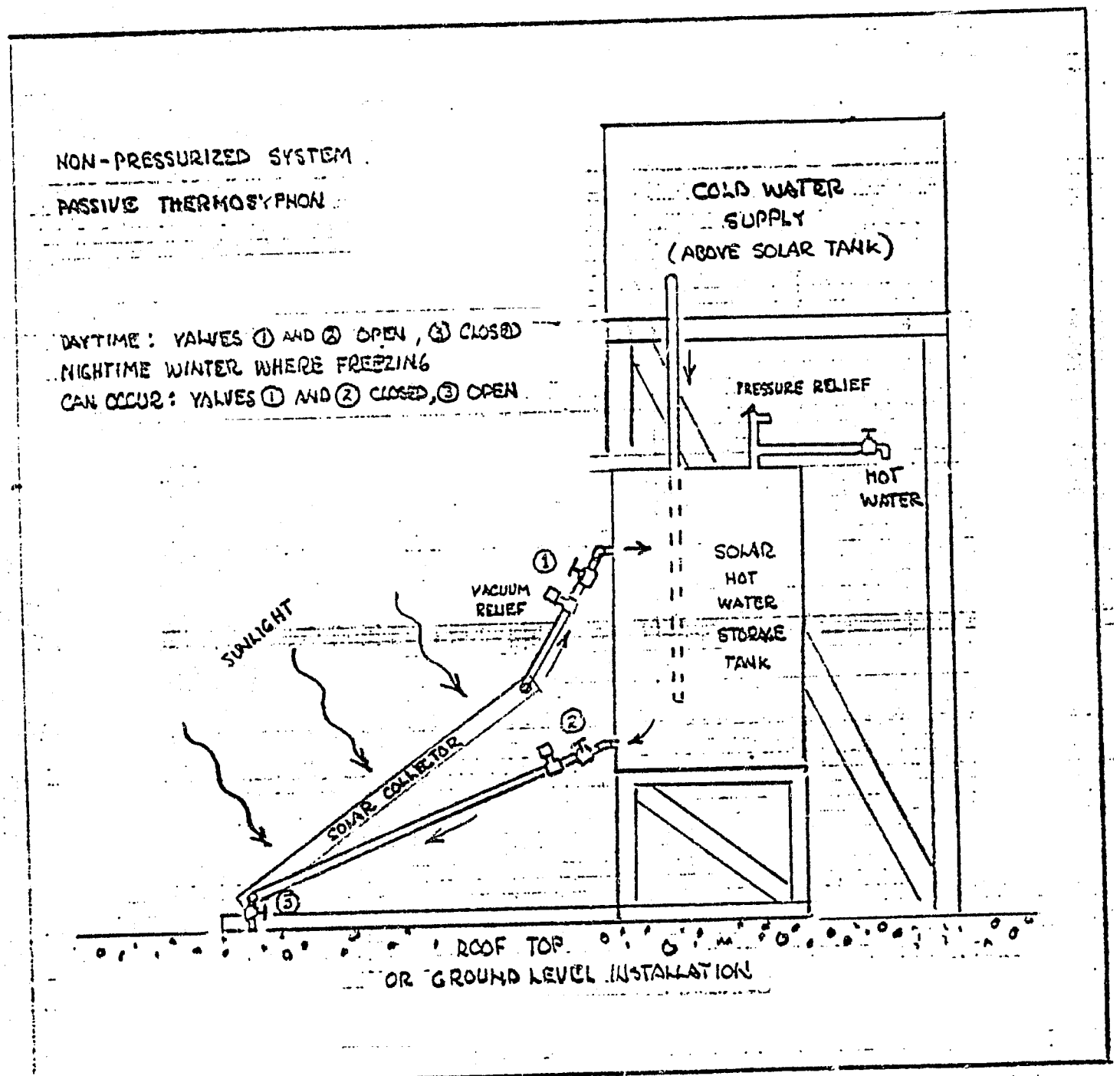


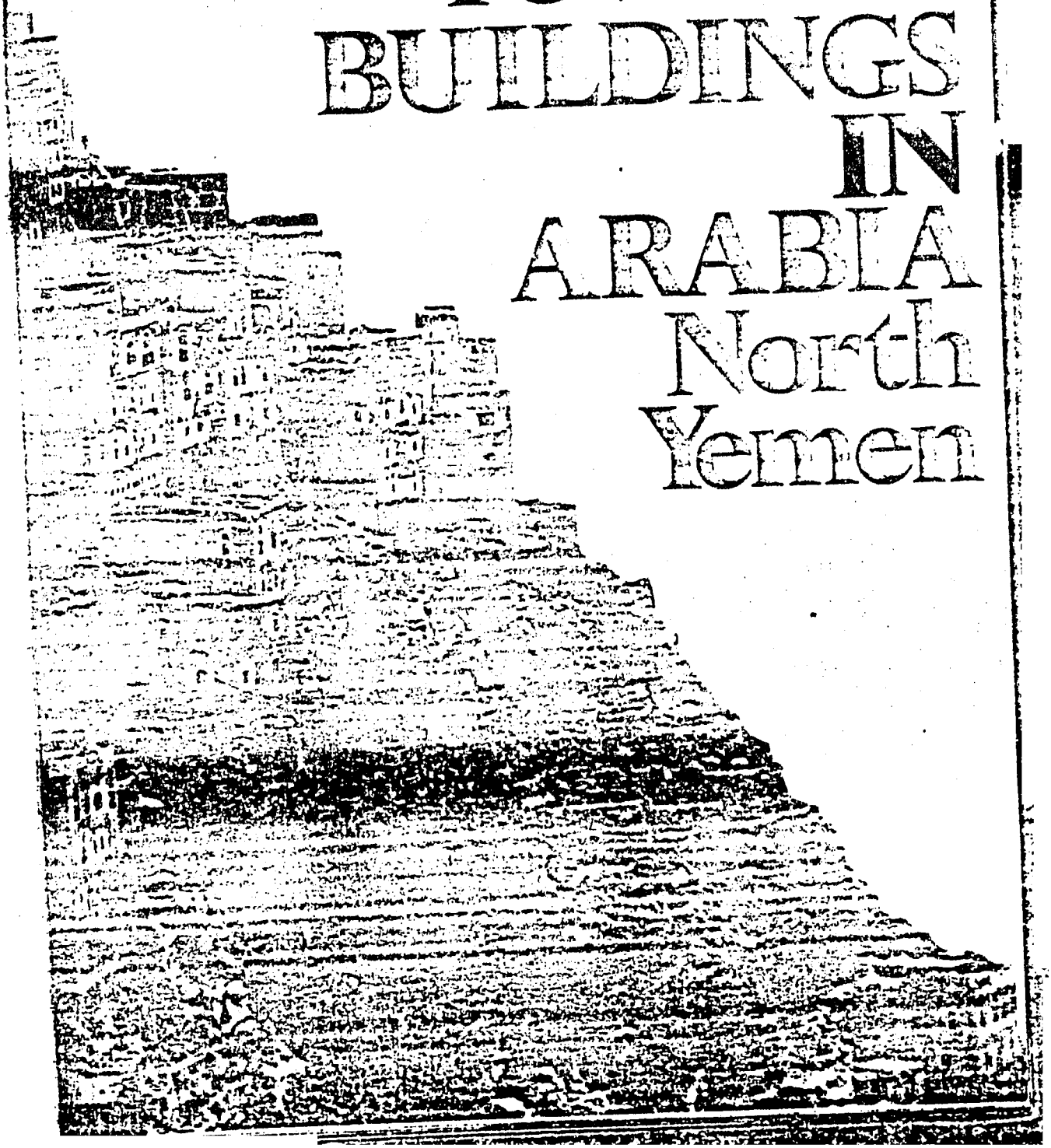
FIGURE 8

Architectural Association Quarterly
8:1
1976.

Ronald Lewcock

TOWNS & BUILDINGS IN ARABIA

North Yemen



Ronald Lewcock

Traditional architecture in South Arabia

The publication of this article coincides with the Nomad and City exhibition at the Museum of Mankind, part of which is devoted to the reconstructions of the suq and rooms from houses in San'a', the capital of Yemen. Ronald Lewcock, who was largely responsible for the exhibition on that Islamic city, here widens his scope to discuss the architecture of the whole region.

The first words of K A C Creswell's classic *Early Muslim Architecture*, 1958, reflect the narrow view that everyone had always held: 'Arabia, at the rise of Islam does not appear to have possessed anything worthy of the name of architecture.' Yet the statement is surprising, given the wealth and importance of Arabian architecture that is now being revealed. The explanation lies in the fact that the kernel areas of ancient Arabian culture, North Yemen and south-western Saudi Arabia (which are parts of one continuous cultural zone) were almost entirely inaccessible to non-Moslems, a situation which has only effectively changed within the last decade.

From Mecca southwards a range of mountains runs parallel to the Red Sea, reaching heights of more than 3000 metres. It induces a mild climate and traps the monsoon rains; from ancient times this region has held 80 per cent of the population of the Arabian peninsular. To the east, along the Indian Ocean, lay the groves of frankincense and myrhh which supplied Ancient Egypt, reaching there by travelling up caravan routes along the eastern edge of the mountains. Later, the same routes saw the passage of luxury goods from India and China, and the gold and silver of the Mediterranean returning in exchange.

Mecca was a trading city on this route, heavily reliant on alliances with the rulers of the great kingdoms of the south for its prosperity. The prophet Mohammad's father

previous page (title):
Characteristic town in the Yemen mountains. Kuhlan, north-west of San'a'
right, top:
Square defensible farmhouses in a wadi near San'a'. These are built of thick mud layers
right above centre:
A circular tower house of layered clay in a village in the central plateau of the highland region, near San'a'. The original reception room – the *majraj* – has been replaced here in recent years with a square brick room, cantilevered at the corners. The imaginative, fantasy quality of the Yemeni houses does not seem to be wholly accidental
right below centre:
The divan in a circular tower house. Above one shuttered opening is a fixed light of translucent alabaster; above the other is a fixed light of gypsum tracery holding small pieces of glass
right bottom:
The staircase in a circular tower house; built of rough stone over sapling beams spanning between rubble walls then plastered with gypsum plaster (see figure 1)

had travelled to Yemen before Mohammad was born, and Southern Arabia was one of the first areas to be brought under the influence of Mohammad's new teaching. It was from this region that the bulk of the soldiers who conquered vast territories for Islam were naturally drawn, to eventually settle in Kufa, Basra, North Africa, and as far afield as Spain.

Topography and climate

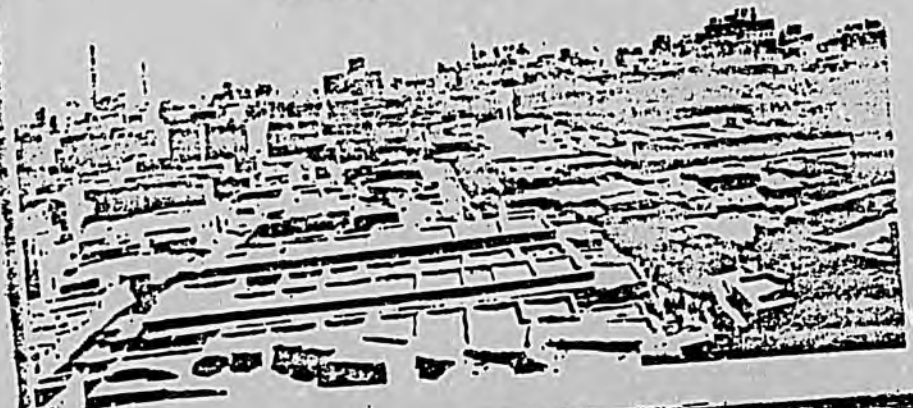
The diversity of the architecture of North Yemen reflects the division of the country into four natural regions all parallel to the Red Sea. The lowland strip, known as the *Tihamah*, is an arid, semi-desert, coastal region along the Red Sea. It has a hot and humid climate, with temperatures often reaching 50 C.

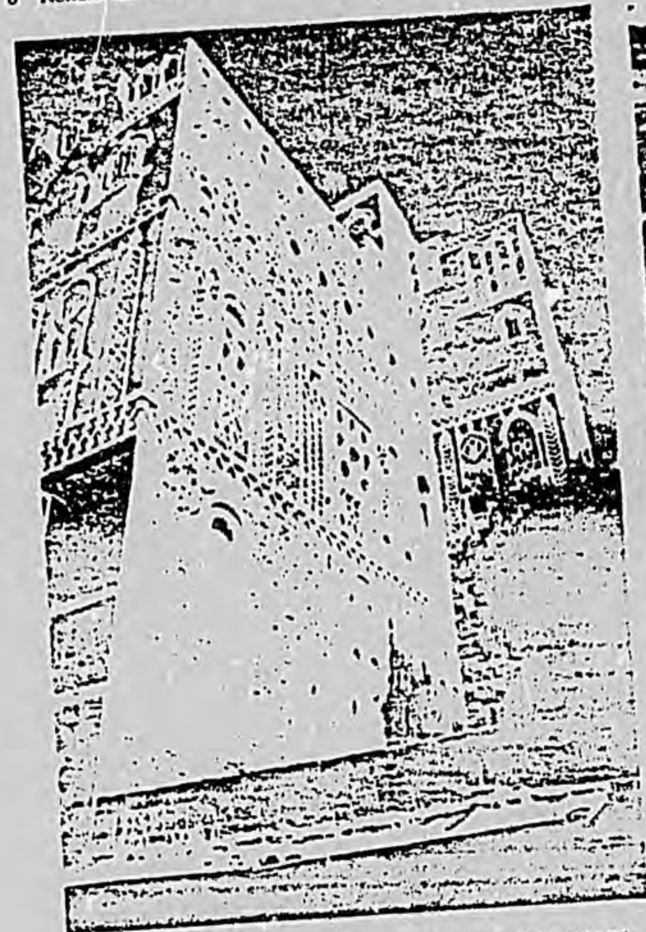
The midland, known as the *Jibal*, or mountains, has a milder climate with heavy rainfalls during the rainy season from June to September. Ta'izz, at various times a chief administrative and capital city for the entire country, is situated in this area. The district of Ta'izz is extremely fertile and at the junction of major trade routes.

The highland region averages between 2200 and 2700 metres above sea level and lies to the east of the crest of the *Jibal*. The largely volcanic mountain blocks to the west have disintegrated to deposit thick layers of sandy soil, very like loess and with the same property of soaking up and holding rainfall like a sponge. This accounts for the fertility of parts of the highlands, even though the rainfall is limited to a relatively short period in early and late summer. In many areas it is possible to dig wells and thus to create, from the steppe which would otherwise be almost arid in the dry season, gardens and oases which bloom all the year long. The climate is temperate, with very dry and mild weather; the temperature difference between daytime and night-time can sometimes reach

A village of square tower houses, protected by circular towers, on the edge of a wall flanking the central highland plateau. Such a scene is thought to have been characteristic of the country in ancient times

The market in the centre of the old city of San'a'. High caravanserais and houses rise around the low shops. On the right is a pair of mosques and their round minarets. In the distance is the citadel





Patterned brick decoration on a single occupancy, eight-storied tower house in San'a'

Tower houses in San'a'. The stepped stonework of the lower storeys of the house in the foreground is of a type used in A... buildings, more than twelve hundred years ago. A band of decorative brickwork separates the stone wall surface from ... brick surface. Both in the bands higher up between the store... and in the crowning cornice band, this decoration usually co... of variations of a zig-zag motif

Older houses have upper windows above openings which ... made of one, two or more large circles originally filled with alabaster, but in some cases afterwards renewed in stained g... The circles are often contained in double frame which resem... an arched window (see figure 3)

30 C. During the dry season there is only a little ground cover, but the first spring rains cover the whole plain and the slopes of the mountains with the fresh green of thick vegetation, much of it aromatic and fruit-bearing growth which remains throughout the summer. San'a', the capital, is situated in the centre of the highland zone.

Further east a low range of mountains separates the highland zone from the deserts which descend in a long slope to the Arabian Gulf hundreds of miles to the north-east. Sheltering against the edge of the mountains lie the regions of the Jawf and of Ma'rib, ancient Saba, where irrigation in early times made possible the development of a rich civilization. Today, with ancient dams and reservoirs silted up or broken, only a few scattered settlements survive; they depend on the small wadis which come down from the western highlands for their existence. Only in the south-east corner of the country is the rainfall sufficient to sustain more than a small number of permanent settlements.

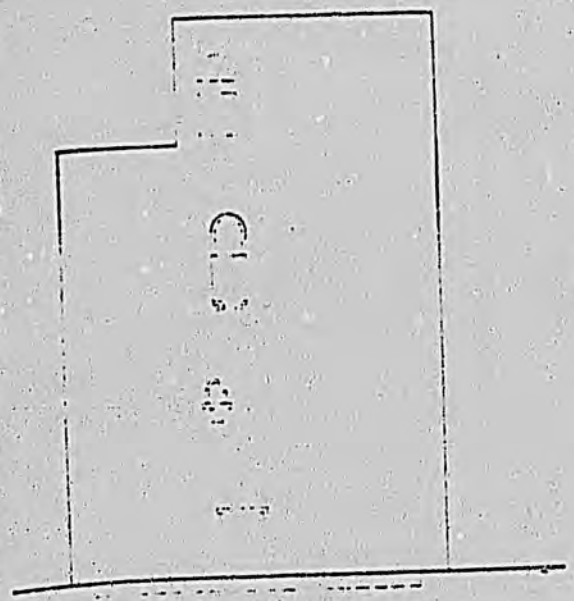
The climate of the coastal strip, the *Tihamah*, is markedly different from that in the other three zones. For the purposes of this study, the midland and the highland zones are grouped together, the eastern zone is considered briefly, and the Tihamah zone is studied separately.

Archaeological evidence suggests that the formative region of the country was the eastern highlands. ... earliest settlement known to have evolved into a ... state was that of Sirwah, 40 kilometres to the ea... San'a', before the eighth century BC. The unique ... land architecture of today can be traced back to ... Islamic times (see below). For this reason, and beca... is the most characteristic architecture of Sou... Arabia, the highland architecture will be considered ...

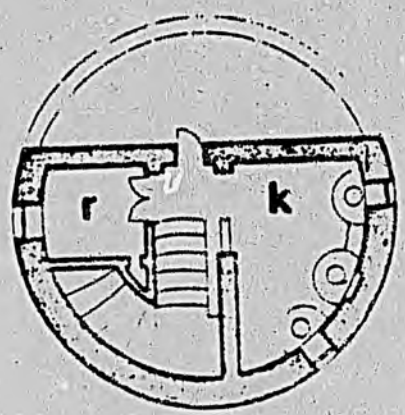
The architecture of the midland and highla... zones

As trees are relatively rare and small, the architect... the region relies as little as possible on the use of ... Flat floors and roofs are made possible by acc... twisted small beams, most of them spanning no ... than 3 metres covered with layers of brushwood ... earth, on top of which the horizontal, plaster-and ...

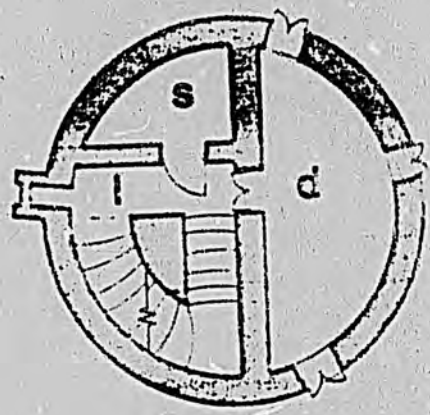
Figure 1
A circular fortified farmhouse, *nobah*, San'ā'; The house originally had another floor at the top, the *majraj* level (see illustrations p.4)
a Animal Stalls
b Bathroom
d Diwān
e Entrance
k Kitchen
l Lobby
m Mill
r Room
s Store



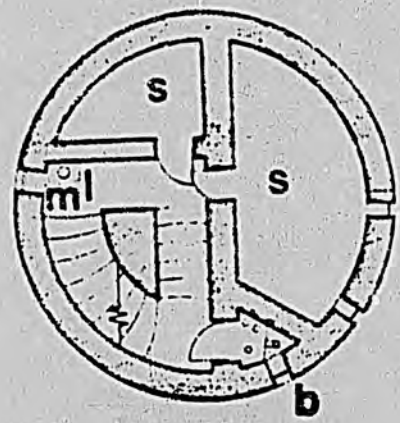
Elevation from east



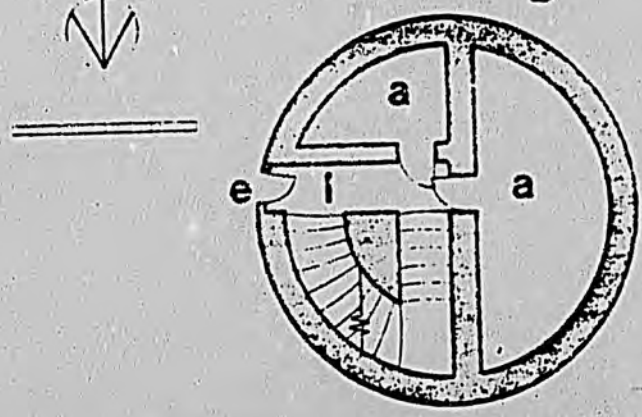
Third floor plan



Second floor plan



First floor plan



Ground floor plan

...lower
...in Abbasid
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...which are
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The old city of San'a'. The square tower houses are seen rising high above the walls and the dry bed of the wadi which runs through the city

or stone surfaces are laid. The construction of finished ceilings with larger wooden beams is so expensive that it is found in only a few mosques and palaces.

Primary building materials are stone and derivatives of clay made from the loess-like plains between the mountains. Sometimes gypsum and limestone deposits occur, and from these are produced, by low-temperature firing in kilns, the splendid gypsum plaster ('plaster of paris') and whitewash for waterproofing. Vaults and domes were not part of the domestic architectural tradition and seem to have been introduced as a means of roofing larger spaces in monumental buildings, under Byzantine and possibly Persian influence, in the centuries preceding Islam.

Patterns of settlement

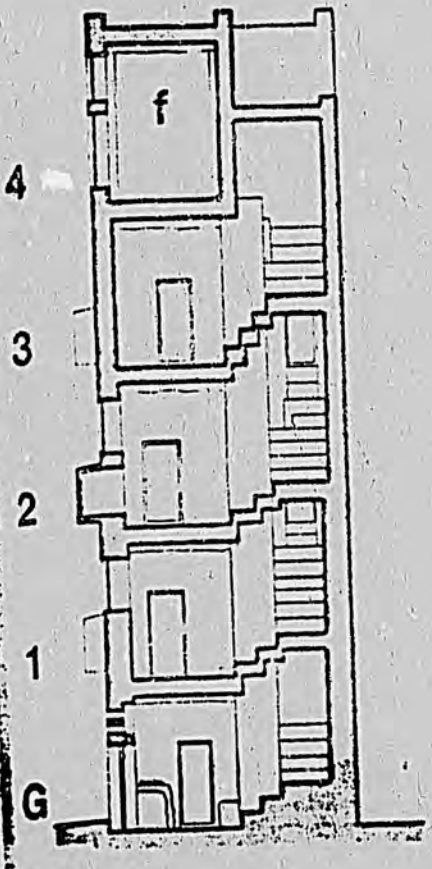
It seems fairly certain, from surface remains, that in remote antiquity agriculture was of two types. It was either carried on in wadi beds, which were sometimes irrigated from dams built across their upper valleys, or in stone terraces built on the slopes of the mountains to retain the moisture in horizontal soil beds. Habitation seldom took place on valuable agricultural land but was concentrated on dryer high points in the valley floor, on slopes and

top:
Most crafts in Islam are passed down from father to son. The stonemason is paid per block; each is shaped largely by eye, the only tools being the hammer, a straight edge and an angle. The block is a finished rectangle or square on face, the remainder being roughly tapered to fit into the rubble core

above:
A row of outer facing blocks laid in position. They are held at right angle with small stones acting as wedges until a fine mortar joint of gypsum is laid on the bottom facing edge. After the facing blocks are laid, by a craftsman of a different trade, a third trade lays the rubble core, grouted in with clay

Figure 2
A typical small house in San'ā'. San'ā' architecture, even in small houses, has a strong ingredient of conventional formality. It is this which gives a quality of ordered repose to the exteriors, a characteristic which is even more strongly felt in the interiors, with their plain whitewashed cubic or rectangular rooms punctuated with evenly spaced doors, square or circular windows and shelves (see illustrations pp. 8, 15)

a Animal Stalls
b Bathroom
c Living Room
d Diwān
e Entrance
f Reception Room
h Excrement
k Kitchen
l Lobby
m Mill
r Room
s Store



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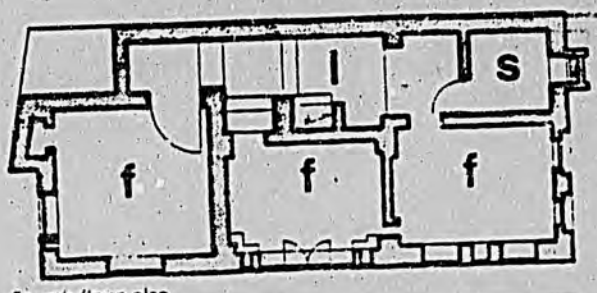
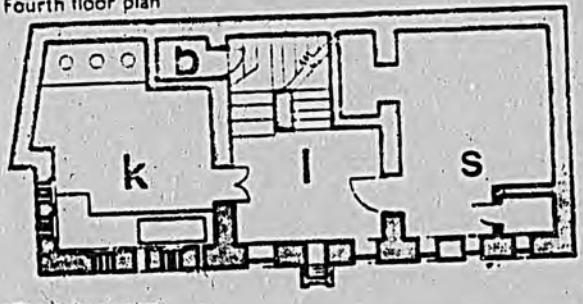
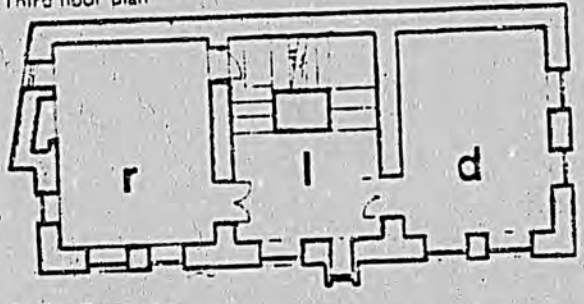


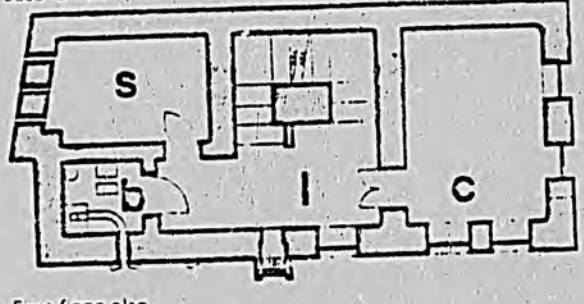
Fourth floor plan



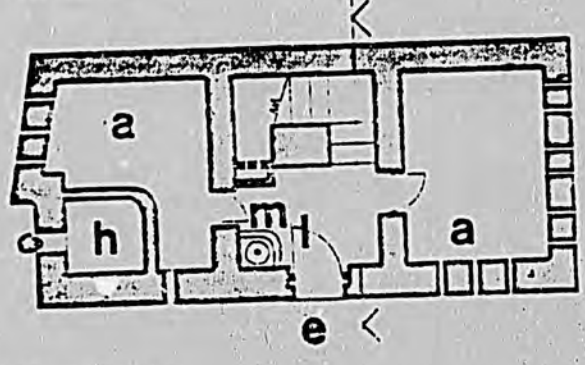
Third floor plan



Second floor plan



First floor plan



Ground floor plan

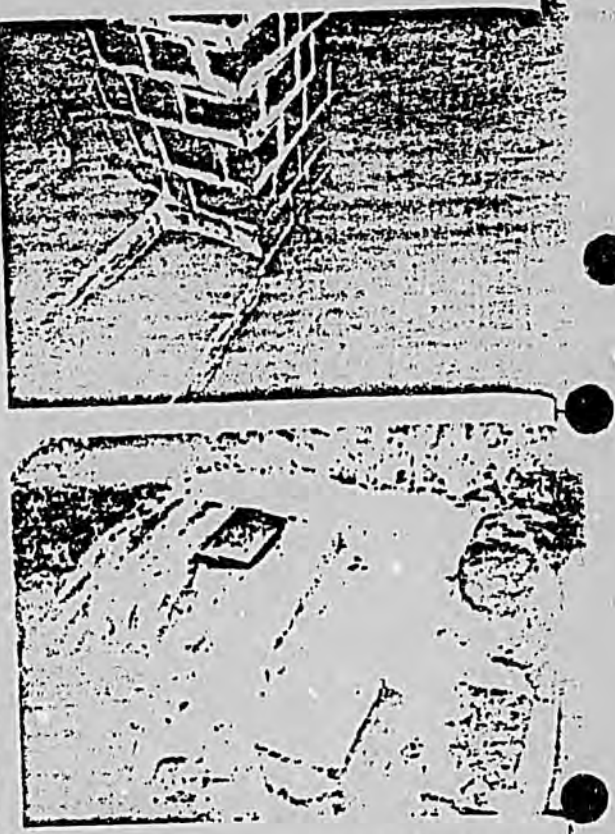
39

hillsides which were too steep or rocky for agriculture, or on the tops of hills. Isolated farm houses, although they did occur, were rare. More commonly, clusters of buildings were erected together for mutual protection to form small villages.

The mountainous terrain afforded good shelter for marauding tribes who might at any moment descend to pillage the villages and farms of the agricultural areas. Throughout the region, towers built of cyclopean stonework, of a kind identified in ancient Sabaean buildings, seem to have been used for domestic purposes. Some northern villages still retain clusters of them too numerous in number to have been part of a fortification system. It seems likely that the modern, square, tower-houses seen in farms, villages and cities are sophisticated descendants of such a prototype. An intermediate phase may be represented by the circular farm-houses, the *nobah* or *nasbah*, which continued to be built until recent times. A large farm would have only one such circular tower as its main resort in time of attack, surrounded by a number of lower rectangular buildings. The distribution of accommodation is basically the same in all these tower houses. The ground floor is used for the accommodation of animals, ranging from cattle and beasts of burden to sheep and goats. From it a stair leads up to the first upper level, sometimes a mezzanine above only a small part of the ground floor. This first level is used for the storage of grain and fruit. It sometimes contains the circular stone mills for grinding the grain; alternatively these mills are placed on the ground floor, inside the entrance. In large farm-houses or merchants' houses in the towns there may be more than one level for storage of this type. Above these levels is the first domestic level, usually containing a family living-room in which business may be conducted and visitors initially received. The staircase opens into a large lobby from which access to the living-room is obtained. There will usually be another small room on this level for the preparation of beverages and the charcoal brazier for lighting pipes, as well as a lavatory or bathroom. The floor above this is usually devoted to the *diwan*, the formal room of the house, kept locked and opened only for important family occasions, childbirth, weddings, feasts, and the laying-out of the dead. The kitchen is generally on a floor above this level, together with smaller rooms used mainly by the women and children. On the roof, or at the top of the building, there will be at least one room used for the afternoon entertainment of close friends; here the owner of the house relaxes with his companions or business associates to chew the stimulant leaf *qat* or smoke the water pipe. This room is customarily the most elaborately decorated in the whole house; it has large window openings closed by folding shutters to allow views in three directions; the fourth direction, the north side, is kept closed to prevent the entry of cold winds.

Because the walls of the houses are of masonry, and thickly plastered, the extremes of heat and cold experienced from noon to mid-night are rarely felt indoors. The thermal capacity of the walls introduces a heat lag which smoothes out most of the temperature difference. There is no heating, although the climate is quite cold in winter.

Permanent ventilation is provided in the staircases and lobbies by means of projecting masonry cooling boxes.



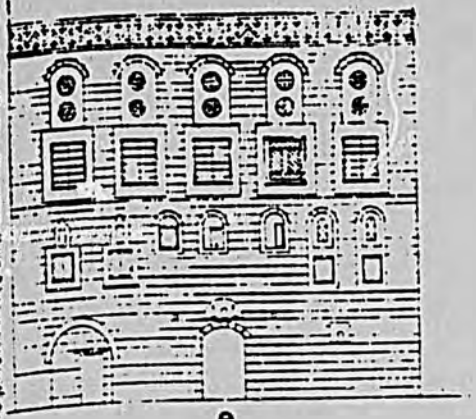
top):
The staircase usually continues up unbroken from the bottom to the top of the house, a solid construction of stone with a massive central stone pier, acting as a kind of structural spine to strengthen the whole building. The steps and the landing are of stone, and have steep goings: steps are wide (33-38 centimetres) and the risers are very high (25-33 centimetres). Nevertheless the 23 metre climb to the top floors of some of these high houses is less arduous than might be imagined. Owing to the square plan of the staircase there are rarely more than three risers in a flight before the corner landing necessitates a change in pace.

above:
The bathroom-lavatory of the house shown in *figure 2*; this typical bathroom contains a 'long-drop' lavatory and a 'bucket shower'. The lavatory, a plastered stone platform is built over a vertical shaft which drops down into a masonry room at ground level in which the excrement dries. In the front of the lavatory platform is a sloping section leading liquids down to a channel in the stone floor. The liquids run through an opening in the outer wall.

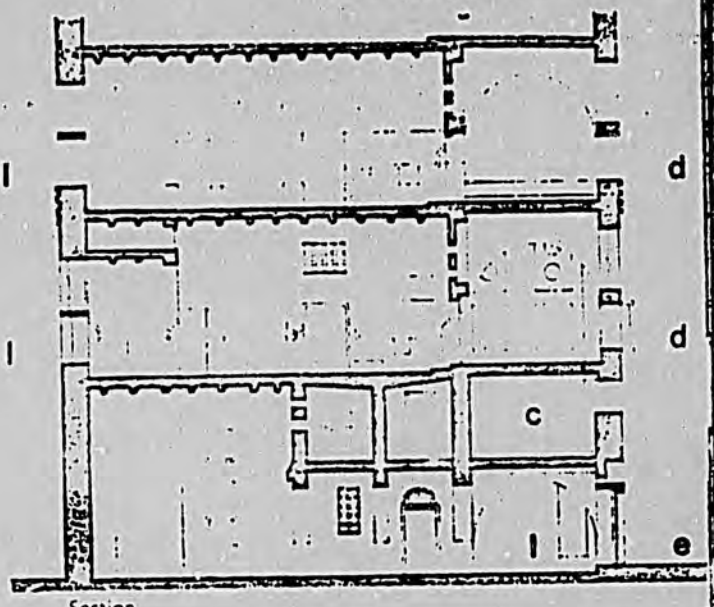
Smells are completely eliminated from the lavatory in two ways. Firstly, by ensuring that liquids are not led into the 'long drop' shaft or soil chamber far below, so that the excrement dries very quickly (San'ā' has a low humidity) and becomes odourless. Secondly, a pot or ladle (*maghraf*) stands on a stone cylinder near the lavatory, and with this, surfaces over which the liquids run down are swilled after washing.

The shower consists of a pair of square stones spaced apart, on which the user squats, and a cylindrical stone centrally in front of them with a recessed top to receive a container of water which is poured over the head and body.

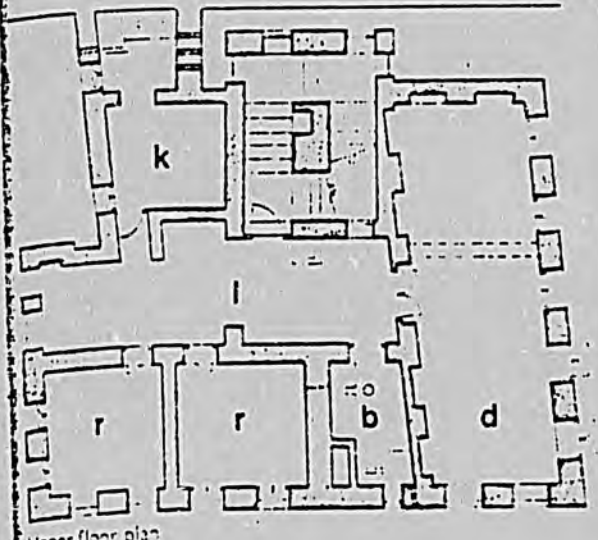
figure 3 (right)
The lower levels of a medieval tower house in San'ā'. (Same key as, *figure 2*)



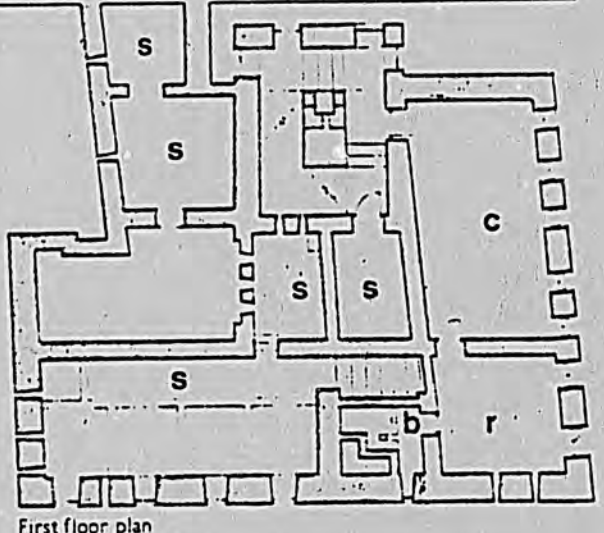
Elevation from north-west



Section

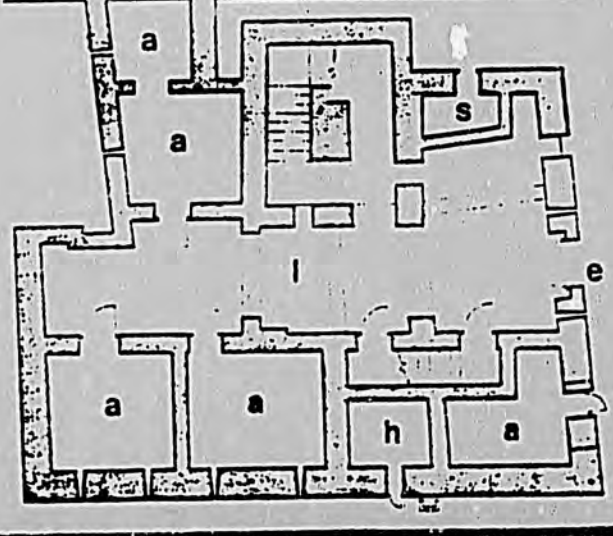


Upper floor plan



First floor plan

Ground floor plan



These have shuttered doors which can be closed in cold or windy weather. Rooms are normally ventilated at a high level by tiny ventilation flaps set in the walls between the fanlights. In the rare event of high humidity after rain, the lower shutters can be opened to provide cross ventilation at body height into the lobbies.

The lighting levels are high, due to the large areas of fanlight above the low shuttered openings. In some cases the fashion for coloured glass has reduced them, but in the older houses the alabaster panels above the shuttered windows flood the interiors with a golden light.

Yemeni houses are normally built for one family unit; old houses may have two, or even three, closely related families living in them; in a few cases houses are owned by a sheikh, or are *waqf* foundations, in which case they may be subdivided.

The upper entertaining rooms: In a large house these focus ro... the *mafraj*, a large high room with long low windows on at le... three sides, used by the master of the house for chewing a ... stimulant leaf qāt and entertaining in the afternoons. There ar... also other rooms for similar use. Often one floor below the *mafraj*, there is a smaller version of the same room, perhaps ... view windows on only two or even one side. The furnishings ... the *mafraj* follow the traditional furnishings of all Yemeni livi... rooms, but they are usually of richer materials

Towns and cities

Most Yemeni towns are not walled. Sometimes the Jewish quarter was segregated from the surrounding area by building the houses so that their walls were continuous to form a completely enclosed quarter with only one or two entrances. Often, however, the Jews were separated from the Moslem town by some distance, and in these cases continuous enclosures of this kind were not necessary.

Moslem towns are usually concentrations of high houses slightly more sophisticated in structure and decoration than rural houses, but in most respects quite like them. From a fairly concentrated central area the houses spread out to merge into the scattered towerhouse farms at the edge of the town. Only rarely is there any fortified town wall. Yet some pre-Islamic towns were walled, as is clearly evident from the surviving deserted towns in the *Jauf*, which are ringed by high vertical walls, built of large rectangular blocks of ashlar stonework with square projecting bastions at short intervals. The finest surviving town walls are those of San'a', 'Amran, and Sa'dah, but there is evidence that a number of other large towns and cities had such walls until the present century, including Ta'izz and Yarim. The surviving walls have bastions which are semi-circular, spaced 200–300 metres apart, and mainly built of layered clay with foundations and lower courses of rubble. Often the town grew up around the foot of a citadel, so that eventually the town and hence the town wall completely enclosed the citadel within its compass (Sa'dah, Rida'). But at San'a' the citadel remained above the town and therefore became part of the eventual town wall. Citadels were generally built throughout of stone for greater strength, and the parts of the town wall of San'a' which are actually the original citadel wall are variously composed of rubble stone, rough ashlar, smooth ashlar and baked brickwork. In addition there are two circular bastions and an ancient gateway built of large boulders, roughly-shaped, fitted together with very fine joints, work which is believed to be pre-Islamic in date. There are two ancient gateways of the same type at Sa'dah.

Within each town of any size the main focus is the Friday mosque. Markets are not usually within the town walls but more commonly outside one of the gates as at Shibam-Kawkaban and 'Amran. In the biggest cities, however, the market is within the city wall, probably having been swallowed up in the expansion of the c... Examples are San'a', Sa'dah, Dhu Jibla, and Ta'izz. ... market area is usually an open space, with semi-perma... or permanent single-storey buildings containing ... raised stalls, with occasionally workshops or store ro... behind them. Encircling the market area there ... frequently the high enclosed caravanserais of character... Yemeni type.

The streets of the towns are generally narrow ... flanked by towering houses with no sight of vegetation ... water to relieve the eye, yet behind the houses and exte... ing right up to them there are frequently large gard... These are the *waqf* foundations which support ... mosques; they are planted with vegetables and tree... fruit which are sold to the encircling houses, the su... going to the market. Thus almost every house eve... San'a' has a view through its windows into exte... market gardens. The gardens frequently appear su...

but this may be ... centuries of re... building and str... the original gr... the gardens may ... Attached to eac... water being dra... who move dow... are unusual in g... from the sun. Th... which the fields ...

A constant do... and cities was e... conduits on the ... water collected ... the mountains ac...

The predomin... visitor with thei... five storeys high ... eight or even nine ... with many hund... other above th... impression.

The houses ar... architectural faca... another, appears ... little attention t... Many of the large ... have an entra... hidden by wall...

...e family living roo... ...e Yemeni rooms. ... ...eeping or for all th... ...or is generall... ...side the room... ...arpeted and ringed ... ...attresses. Behind ... ...urfaces stand vertic... ...bove these are som... ...ten with fringed v... ...rm rest cushions. S...

but this may be a delusion, produced by the accretion of centuries of rebuilding along the streets, so that the building and street levels are raised several metres above the original ground level. Occasionally the sinking of the gardens may be due to their location in old clay-pits. Attached to each garden there is a well ramp, the well water being drawn by animals, usually working in pairs, who move down excavated slopes. Yemeni well ramps are unusual in generally being roofed to shade the animals from the sun. The water is passed into masonry tanks from which the fields are irrigated.

A constant domestic water supply for the larger towns and cities was ensured by the provision of underground conduits on the Persian or Omani model, which brought water collected from clusters of wells in the foothills of the mountains across distances of as much as 18 kilometres.

The predominant square tower houses impress the visitor with their height. Many houses are more than five storeys high, the largest commonly having seven, eight or even nine storeys. A view of a city from a distance, with many hundreds of these houses soaring behind each other above the city walls, makes an unforgettable impression.

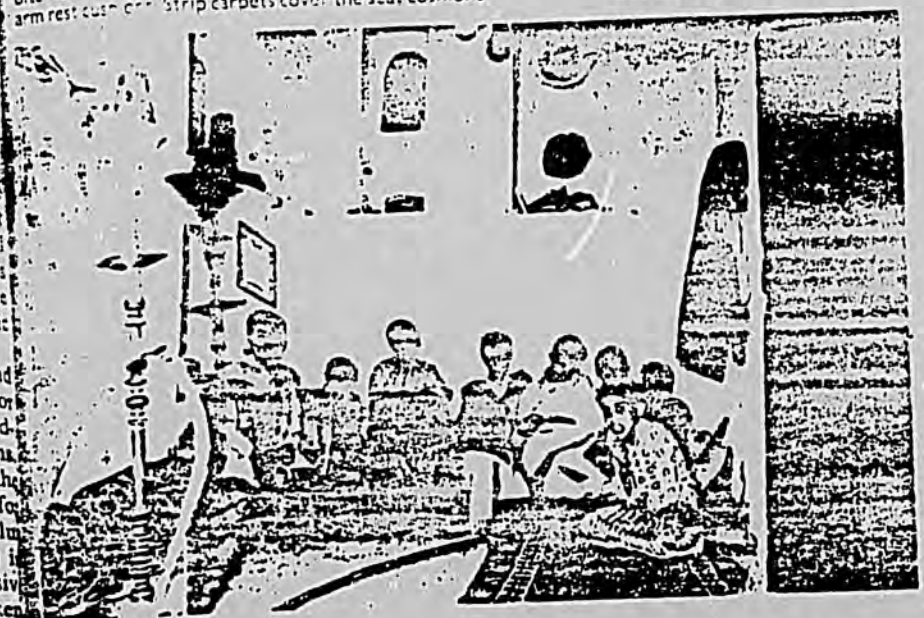
The houses are seldom joined together to make one architectural facade. Each house, even if wall to wall with another, appears to want to be looked at for itself and pays little attention to an exact alignment with the others. Many of the largest houses are so packed that they do not have an entrance court, others stand in small gardens hidden by walls from the alleyways.

The *diwān* of the large San'ā' house shown in plan and section in *figure 3*. This typical *diwān* is entered by a pair of double doors which are usually kept locked as it is only used on formal occasions. In an average house the diwān would be 5-6 metres long and 3-4 metres wide. Such big rooms are usually crossed with masonry arches to strengthen the structure. Generally one end of the room is more important than the other, and is kept furnished with cushions, rugs and carpets

The family living room is furnished in the fashion of almost all the Yemeni rooms, whether they are used for eating, sitting or sleeping or for all three functions together, ie the area nearest the door is generally kept clear to allow one to leave shoes just inside the room, and part or all of the remainder of the space is carpeted and lined round the walls with a continuous seat of mattresses. Behind these mattresses against the plaster wall surfaces stand vertical cushions as backrests, stuffed with straw. Above these are sometimes placed smaller cushions as neadrests, often with fringed white antimacassars. There are usually hard arm rest cushions. Strip carpets cover the seat cushions

The houses of San'a'

The houses of the capital city, San'a', the largest city in South Arabia until recent times, are noticeably finer and richer than in most areas of the rest of the country. They are constructed of ashlar stonework up to approximately 6–10 metres above street level and have exposed brickwork above that. The stone walls are not solid but have a rubble and clay core, with a facing on each side of squared stones tapering slightly as they penetrate the wall. The bricks are flat square bricks made from the clay of the surrounding plains and averaging 16.5 centimetres square and 4 centimetres thick. Externally the lower levels are simply whitewashed or allowed to remain as bare stone. They are entered through only one opening, a squat wooden door usually in the middle of the southern side.



below:
Fixing the hinges, catches and locks of doors and windows is done before the frames are built into buildings. The hinges and catches are all made of various types of hooks fitting into rings. This not only allows the windows and doors to be unhooked while the frame is built in, and then assembled quickly afterwards, but permits sashes to be easily removed for repairing glass, or for interchanging with shutters or sashes of another type

bottom, left:
Window tracery is made by special craftsmen away from the building site. It is carved from a slab of gypsum plaster before it has dried. Normally the outer tracery is unglazed and there is another layer of tracery set on the inside face of the wall which contains coloured glass. The latter is manufactured by laying the small pieces of glass over a dry tracery panel, then casting another sheet of gypsym over the inside face which is finally carved to match the existing pattern. No elaborate setting out is done, the gypsum worker carving the front and back patterns from memory and at high speed

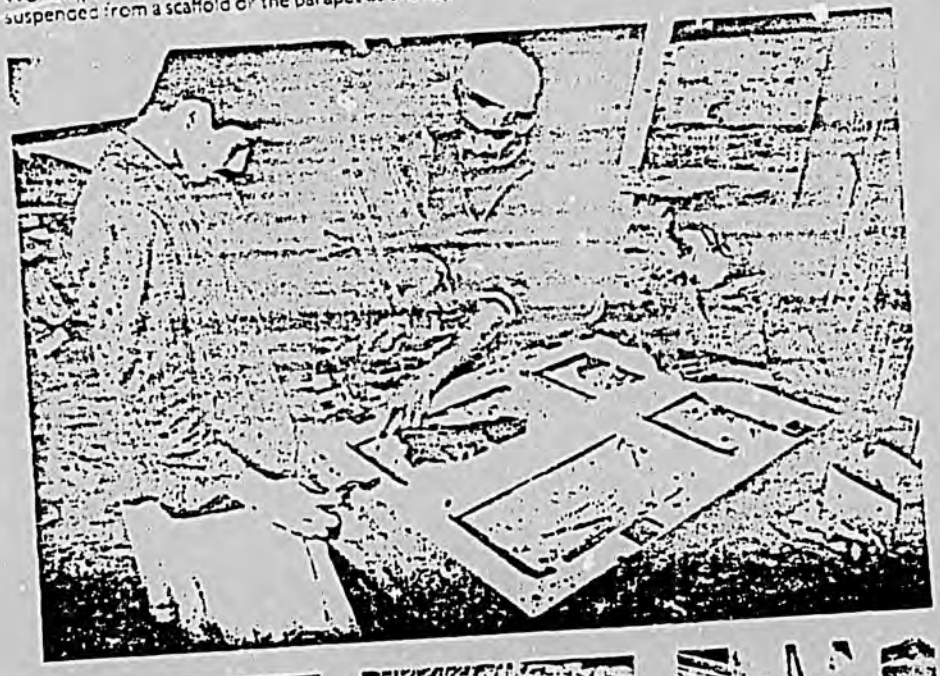
bottom, centre:
Laying a floor, with rough branches as beams, seldom spanning more than three and a half metres, bundles of sticks spanning between them, and 30 centimetres of clay above that. Finally thin stone slabs will form the floor

bottom, right:
Working on the outside of a building, craftsmen are normally suspended from a scaffold or the parapet at the top

Upper walls are generally two bricks thick, that is 3[illegible] centimetres or more, on lower levels two and a half or three bricks in thickness. The upmost storey and parapets are sometimes only one brick in thickness, with extra reinforcements provided by piers.

Wooden bands run around many of the houses, especially those of lower storeys built in stone. They appear to be carefully joined so that they form a continuous girdle holding the walls from bulging out in the older buildings. They would naturally take up stresses due to unequal settlement or earthquake shocks. There are usually two of these bands above and below the lower large windows, acting as cill and head, and sometimes another running through the stonework below. They are often whitewashed for weather protection, therefore not immediately recognisable as wood.

The roof is constructed of an extra thickness of clay and finished with special plaster, loam and crushed volcanic rock mixed, which is renewed annually. Rain which falls on the roof is collected at the low parapets and then discharged well clear of the walls by means of wood spouts averaging nearly a metre in length.



The age of the tower houses

High houses seem to have existed in the Yemen in pre-Islamic times. A Himyaritic inscription in Ta'izz Museum refers to the construction of a house with 'six floors and six ceilings'. A stone of unknown provenance shows a graffito of a house with nine storeys. The great San'a' palace of Ghumdan is attested in many Islamic histories. It had at least seven high storeys, possibly as many as 13, and its height awed all the historians. Reports vary from 70 metres upwards. It was a square building with a special room at the top 'with windows' each fitted into a frame of marble, which in turn was held 'in a jamb made of teak and ebony'. It was possibly erected in the third century AD, and destroyed on the orders of Uthman, the third orthodox caliph, in the first/seventh century.

The first description of San'a' houses in Islamic times occurs in *Ibn Rusta* (c 290–300/903–913).[1] Al Hamdani (died 330/943) includes several references to San'a' houses. One compares mud towers elsewhere to the towers of San'a' 'because of their height',[2] another refers to the cleanliness of the sanitation.[3] Al-Razi quotes him as speaking of 'the loftiness of structure' of the San'a' houses.[4] Al-Razi says elsewhere that the houses were 'tall and imposing and many had high prices'. Other early references describe the use of alabaster in windows and the spaciousness and clean white interiors of the San'a' houses.

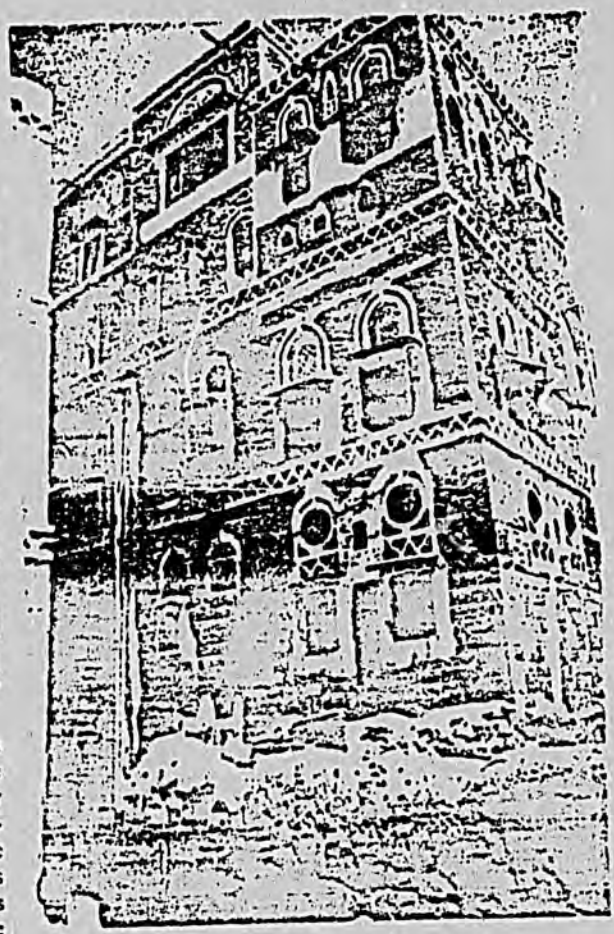
The oldest surviving houses have frequently been rebuilt in their upper levels. The thinner brick walls have decayed, or lower cracks have been exaggerated as they reached the top of the building. At various times, tribesmen have sacked San'a' and then the *mafraj* storeys of the larger houses have been sacked and sometimes burnt. It is clear, however, that the lower levels of some of the houses are extremely old. Documentary evidence points to an age of up to 800 years for a few of them. Most of the houses do not have an age extending back beyond 300 years; the topmost storeys are usually less than 100 years old.

The highland house – an alternative type

Not all houses have their reception room, *mafraj*, on the roof; some have the *mafraj* with a reflecting pool at ground level. As this takes up considerable ground area, there are now very few of this type within the walls of the old cities, but newer towns such as Rawda have many such houses. Outside of the old walls of San'a' are the garden quarters which were particularly popular during the Ottoman occupation and the second Turkish occupation, and these contain larger houses and palaces which commonly have a *mafraj* of this type, although the richest may have another on the roof as well (see illustration p. 17).

Although situated within the volume of the house, the *mafraj* is characteristically not entered directly from the house; there is a separate outside entrance to it past the reflecting pool. An open arcade of lime-washed plastered brickwork shields the *mafraj* pool from the surrounding garden, providing a sense of enclosure; it is overhung by trees planted just beyond the arcade. A trellis for vines crosses the pool and its central fountain, sometimes supported in the centre by columns which rise through the water of the pool itself.

A large arcade frames a loggia which separates the pool from the *mafraj*; in some houses the top of the loggia acts



top:
The front of a small tower house in San'a,' shown in plans and section in *figure 2*. To the left is the vertical drain for the disposal of liquids from the bathroom; it is made of waterproof gypsum plaster. Frequently vertical drains are elegantly shaped and decorated. As they reach the ground liquids disappear into an underground drainage sump, from which they are led to a French drain for disposal in the soil

above:
Houses in Sa'dah. The curved courses strengthen the clay houses, as does the batter on the walls. A few of the houses have been finished in a clay plaster so that the coursing is no longer visible

as a screened terrace for the private use of the women of the house.

Tower houses throughout the midland and highland regions

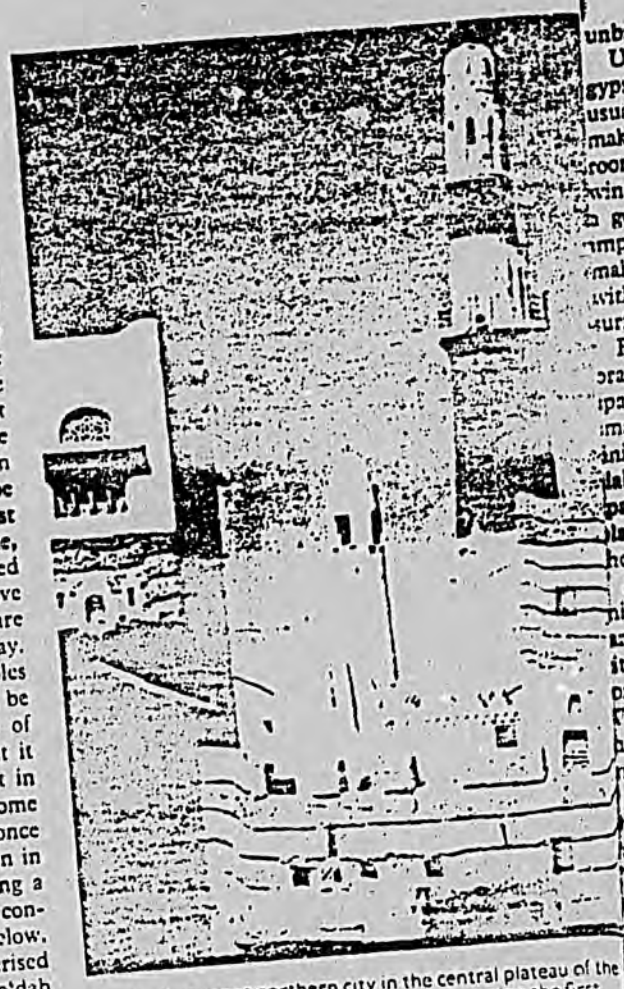
High houses are found throughout most of the central plateau of the Yemen and to the east; they occur further north, in the southern part of present day Saudi Arabia, and further south and east in Southern Yemen and the Hadramawt. Although there are local variations in concept, especially in detail, the essential nature of the house does not change; that is, it has four or more storeys, the lower ones serving to house animals and storage, and the upper ones for habitation, with the most important entertaining rooms on top level. There is usually only one entrance door and the house is simple and massive in bulk. Villages comprised of houses of this type may be seen within a few kilometres of San'a' and present just as urbane appearance as the houses of San'a' itself. True, in villages only the most important houses have squared ashlar stonework in the lower storeys, and fewer still have burnt brick above. More commonly, the upper storeys are sun-baked brick, and the lower storeys coursed clay.

Farm houses are often the same type, with all the stables and store rooms within a single building. They may be either square or cylindrical. An obvious advantage of using the cylindrical shape for these houses was that it increased their stability, especially if they were built in soft coursed clay. In addition it is claimed by some inhabitants that the existing cylindrical houses were once much higher. Evidence of their strength may be seen in the fashion, perhaps of fairly recent date, of building a large square *mafraj* at the top, often cantilevered considerable distances beyond the sides of the cylinder below.

The northern part of the central plain is characterised by buildings in coursed clay. The Zaidi capital of Sa'dah is almost entirely built of this material.

Coursed clay (*zabur*) is laid in courses approximately 50 centimetres high, the bottom of each course slightly overhanging the one below and then tapering gently to be thinner at the top, creating a visual separation between the courses which is frequently accentuated by weather-proofing. The foundation of coursed rubble usually extends above ground to a height of between 30 and 40 centimetres. The clay is taken from a borrow pit near the site. It is mixed with sand, straw and chaff, water is added, and then it is beaten or trodden underfoot. It is left to mature for two days, during which time chemicals from the straw and chaff mix with the clay to produce a stonger and more water-resistant material.

It is passed from the ground to the workman on the wall by shaping it into balls which can be easily thrown. The builder catches them and lets them drop into position on the wall, then pummels them into shape so that they make a homogeneous mass. There is no shuttering. Each course is completed and left to dry for two days to a fortnight before the next course is begun. Openings are braced with stone slabs, or with rough timber reinforcing built into the thickness of the clay courses. Each course is slightly curved upwards from the centre. Before it reaches the corner, it steps up in an even more pronounced fashion. The walls batter slightly inwards as they rise. As a result of these precautions, cracking due to weathering or earthquakes does not result in the corners falling wards, but the building tends to consolidate itself age. It is a technique which seems clearly relate construction in ancient Egypt.



Sa'dah, the ancient northern city in the central plateau of the highlands. The Great Mosque was founded during the first period of Islam. The fluted domes appear to date from the fifteenth-seventeenth centuries. In the foreground the turre corners of the mud courses of the buildings is clearly visible

In other areas of the highland plateau unbaked is used, particularly for the upper levels of the h Unbaked brick (*libun*) is sun dried, and contains stra chaff for greater strength. It varies in size fro common size of baked brick, ie 16·5 centimetres squa 4 centimetres thick, up to the massive size us some houses of approximately 44 centimetres centimetres × 11 centimetres; even larger size sometimes seen. Mouldings are usually execut lightly-baked, small, common-sized bricks, or in baked, red bricks. Openings are bridged using arc the same material, or flat arches of small bricks on a row of thin timber beams. The mortar used is sand and straw mixture (*malajah*), sometimes with manure added.

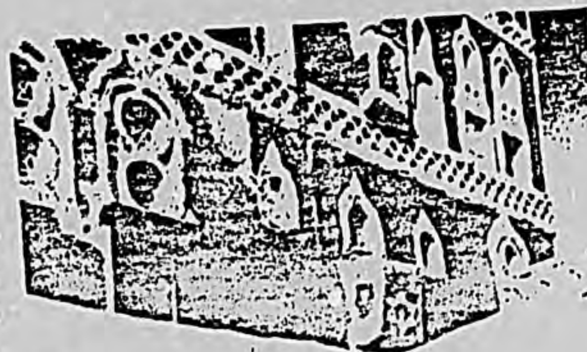
Unbaked brick walls are frequently used on work above stone plinths or lower walls. Occasion highest, thinnest sections of a house built ma

unbaked brick will be executed in baked brick.

Unburnt brick is usually protected or decorated with gypsum wash or with clay plaster. Gypsum plaster is usually reserved for internal decorative plaster and for making plaster shelves, small flights of stairs to upper store rooms, as well as for constructing pierced and tracery windows. It is not usual to paint clay plaster, which retains a good appearance, except possibly an area around an important window which is whitened with gypsum wash to make a frame. Sometimes clay plaster is repainted annually with a wash made from animal manure, which hardens the surface and has a good appearance.

Floors are made by laying heavy tree trunks and branches stripped of their bark and leaves across the space between the walls, then placing thick bundles of small sticks spanning between these above them, and finishing with a layer of clay plaster covered with stone slabs or a plaster surface for the floor. The beams are spaced 60 centimetres to 1 metre apart. The soffit is plastered with gypsum plaster and whitewashed to form the ceiling of the room below.

Stone houses are built in the mountain area of the midlands and generally in the southern part of the high-lands, particularly in the area around Ibb, and in that city itself. The stonework is frequently a rough rubble, sometimes coursed, the interstices filled with plaster. Windows in these areas are often much smaller than in the capital city, San'a', possibly because the alabaster and stained glass have to be imported from there.



A highland house of the second type, with the main entertaining room, the *mafraj*, almost at ground level, opening to a raised terrace containing a large pool. The type is normally associated with summer resort areas outside the city walls

Other building types

Public baths

There is some evidence that public baths existed in the Yemen before Islam. The oldest that can be identified have a form close to that of a provincial Roman bath. They are largely built underground in order to provide maximum insulation, they are roofed with domes and vaults, and the rooms which make up the hot area of the bath are heated by means of hypocausts and flues in the vertical walls. The domes are built of a specially fired baked brick, and seldom exceed 4 metres in diameter in the hot rooms of the bath and 6 metres in diameter in the changing room area. A characteristic feature of the plan of the Yemeni baths is that the temperate and hot zones are formed of six rooms, a central room and two side rooms in each zone.

Dhū Jiblah, a typical midland city. The houses are of rough stone, frequently with the small circular fanlights characteristic of early medieval architecture

Mosques

Although the use of vaults and domes appears to have been known in the Yemen before Islam, the earliest mosques that can be dated do not use them but are flat roofed. A possible reason for this is the influence of the Persian royal hall, the *apadana*, which may explain the construction of a number of high mosques with elaborately moulded and decorated ceilings carried on high slender columns.[5]

The Great Mosque in San'a', traditionally built at the instruction of the Prophet himself, had, in the form in which it was rebuilt in the third/ninth century, arcades parallel to the *qiblah* wall, which carried the flat roof. It seems likely that these arcades date back to the earliest construction of the mosque and are derived from Byzantine influences in the Yemen at a time when the largest church in the Axumite kingdom was erected at San'a'. Early Islamic historians say that Byzantine architects were involved in the design and construction of this church, the mosaics of which were used to decorate

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...land plateau unbaked bri... upper levels of the hous... dried, and contains straw ... It varies in size from ... 16·5 centimetres square ... to the massive size used ... mately 44 centimetres × ... tres; even larger sizes ... are usually executed ... mon-sized bricks, or in ha... es are bridged using arche... arches of small bricks resu... ams. The mortar used is a ... (*...alaiah*), sometimes with ani...

...are frequently used on che... or lower walls. Occasionally ... ns of a house built mainly ...

the Ka'ba in Mecca in 71/684. A door in the Great Mosque with panels containing pre-Islamic inscriptions has arcades as part of its decoration. The small early mosques had merely a clearing in front of them and no proper courtyard, the larger ones had a northern prayer hall with four or five aisles, a southern prayer hall with one aisle less, and two side aisles on either side of a roughly square central courtyard. The use of domes in mosques, apart from their use over small tombs, appears to date from the period of the Rasulid dynasty of the fifth/eleventh to ninth fifteenth centuries.[6] Splendid mosques with large domes were built after the Ottoman conquest of the country in the tenth/sixteenth century.

Caravanserais, or khans (*samsarah*) were built both with courtyards and without. The latter seems a curiously Southern Arabian type. It has large stables for animals on the lower levels, surrounded on two or three storeys by store rooms, to which the goods are carried up staircases. High columns rise through these lower mezzanine levels to carry the main roof which is piereced with openings to allow shafts of natural light to reach the stables.

Above the roof rise two or three levels of rooms for lodgings in which the members of passing caravans may stay. These rooms are arranged around courtyards which are located over the high stables below. The vertical arrangement of stables, store rooms and living spaces follows the same pattern as that in the Yemeni houses. It seems likely this is an ancient Southern Arabian building type which has come down to the present day.[7]

The eastern desert zone

The towns and farms which shelter along the eastern fringe of the desert depend for their water on the wadis coming down from the highland zone; they have an architecture which is closely related to that of the midland and highland zones but is entirely executed in coursed clay and mud brick.

The Tihamah

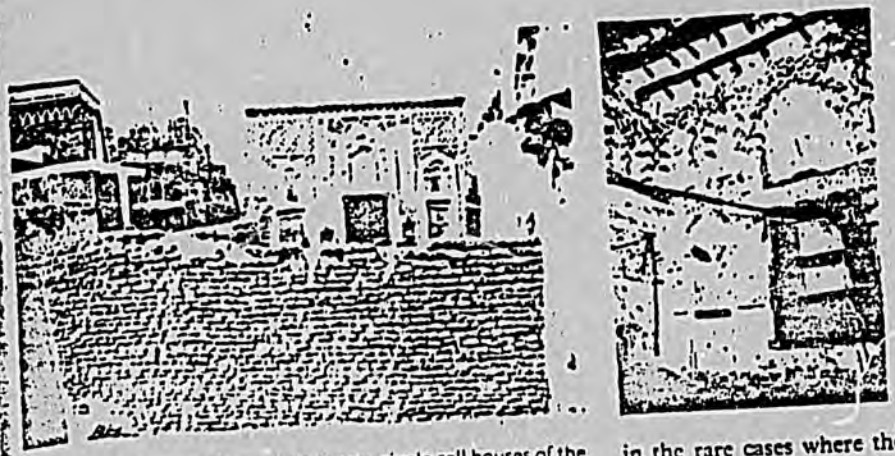
Three types of architecture are seen in the coastal plain along the Red Sea.

The first is an ancient architecture of grass thatch over a timber framework. Two types of form are observed, as happens in many parts of the world where these materials are used. One is a beehive shape, that is, a slightly curved cone made by arranging poles with their bottom ends forming a large circle in the ground and their top ends tied together. The other shape resembles a double-pitched roof, or a tent, made by placing two pairs of poles with their ends in the corners of a rectangle and crossing the pairs of poles at each end, and then laying a ridge pole across between them; the whole structure is lashed until it is rigid. In both cases a sub framework of smaller poles is used for tying-on the thatch.

Both types of thatched house frequently have plastered interiors with a colourful folk decoration.

The second type of Tihamah house is found only in the big coastal ports. This is a kind of architecture occurring in all the Red Sea ports, and called by Derek Matthews 'the Red Sea Style'.[8] It is characteristic of Jeddah and Suakin. It is, again, an architecture of high buildings, usually four, five or six storeys high, made of a timber framework filled in with clay and plastered with lime plaster to provide weather protection. Because of the h humidity every room has wide openings closed by l wooden shutters and lattices to ensure cross ventilat The house does not have the defensive characteristic

below, top:
Ma'rib, a modern descendant of a legendary Sabaean capital in eastern desert fringe. The houses are of clay brick, and cluste the ancient tel, without a surrounding wall
below, centre:
Typical houses of the south-eastern desert fringe near Radā'. Built of clay brick with alabaster fanlights surrounded by anci patterns
below, bottom:
Houses of the 'Red Sea Style' on the waterfront of Hodeidah the Tihamān zone. Their main rooms are used by the men for business as well as relaxation, and are mostly on street level



Exterior and interior of the single storey, single cell houses of the inland Tihamah zone along the Red Sea. The courtyard in front serves as the main living room in the cool evenings and mornings and is screened by a high wall. Great attention is paid to richly decorating the single building, its facade with bas relief brick ornament and its interior with gypsum plaster patterns surrounding niches and openings

the highland houses, and for that reason there is commonly more than one door; the ground floor is not used for animals, nor the first floor, as a rule, for storage. Instead, the lower levels are frequently used by the men for smoking and entertaining while the upper levels of the building and the roof are private zones used only by the family.

Decoration of the entrance door, the plaster frame around it, and of the wooden lattices is frequently very rich. Sometimes the houses have stone walls on the lower levels, often the upper levels cantilever out using the natural strength of the timber framework so that each floor overhangs the floor below. Projecting window boxes are frequently as large as the opening themselves, sometimes big enough for a group of people to sit within them. The roof areas are screened with lattices or plaster arcades and do not have a *mafraj* or a room for public entertaining.

The third type of house is found particularly in towns somewhat inland from the coast, particularly in Zabid and Bayt-al-Fagih. It is quite possible that this style antidates the Red Sea Style in the Yemen Tihamah.

This third type of house is usually single storeyed, a rectangular building which contains a single large room with a courtyard or open space in front of it. In an urban situation the courtyard is enclosed with walls more than 2 metres high entered through a formal doorway. In a rural setting the houses have frequently no courtyard wall. Ancillary accommodation is sometimes, but not always, provided in other smaller rectangular buildings clustered around the courtyard in front of the main room.

These houses are built in baked brick, less commonly in small pieces of stone. The masonry is patterned in relief on almost the entire surface of the front wall of the main building. There are frequently crenellations or finials against the sky. The roof is flat and waterproofed with lime water. The enclosing wall and walls of the rear and sides of the main building and the ancillary buildings are undecorated except for occasional string courses of simple ornament.

These houses sometimes have battered walls, especially in the rare cases where the house climbs to a second or even a third storey. Internally the rooms are very richly decorated with many niches and shelves. Although some of this decoration is built into the masonry, it is plastered and moulded before being whitewashed or painted in colour.

Furnishings consist of high sitting-beds instead of the low cushion seating of the midlands and highlands. Often there is one set of beds in the open space in front of the house, made of wooden frames with woven cane or rope mattresses, and similar beds are arranged around the walls of the large room. In cool mornings and afternoons the open courtyard is used as a main living space, and in this courtyard cooking and washing activities also take place. During the hottest time of the day retreat is made into the living room, or alternatively awnings are stretched across parts of the courtyard to provide shade. At night the courtyard is used for sleeping, on colder nights the enclosed room. Women are customarily secluded in the ancillary rooms or neighbouring houses when strangers are entertained.

The lighting and ventilation of the rooms is provided through the doorways and high openings on both sides of the rooms.

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8 'The Red Sea Style' and 'Suakin Postscript' *Kush*, Khartoum 1954, I, pp.60–86 and 1955, III, pp.99–111.

YEMEN: the "long drop" latrine

In the old part of the city of Sana the houses are slender and tall, rising five to nine storeys from the narrow streets. A house is usually occupied by one extended family. Each floor has one or two lavatory-bathrooms located next to a vertical shaft extending from a receptacle at the street level to the uppermost bathroom as shown on the figure below.

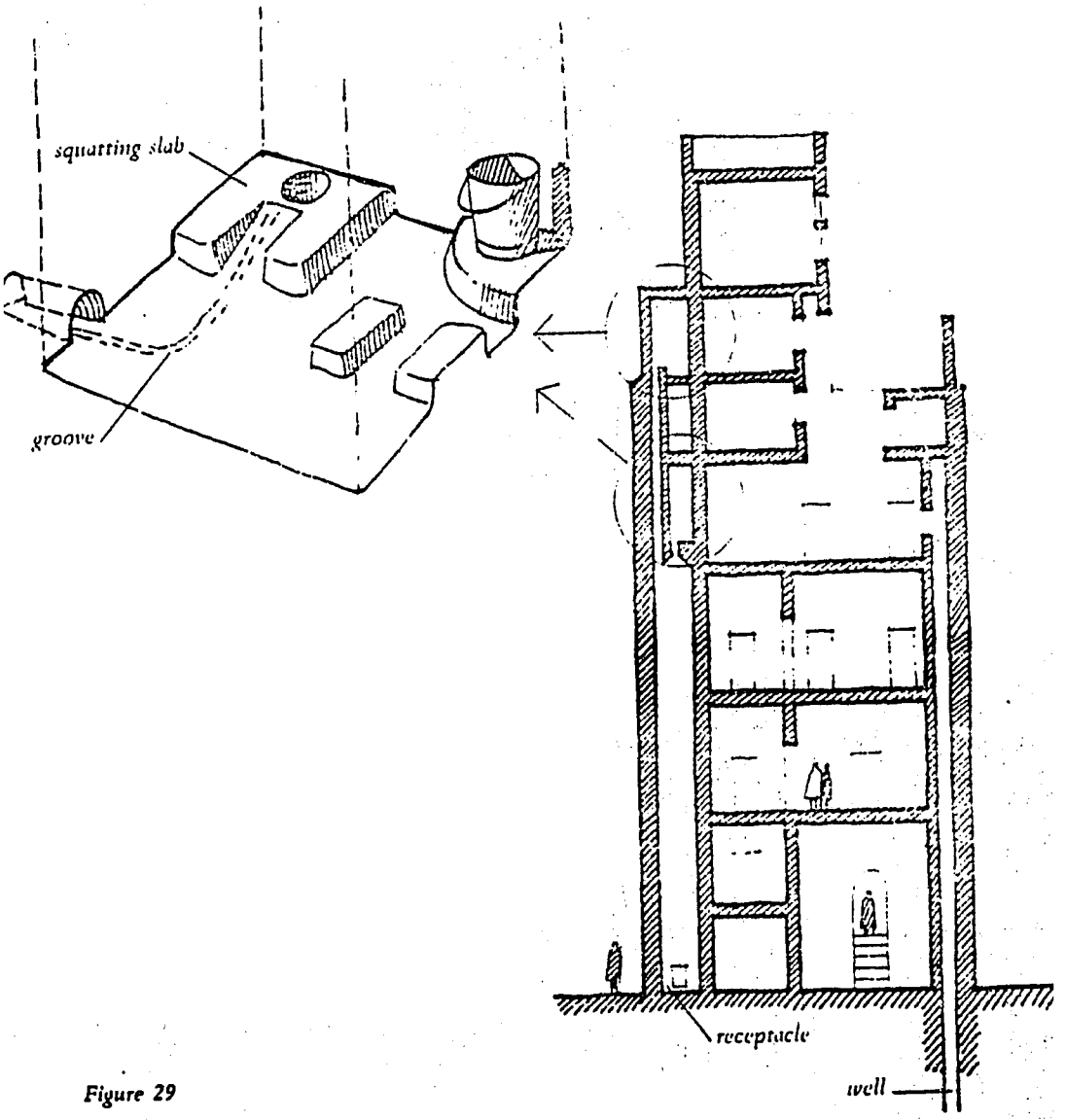

Figure 29

The faeces drop via a hole in the squatting slab down the shaft to the receptacle from where they are collected at frequent intervals and brought to the public baths.

Sana has eighteen public baths, the oldest dating back to medieval times. The baths are used by almost everyone once a week. They are run by hereditary bath-keepers who charge a small fee for their use.

At the bathhouse the faeces are spread out on the roof to dry. Wood is scarce in Sana and the dried faeces are therefore used as fuel supplemented by the refuse of skins and bones from the slaughter yards. After burning, the ashes are sold as fertilizer for the orchards and vegetable gardens in town.

The urine is drained away from the squatting slab to a groove in the stone floor, from where it passes through an opening in the outside wall, to run down a vertical drainage surface on the outer face of the building. These drains are often elegantly shaped and decorated. As soon as it reaches the ground, the part of the liquid not evaporated on the way disappears into an underground drainage sump.

Anal cleansing takes place on a pair of square stones next to the squatting **slab. The used water is drained away the same way as the urine. No liquids are thus led into the "long drop" shaft or the receptacle below. As Sana has** a hot, dry climate the faeces quickly dehydrate which facilitates removal (Kirkman 1976, Lewcock 1976).

This system may seem odd but is indeed well adapted to the local situation: multi-storey buildings, extremely dry climate, scarcity of water and lack of firewood. Ecologically it is sound: There is no pollution of water or soil.

From a health point of view it would hardly be acceptable as it involves handling of fresh excreta. Whilst drying on the roof of the bath the faeces are accessible to flies.

The final disposal of ashes is safe as burning efficiently destroys all pathogenic organisms.